Norwegian School of Economics
Bergen, fall, 2021

Supply Factor Analysis of the Norwegian Housing Market

How do Supply Factors in the Property Market Affect House Prices in the Short Run?

Mathias Norvik Aksnes and Bjørn Bue Kessel

Supervisor: Ola Honningdal Grytten

Master Thesis in Financial Economics

NORWEGIAN SCHOOL OF ECONOMICS

Abstract

The purpose of this thesis is to examine whether supply factors in the property market affect house prices in the short run. By applying time-series regressions, we examine how changes in supply factors affect housing prices for several Norwegian cities and study the differences during the time period of 1993-2020. Previous research primarily focuses on the demand as a determinant for the Norwegian Housing prices, while this paper emphasizes the supply side. Firstly, relevant theory for the supply and demand mechanisms are presented, which serve as a foundation for our estimated model and analysis. Furthermore, we study the historical development of the Norwegian housing market and the regulatory environment.

We find that construction cost, housing initiations, interest rate, and housing completions affect housing prices in the short run. Additionally, housing initiations are found to be affected by construction costs, prices, and interest rates. Furthermore, we find regional differences between the Norwegian cities. Contrary to other cities, Oslo is less sensitive to factors which are unrelated to financings, such as housing completions and construction costs. The housing market in Oslo seems to be affected by an unresponsive housing supply compared to Trondheim and Bergen. We believe that the reason is the lack of dwelling approval for residential purposes. Overall, we find evidence that housing supply factors affect prices in the short run.

Preface

This thesis is written as a part of our master's degree in Financial Economics at the Norwegian School of Economics. During our time at NHH, we have collaborated on several subjects and also discussed various topics for our research. However, we both share an interest in the real estate market which led us to discuss various aspects of the housing market with our supervisor and found a way to examine our topic on the real estate market by focusing on the supply side.

Writing this thesis has been challenging yet educational and rewarding as we have gained valuable knowledge and skill-sets we will take with us in our future careers.

This project would not have been possible without support and constructive feedback from our supervisor, Ola Honningdal Grytten. His guidance has been insightful, and we truly enjoyed the conversations we had at his office, which we will miss. We also want to thank Eiendom Norge for providing us with data for our research. Finally, we want to thank all the lecturers and fellow students at NHH for the great conversations and unforgettable memories we made during our years as students at NHH.

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Background

Since the housing policy of property ownership was introduced in 1945, developments within the Norwegian housing markets have become a common and well debated topic (Reiersen et al., 1996). The housing policy effectively subsidized both the demand- and supply side of the Norwegian housing market to strengthen self-ownership. This policy has led to the development of a peculiar desire for self-ownership as compared to other Scandinavian countries (Eurostat, 2020).

The last three decades have been extraordinary in the Norwegian housing market, with more than quadrupled real housing prices (Grytten, 2018a). The price development has led to a substantial increase in the net fortune for households who own their dwelling, causing tremendous publicity in the media. A surprising rise in the housing prices under the Corona pandemic culminated into a debate in October-2020 on NRK, where the price development and its consequences for increased inequality were discussed (Solvang, 2020). The debate focused on the supply side and the lack of housing construction relative to demand in Oslo. NRK invited developers, authorities, and landlords to discuss issues related to housing regulation and access to building plots to improve market balance. The debate strengthened our interest in the housing market hence leading us to investigate and examine the supply-side of the Norwegian housing market in our master thesis.

This thesis aims to examine the relationship between the various housing supply factors and the Norwegian housing prices. We are investigating the relationship using the period from 1993 until 2020 due to the extraordinary continuous price appreciation in this period.

1.2 Research Problem

Our master thesis investigates to what extent the various supply factors are determinants of the Norwegian housing price in the short run. To explore this relationship, we have chosen the following research question:

> *Supply Factor Analysis of the Norwegian Housing Market: How do Supply Factors in the Property Market Affect House Prices in the Short Run?*

1.3 Previous Research

Since 1993, there has been a high level of housing self-ownership as well as an explosive appreciation in the housing prices which has made the Norwegian housing market a popular research field. This chapter seeks to present the relevant research from which we have drawn deep understanding from.

This research is inspired and based on the research, *Historisk blikk på eiendomsmarkedet: prisdrivere for boliger*, by Grytten (2018a), which was presented as a part of, *Eiendom og eierskap* (Kristoffersen & Røsnes, 2018). This article gives an overview of the determinants of housing prices which are based on previous research, as shown in chapter 2. The overview is among others, based on the article, *Boligboble? Empiriske indikatorer i historisk perspektiv* (Grytten, 2009). From this article, we took inspiration from the discussions regarding construction costs and the challenge of interpreting its possible influence on the housing prices based on an index consisting of volatile input and quality factors.

Grytten's article is also based on research from Jacobsen and Naug. They presented an empirical housing price model in the article, *Hva driver boligprisene?*; which found that interest rates, housing construction, unemployment, and household income are the essential determinants for housing prices (2004). In our research, we have used their demand function to explain the housing market's mechanisms to enhance our analysis and conclusions.

Additionally, we have been inspired by the 50th-anniversary book of Husbanken, *De tusen hjem* (Reiersen et al., 1996). The book gives an embroidering review of the development of the Norwegian housing market, the history of Husbanken and the regulatory environment which has strengthened our understanding of the market.

In our thesis we have also applied new research from Jardar Sørvoll, *Husbanken og boligpoltikken 1996-2021: En jubileumsbok* (Sørvoll, 2021). In this book, Sørvoll elaborates on Husbanken's history and its changed mission after the end of the 1990s. From initially being a provider of housing financing to ordinary citizens, Husbanken's mission is now to support the needy with housing and encourage sustainable upgrades of existing homes. This change also reflects the developments in the Norwegian housing policy as Sørvoll writes in the paper, *Den boligsosiale vendingen: Norsk boligpolitikk fra midten av 1990-tallet i historisk perspektiv* (2011a). From 1945, the Norwegian housing policy changed from subsidizing and encouraging general self-ownership to today's housing policy which aims to secure housing for the less fortunate to hinder negative inequality development.

An important aspect of the Norwegian housing market is the housing cooperatives. In the study of housing cooperatives, we took inspiration from both the 75th-anniversary books of Bergen og Omegn Boligbyggelag and Vestbo: *Tuftet på fortiden – bygger for fremtiden* and *Rom for Alle* (Gjerstad et al.; 2018, 2021).

Another research we used to understand the Norwegian housing market is *Krakk og kriser i historisk perspektiv* (Grytten & Hunnes, 2016). The book gives an embroidering historical review of financial crises. This research deepened our understanding of the economic crises' implications for the Norwegian economy and the housing market.

There has been research done on housing supply with a focus on price responsiveness for OECD countries, where we have drawn some insights (Caldera & Johansson, 2013). This study focuses on the speed of supply adjustments, while our focus is on supply factors' effect on housing prices in the short run for the discussed cities in Norway.

Finally, regarding the use of the HP-filter and our regression design, we have taken inspiration from the article by Grytten, *Eiendomsbobler før og nå?* (2018b). This article was presented as a part of *Eiendom og eierskap* (Kristoffersen & Røsnes, 2018).

1.4 Scope and Delimitations

This thesis examines the supply factor's short run effect on the Norwegian housing price from 1993-2020. We chose to analyze the supply factors in isolation because several fellow master students have examined demand factors as determinants for the Norwegian housing price. However, to make qualified conclusions based on our results, we have examined demand in chapter 2 and the regulatory environment in chapter 5 to understand the underlying factors of the Norwegian housing market.

To answer our research question, we have chosen various supply factors based on an overview of determinants of the housing price constructed by Grytten (2018a). We chose to investigate the following supply factors: housing completion, housing initiation, construction costs, capital access, and interest rate. We chose not to examine business cycles as a variable because other students have covered this widely in previous master theses. Other supply variables that we did not investigate quantitatively were market return, alternative capital return, tax, expectations, and history. However, we include them for interpretation in the analysis.

The time period of 1993-2020 is chosen due to the extraordinary continuous price appreciation in this period. To examine our research question we have chosen the following cities: Oslo, Bergen, Trondheim and Kristiansand.

1.5 Disposition

The thesis is structured as follows. In chapter 2, we will examine the housing market theory by exploring a selection of demand and supply factors summarized in an article by Grytten (2018a). We will apply an empirical housing price model constructed by Jacobsen and Naug to examine the housing market's underlying demand factors (2004). Finally, the supply side will be described using its underlying factors and a pricing framework for supply and demand in the short- and long-term.

In chapter 3, we will present our chosen methodology for investigating our thesis. The chapter consists of elaborating on time series' assumptions and measures we are using to avoid violation of these assumptions.

In chapter 4, we will introduce the data we apply to examine the possible significance of our chosen supply factors. In addition to describing our datasets, we will explain the methods we used to transform our data into stationary. Thereafter, we will elaborate on our research's possible validity and reliability issues.

Chapter 5 will briefly introduce the Norwegian economy and a historical review of the Norwegian housing market from 1945 until today. Additionally, we will describe the regulatory environment on both the supply and demand side. The purpose of this chapter is to get a deeper understanding of the Norwegian housing market specifics in order to make qualified conclusions in the analysis.

In chapter 6, we will present our specific time series regressions for the analysis of the Norwegian cities. The purpose of the chapter is to present our models and the specific statistical techniques applied for our regressions.

In chapter 7, we will present our empirical results from the regressions. Furthermore, we will discuss the results to provide a comprehensive analysis of our findings.

In chapter 8, we will present our overall concluding remarks for the master thesis.

2. Housing theory

Housing prices are determined by the interaction of supply, demand, and the regulatory environment. An article by Grytten gives an overview of some of the most important factors that influence housing prices in Norway (Grytten, 2018a). The factors, categorized in demand, supply, and the general regulatory conditions are summarized in Table 1 (Grytten 2018a; Jacobsen, 2004; Kahn, 2008; Larsen & Mjølhus, 2009; Grytten, 2009; Jansen 2011, Larsen, 2015):

Table 1: *Determinants of Housing Prices*

Demand factors	**Supply factors**	**General Regulatory Conditions**
Disposal income	Housing construction	Regulatory regimes
Business cycles	Access to plots	Tax policies
Unemployment rate	Business cycles	Building code
Population growth	Construction costs	Monetary and credit policy
Urbanization	Capital access	Public housing
Fortune conditions	Access to credit	Building plots
Access to credit	Market return	Infrastructure
Interest rate	Alternative capital return	
Alternative capital return	Tax	

Tax Market return Rental housing market Expectations History	Interest rate Expectations History	

The housing market is very complex, as seen from all the factors above. Strong public regulations and asymmetric information persists, as sellers are mostly better informed than buyers (Kurlat & Stroebel, 2014). Transaction costs are high due to fees, taxation, and commission for buyers and sellers. Therefore, accounting for all the aforementioned factors and the interactions between them in an exhaustive prediction model is probably impossible. Hence, it is extremely challenging to construct a model that can predict the housing market's equilibrium. Due to this challenge, and that several of the previous master thesis' focus on the demand side, we will focus on the supply side of the housing market.

In order to make qualified conclusions based on our results, we need to understand the complexity and intersection between supply, demand, and the regulatory environment. Hence, we must understand the underlying factors of the housing market. Before examining the different factors, we will apply a supply and demand framework with simplified assumptions to understand the basic mechanisms.

2.1 Demand-side model

We will apply an empirical housing price model constructed by Jacobsen and Naug to examine the housing market's underlying demand factors and their importance for housing prices (2004).

Jacobsen and Naug split housing demand into two categories: (1) demand by owners who intend to live in the house, and (2) demand by housing solely for investment objects (2004). Most emphasis is on category 1, based on an assumption of a higher fraction of transactions of houses in category 1 relative to category 2. Moreover, an assumption for the model is that the total demand for housing is equivalent to the demand for owning; hence demand for renting is not considered. Furthermore, despite the fact that housing has different characteristics, it is regarded as a homogeneous product for simplicity in this model. The model is presented in equations (1-1.2) below.

2.1.1 Demand-side function

Demand for housing is expressed in equation (1) below, reproduced after Jacobsen and Naug's aforementioned article (2004).

$$H^D = f\left(\frac{V}{P}, \frac{V}{HL}, Y, X\right), \qquad f_1 < 0, f_1 < 0 \quad f_3 > 0, \tag{1}$$

where:

$H^D = Housing\ demand$

$V = Total\ costs\ of\ housing\ per\ household$

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

$HL = Total\ renting\ cost\ for\ a\ typical\ tenant$

$Y = Households\ real\ disposobale\ income$

X $= a\ vector\ of\ other\ fundemental\ factors\ that\ affect$

$housing\ demand$

$fi = derivate\ of\ f(\bullet)\ with\ respect\ to\ argument\ i$

Other mentioned fundamental factors included in variable X in equation (1) are demographic conditions, bank lending policies and household expectations of future revenues and costs. We observe that housing demand positively correlates with the household's real disposable income. Another insight is that decreasing renting cost and the cost of other goods relative to costs of owning decreases housing demand.

2.1.2 Cost of owning

The cost of owning is represented by the opportunity cost of owning a dwelling. We derive the cost of owning, reproduced after Jacobsen and Naug (2004). The cost of owning is formalized in equation (1.1) below:

$$\frac{V}{P} = \frac{PH}{P} BK = \frac{PH}{P} [i(1-\tau) - E\pi - (E\pi^{PH} - E\pi)], \tag{1.1}$$

where

$$BK = Cost\ of\ housing\ per\ real\ krone\ invested\ in\ a\ dwilling$$
$$PH = Average\ housing\ price$$
$$i = Nominal\ interest\ rate$$
$$\tau = marginal\ tax\ rate\ on\ capital\ income\ and\ expenses$$
$$E\pi = Expected\ inflation$$
$$E\pi^{PH} = Expected\ rise\ in\ the\ average\ housing\ price\ (measured\ as\ rate)$$

Equation (1.1), [i (1-τ) - Eπ] expresses the real after-tax interest rate on the dwellings. The expression measures the cost of having a mortgage loan and the opportunity cost of using equity on a dwelling, measured by the real interest income lost. The opportunity cost of investing in a dwelling increase by higher interest rates, which increases the cost of owning a dwelling. [$E\pi^{PH}$- Eπ] expresses the anticipated real growth in housing prices. Expected real growth in housing prices leads to lower real housing costs of owning. This will lead to increased demand for owning a house due to the increased advantage of owning a home compared to renting. Over the last 28 years, we have seen a strong growth in housing prices, which partially can be explained by lower interest rates as it is an important explanatory variable for changes in housing price on the demand side.

2.1.3 Nominal disposable income

Another factor which determines housing demand is the nominal disposable income, which is income after tax for households. To understand the nominal disposable incomes effect on demand, we derived and formalized this factor below (Jacobsen & Naug, 2004):

$$Y = \frac{YN}{P^{a_1} HL^{a_2} PH^{a_3}}, \qquad a_1 + a_2 + a_3 = 1, \tag{1.2}$$

where

$$YN = nominal\ disposable\ income$$

Equation (1.2) expresses that increased housing prices reduce nominal disposable income. The reduced nominal disposable income comes from tenants saving for a dwelling. An underlying assumption for the reduced effect of increased housing prices on nominal disposable income is that the increased wealth gained from the sale is not used on a new dwelling. Hence, the total effect of increased housing prices is reduced purchasing power in the housing market.

2.1.4 Other fundamental factors

Other fundamental factors influencing housing prices are: demographic conditions, bank lending policies, and household expectations of future revenues and costs in general (Jacobsen & Naug, 2004). Areas with high housing demand and inelastic supply can result in a housing deficit in the long run. Urbanization and population movements especially from people in the start-up phase have led to increased price pressure on popular areas in the city center of the major cities in Norway. Furthermore, the bank's lending policy affects housing prices as debt is the primary financing source. A decreased credit availability in isolation can reduce housing demand, leading to decreased prices. Finally, expectations regarding the household's ability to consume and pay rent are important. Both changed expectations regarding interest and labour market will affect the household's economy, hence leading to change in housing demand.

2.2 Supply

To examine the supply-side, we need to first define housing supply. Housing supply is equivalent to the total amount of the housing stock. The housing stock can be determined like an inventory of goods, with a depreciation factor as seen from equation (2) below (Kenny, 1998; Hendry, 1984):

$$H_t = (1 - \delta)H_{t-1} + A_t \tag{2}$$

where

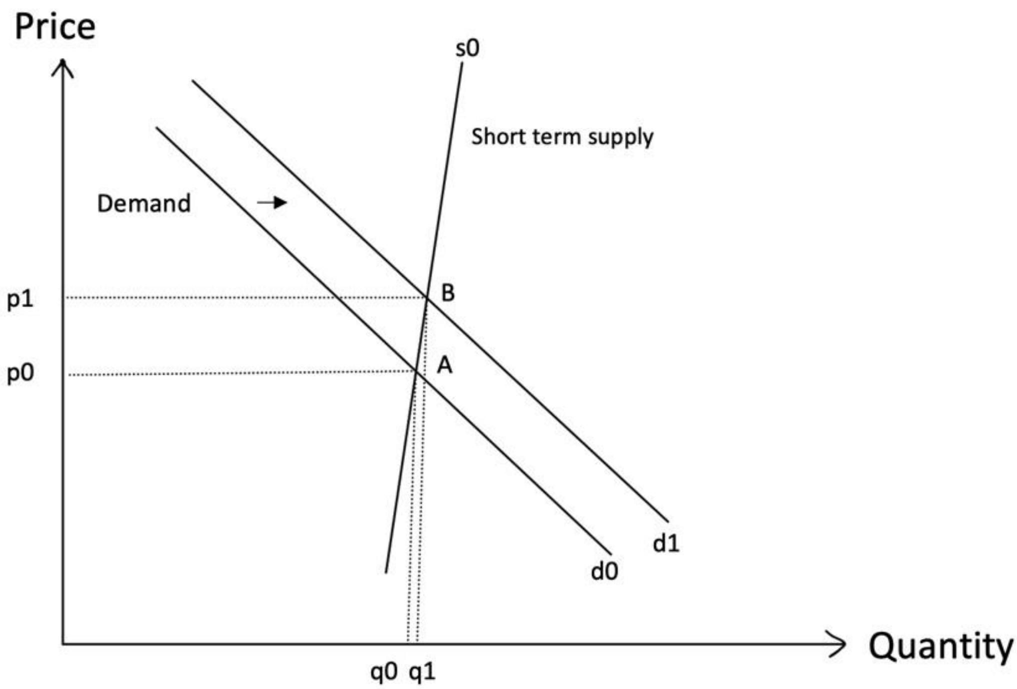
$$\begin{aligned} H_t &= \textit{Total housing stock at period } t \\ H_{t-1} &= \textit{Total housing stock in the previous period} \\ \delta &= \textit{Depreciation rate} \\ A_t &= \textit{Completion at period } t \end{aligned}$$

Equation (2) shows that today's housing stock equals the sum of new completion and the last period's housing stock, minus depreciation. Dwellings will depreciate every year due to the wear and tear, and without renovation, some units will be unavailable. For further elaboration, we will dig deeper into the mechanisms of long and short run supply.

2.2.1 Supply in the short and long run

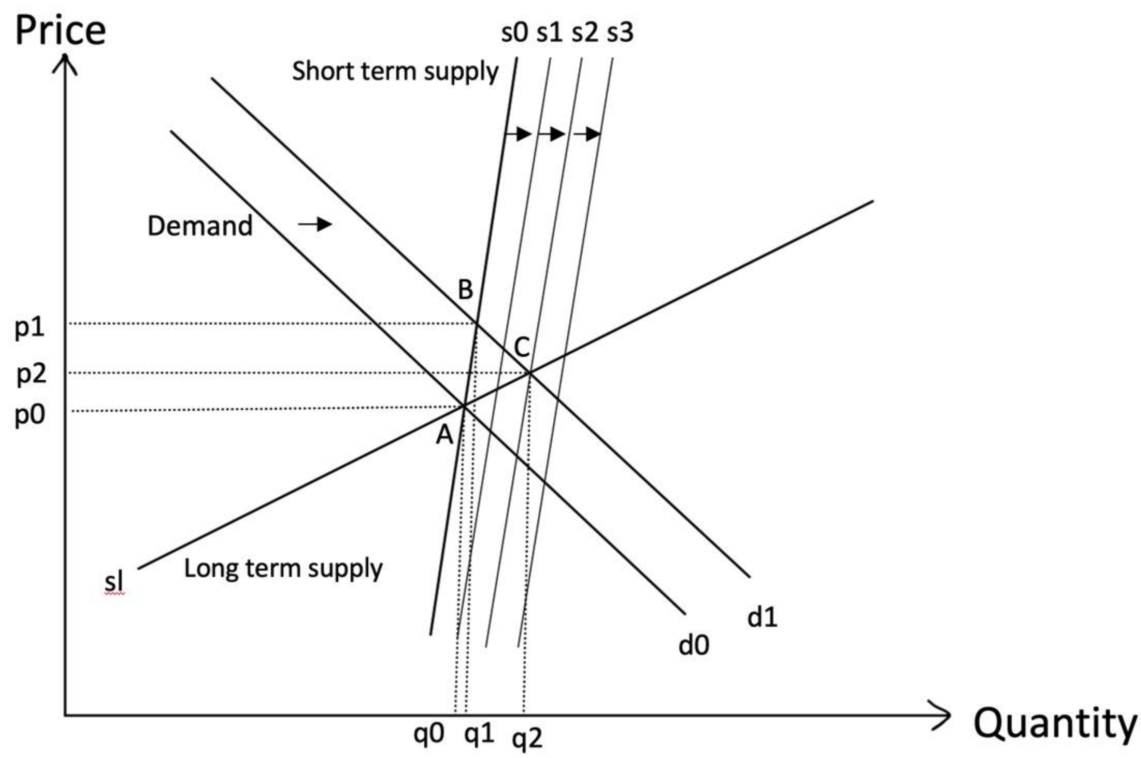
Like any other product, the housing market consists of buyers and sellers. The supply curve shows the quantity of the goods that are supplied for a given price. The curve is upward sloping due to higher prices resulting in higher quantity supplied. The demand curve is downwards sloping, such that lower prices result in higher quantity demanded and vice versa. Where the two curves intersect is described as an equilibrium. In the short run, the housing supply is nearly fixed due to low levels of completion relative to the total housing stock and long duration of construction as seen in Figure 1 (Jacobsen & Naug, 2004).

Figure 1: *Short Run Supply and Demand Framework*



From Figure 1**,** we observe that the short run housing supply is relatively inelastic. A shift in demand from q0 to q1 will lead to a short run equilibrium in B, with a new price level of p1 due to lag in construction. Factors that can contribute to make housing supply inelastic are technical requirements, construction capacity, access to plots and regulations. make housing supply inelastic. However, in the long run, housing supply will meet housing demand and create a market equilibrium as housing stock adapts over time, as seen in Figure 2 below.

Figure 2: *Extended Supply and Demand Framework*



From Figure 2, we observe a positive shift in demand from d0 to d1 will cause prices to rise from equilibrium A and create a new short run equilibrium in B. As prices rise, supply will adapt in the long run, paving the way for a new long run equilibrium at C. The explanation is that housing prices affect construction activity and as prices rise, returns for developers increase leading to greater supply in the long run.

For further elaboration we will examine the different construction factors.

2.2.2 Construction Cost

An important factor for housing supply is the construction cost. According to Jacobsen and Naug, new housing construction is stimulated by increased housing prices in relation to construction costs (2004). Norwegian housing prices have increased by 568% from 1993 to 2020 (SSB, 2021a), while construction cost has increased by 144% in the same period (SSB, 2021b). In isolation, the superior growth in housing prices should increase the housing supply.

However, a challenge with exploring the relationship between construction costs and housing prices is that a construction cost index represents the current cost on inputs- and quality factors

(Grytten, 2009). These are volatile, which implies that it is not a precise tool for estimating future construction costs but shows a snapshot of current expenses. Nevertheless, due to the complementary relationship between the markets for new construction and existing housing, we can assume that it is reasonable that an increase in the construction cost will affect the housing prices (Grytten, 2009).

2.2.3 Access to plots

An essential supply factor is the current available plots regulated for residential purposes. Access to plots for the constructors is often a challenge in cities with a negative surplus of dwellings which leads to an inelastic supply curve. A well-known dispute in Oslo is regarding "Markagrensa", and its possible consequences of improving supply and demand balance (Solvang, 2020).

2.2.4 Interest Rates

Another factor that influences the supply of housing is the interest rates. Empirical evidence shows that fluctuating interest rates, directly and indirectly through demand effects, affects housing supply (Blackley, 1999). The direct impact on construction can happen through financing costs which are affected by credit conditions such as interest rates and risk premiums. An example is the tighter credit supply that occurred due to the banking crisis in the late 1980s which affected credit accessibility, both on the supply and demand side leading to a substantial drop in housing initiations (Reiersen et al., 1996).

2.2.5 Capital Access

Another factor that impacts supply is the capital access for the developers. As argued in chapter 2.2.4, tighter credit conditions, and hence decrease in the developer's access to capital, can lead to fewer initiations. The impact access to capital has on price is through investment activity in new housing, which affects the level of completions and thus new supply. Under major economic crises, tighter capital access can also affect completion through general stops in housing projects in progress due to bankrupt developers and suppliers. The aforementioned situation happened under the financial crisis, which resulted in a significant drop in housing completion (Gran, 2021).

3. Methodology

This thesis explores how various supply factors influence housing prices in major Norwegian cities in the short run. We apply time-series techniques to examine how supply factors affect the Norwegian housing market prices. The results from our regression model will show whether, and possibly to what extent, there is a significant relationship between changes in supply variables and housing prices for our chosen cities. This chapter explains statistical techniques used to examine the relationship.

3.1 Time series models - OLS

We will apply the Ordinary Least Squares (OLS) method to estimate the unknown parameters in our regression model. OLS takes the deviations, squares them, and afterward minimizes them to find the alpha and betas. The simple static OLS regression can be expressed as follows:

$$y_t = \beta_0 + \beta_i X_t + \epsilon_t, \qquad t = 1, 2, \dots, n \tag{3}$$

The dependent variable value, y_t, depends on the changes of the independent variables X_t. The coefficient β_i describes the value y_t changes with a unit change in our independent variable X_t. The constant is β_0 and the error term is ϵ_t, which is the variation in the dependent variable, related to excluded variables.

We will transform our data to a log-scale to get a more understandable interpretation of our regression results. Equation (4) below shows an example of a log-log regression.

$$Log\ (y_t)\ =\ \beta_0 + \beta_i\ log(X_i) + \epsilon_t \tag{4}$$

After the transformation, a percentage change in the independent variable will lead to a percentage change in our dependent variable.

We will use distributed lags to measure the influence of the explanatory variables with time lags (Wooldridge, 2012). This is to account for the time effect which the materialization of supply factor changes will have on prices. This is the finite distributed lag model, which is formalized in the equation (5-5.1) below.

$$y_t = \alpha_0 + \partial_0 Z_t + \partial_1 Z_{t-1} + .. + \partial_q Z_{t-q} + u_t \tag{5}$$

We allow several lags of the explanatory variables to have influence on the dependent variable. The sum of coefficients ∂_q of the explanatory variable can then be utilized to extract the long run propensity, or the cumulative effect of a finite number of lags. This is also known as the Long-Run-Propensity (LPR) (Wooldridge, 2012).

$$LRP = \delta_0 + \delta_1 + \ldots + \delta_q \tag{5.1}$$

Whether the variables are cumulative significant are determined by F-tests where the null hypothesis is that the coefficients together are statistically not different from zero. With the rejection of the hypothesis, the coefficients are jointly significant. The joint significance and coefficients are reported in the regression tables.

3.2 OLS Time Series Assumptions

To use OLS for interpreting causal effects of the changes in our independent variables on the dependent variable, we must fulfill a set of assumptions. The OLS time series assumptions that need to be fulfilled are (Wooldridge, 2012):

OLS time series assumptions.

We will apply the Ordinary Least Squares (OLS) method to estimate the unknown parameters in our regression model. OLS takes the deviations, squares them, and afterwards minimizes them to find the alpha and betas, hence the regression function. To use OLS for interpreting causal effects of the changes in our independent variables on the dependent variable, we must fulfill a set of assumptions. The OLS time series assumptions are (Wooldridge, 2012):

1. Zero conditional mean
2. Linear in parameters
3. No perfect multicollinearity
4. Homoscedasticity
5. No autocorrelation
6. Normality

3.2.1 Zero conditional mean

The zero conditional mean assumption refers to the condition that the covariance between the independent variables and the residuals shall be zero for all time periods t. This is formalized in equation (6).

$$E(u_t|X) = 0, \qquad t = 1, 2, \dots, n. \tag{6}$$

If the assumption is violated, our coefficients will be biased, meaning that our sample's estimate does not converge to the population parameter. The violation creates uncertainty regarding changes in the dependent variable that come from changes in the independent variable or the error term. Hence, in our case, we cannot infer the causal effect between price and the supply factors if the assumption is violated. This can happen if we have an omitted variable, which is a determinant of the dependent variable and correlates with an independent variable.

A challenge regarding this assumption is the difficulty of testing if covariance exists between the error term and the independent variables. To examine the possibility of a violation, we need to use our intuition to interpret if it is plausible that we have omitted a dependent variable in our regression.

3.2.2 Linear in Parameters

Another condition that is required to be able to do a linear regression is to construct the model with linearity in the parameters. Hence; a violation of this condition is, for instance, if the model's equation includes two explanatory variables that are multiplied.

3.2.3 No perfect multicollinearity

A condition that must be fulfilled under multiple regressions is that we don't have perfect multicollinearity. Multicollinearity is the degree of correlation between regressors in a regression model. We distinguish between perfect and strong multicollinearity. Perfect multicollinearity exists when we have a perfect correlation between two or more regressors. Luckily, Stata will not present an estimate if a perfect correlation occurs. Another concern is strong multicollinearity, this happens if the regressors are strongly correlated. Strong multicollinearity can result in an imprecise estimate of the regressors due to the higher variance of affected coefficients. We can do a volatility inflation factor estimation to check whether we have a problem with strong multicollinearity.

3.2.4 Homoscedasticity

Standard errors are homoscedastic when they have the same variance, regardless of the value of the independent variable in any time period (Wooldridge, 2012). A violation of this assumption will affect the variance of the standard error. Our coefficient estimates are not affected in case of violation, but the precision of the estimate changes, and our estimates become less accurate. Biased error terms can lead to wrong conclusions regarding the significance of our coefficients as the T- and F-test uses the variance of the biased error terms. To examine whether we have homoscedasticity or not, we apply both graphical techniques and formal tests.

We examine homoscedasticity graphically through plots of the standard error residuals against the fitted value and observe the patterns. If data points generated are uniformly distributed along the regression line, our data is likely homoscedastic. If there is an uneven distribution along the line, this indicates heteroscedasticity as variance changes over time. Graphical examinations have their limitations and we will use the Breusch-Pagan test for heteroscedasticity (BP test) to strengthen our understanding.

The BP test examines the null hypothesis of homoscedasticity in a linear regression model.
To perform a BP test, we start by applying OLS to estimate the unknown parameters in our linear regression, as seen in equations (7-7.2) (Wooldridge, 2012).

$$y_t = \beta_0 + \beta_1 X_t + \epsilon_t \tag{7}$$

Then we regress the estimated squared residual on our independent variable as seen in equation 7.1.

$$\hat{u}_t^2 = \delta_0 + \delta_1 X_{t1} + \ldots + \delta_k x_{tk} + v_t \tag{7.1}$$

where

$$v_t = E(u_t | x_t) = 0$$

$$v_t = error\ term$$

Furthermore, we use R-squared from the execution of equation (X) to calculate the F statistic as seen in equation 7.2.

$$F = \frac{R^2_{\hat{u}^2_t}/k}{(1 - R^2_{\hat{u}^2_t})/(n - k - 1)} \tag{7.2}$$

where

$$F = F\ statistic$$
$$R^2_{\hat{u}^2_t} = R - squared\ obtained\ from\ equation\ XX$$
$$k = Number\ of\ regressors$$
$$n = Observations$$

Finally, we can determine whether we need to reject the null hypothesis of homoscedasticity from the F-statistic. If the null hypothesis is rejected, we can use Newey-West Standard Errors. We will elaborate on Newey-West Standard Errors in the next chapter as there is need for a deeper understanding of autocorrelation, which is a crucial part of Newey-West Standard Errors.

3.2.5 No Autocorrelation

Autocorrelation violates the assumption of OLS regression of zero covariance between the error terms. Autocorrelation occurs when the error terms are correlated over time. The violation can lead to over or underestimation of the variance of residuals. This can cause inefficient coefficients and lead us to make wrong conclusions regarding significance of a variable.

To examine whether autocorrelation is present, we will graphically assess the residual plots and test it formally through a Durbin Watson test. The Durbin Watson test tests whether the error terms follow an AR1 process, thus if successive errors are correlated. The test is formalized by equation (8) below:

$$DW = (\Sigma_{t=2}^{T}(e_t - e_{t-1})^2)/(\Sigma_{t=1}^{T}e_t^2) \tag{8}$$

where

$$DW = [0,4]$$

If the result from the test is approximately two, then we do not have to worry about the consequences of autocorrelation. If the result from the test is low, then the autocorrelation is positive. On the contrary, if the result is high, then the autocorrelation is negative.

Newey-West Standard Errors is a tool to remove the presence of heteroscedasticity and autocorrelation challenges in time series (Brooks, 2008). Newey-West, modify the error terms without changing the coefficients (Studenmund, 2014). The adjusted error terms result in biased standard errors, making the model non-efficient. Nonetheless, the Newey-West standard errors will be more accurate than the unadjusted when we are facing autocorrelation.

3.2.6 Normality

The normality assumption states that the residuals are normally distributed (Wooldridge, 2012). The residuals are normally distributed when their distribution is symmetric around its mean. Violation of this condition can lead to invalid statistical inference. The violation can happen due to outliers. However, even if a test statistic indicates a violation of normality, it does not need to be of statistical importance if we have a large sample. Consequently, we apply graphical assessments through histograms and QQ-plots for validation in addition to formal tests.

We examine histograms graphically by plotting the residuals and evaluating the distribution. The distribution should be normally distributed around the mean of zero. In addition to histograms, we examine QQ-plots of the residuals. By plotting quantiles from a theoretical distribution and quantiles generated from our regressions, we can see if the quantiles follow a straight line and hence if our residuals are normally distributed.
To formally test normality conditions, we use the Shapiro-Wilk test. Shapiro-Wilk tests whether a sample is independent and identically distributed. For a deeper review, see the original paper from Shapiro and Wilk (1965).

3.2.7 Stationarity

Another requirement for applying OLS regression on time series data is that the time series is stationary. A time series is stationary if its probability distribution does not change over time (Wooldridge, 2012). A probability distribution is the likelihood of obtaining possible values for a stochastic variable. Additionally, stationarity requires that the mean and variance shall be constant. In order to successfully be able to transform a time series into a stationary one, we are dependent on identifying which type of non-stationary process our time series belongs to. Different types of non-stationarity processes are listed in equations (9-11) below:

$$Random\ Walk: y_t = y_{t-1} + \epsilon_t \tag{9}$$

A random walk with no drift or trend is a process where the value of a random walk process depends on the previous value in addition to noise, as shown in equation (8). Due to this dependency, the variance increases with time, and hence it is non-stationary. This dependency can be described as a stochastic trend.

$$\text{Random Walk with drift: } \mathrm{y_t} = \beta_0 + \mathrm{y_{t-1}} + \epsilon_\mathrm{t} \tag{10}$$

Equation (10) shows a random walk with drift. It follows the same process as equation (9) apart from a constant which is added to y for each t. The constant causes drift, which leads y_t not returning to its long run mean. This implicates a non-constant variation, which violates stationarity.

$$\text{Deterministic Trend: } y_t = \beta_0 + \beta_t + \epsilon_\mathrm{t} \tag{11}$$

In equation (11), y_t, depends on both a stochastic and a deterministic trend. A deterministic trend is created due to component β_t, which makes y_t fluctuate around its long-term trend. The dependency for the deterministic component on time makes it non-stationary. This process is non-stationary due to y_t dependence on both the non-stationary components of the constant and the deterministic component.

3.3 Testing for stationarity

To test whether our time series is non-stationary, and which process it follows, we will apply an Augmented Dickey-Fuller (ADF) test. An Augmented Dickey-Fuller (ADF) tests whether a unit root is present in our time series. If the time series contains one unit root, it will be integrated by the first order, which implies that values in the time series are based on the previous and hence non-stationary. The augmented version of Dickey-Fuller is favorable because it accounts for autocorrelation in the error terms, by including lags.

Before applying the model, it is necessary to decide whether it should account for the constant or the constant and trend. For further elaboration of the ADF test, we have formalized the different test versions in the equations (12-14) below (Wooldridge, 2012): Equation (12) shows the version of ADF that does not consider a constant or trend. Equation (13) shows the version of ADF that considers a constant. Finally, equation (14) shows the version of ADF that considers constant and time trends.

$$y_t = \theta y_{t-1} + \epsilon_t \tag{12}$$

$$\Delta y_t = \alpha + \theta y_{t-1} + \epsilon_t \tag{13}$$

$$\Delta y_t = \alpha + \beta_t + \theta y_{t-1} + \epsilon_t \tag{14}$$

The three versions have different critical values, and misspecification can cause spurious conclusions regarding the presence of a unit root. Equation (12) assumes that the time series starts at zero, which in our case is not relevant due to the nature of our supply factors. The second equation (13) tests for stationarity without growth, which can be relevant for the interest rates. The last equation (14) considers both trend and a constant and it is therefore relevant for the other supply factors. Based on the intuition above, we will perform ADF tests with a constant, and a test with a constant and trend to check which process our time series follows.

The last variable we need to consider before executing the ADF test is how many lags we should include. Too many lags can negatively affect the model's power and hence increase the number of Type-II errors due to the removal of several initial observations, which reduces degrees of freedom and, consequently, the absolute values (Brooks, 2008). Contrary, by including too few lags, we risk not eliminating all autocorrelation. By choosing the optimal number of lags, we can minimize the Akaike Information Criterion (Stock & Watson, 2019).

3.4 Transformation of non-stationary data

If we cannot reject the null hypothesis of the presence of a unit root, we must transform the data from non-stationary to stationary based on the results from the ADF test. We will perform the transformation by applying first-difference if our series follows a random walk with or without drift as in equations (9-10). By applying the first-difference, we remove the linear trend from the non-stationary variable as shown in equation (15) (Wooldridge, 2012):

$$\Delta \log(\mathrm{y_t}) \approx \; log(y_t) \; - log(y_{t-1}) \tag{15}$$

If our data follows a deterministic trend as in equation (11), we will transform our data by applying the Hodrick-Prescott-filter (HP-filter). HP-filter is a method that can separate a time series into a trend- and cycle component (Grytten & Hunnes, 2016). Detrending will make the time series stationary, as shown in equations (16-16.1) (Grytten, 2018b):

$$y_t = g_t + c_t \tag{16}$$

$$c_t = y_t - g_t \tag{16.1}$$

The term, y_t, expresses the time series, while g_t and c_t expresses the trend and cycle component. T represents the number of observations. The-HP filter both minimizes fluctuations in the trend and deviations between trend and observations. The determining of the trend components by the aforementioned minimization is formalized by equation (17) below (Hodrick & Prescot, 1997):

$$\underset{\{g_t\}_{t=-1}^{T}}{Min} \left\{ \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} [(g_t \; - g_{t-1}) \; - \; (g_{t-1} - g_{t-2})]^2 \right\} \tag{17}$$

Parameter λ represents the degree of variation that is chosen for the estimated trend. A higher λ leads to a smoother trend. An assigned value on the parameter λ of 0 means that changes in the time series can only be explained by changes in the trend and not by business cycles. (Grytten & Hunnes, 2016). On the contrary, an assigned value of λ that goes towards infinity results in a linear trend that does not factor in structural changes that will affect the time series (Grytten, 2020). This causes a dilemma regarding what value should be assigned to λ, which we need to examine before using the HP-filter. We will use a value of 1600 on λ, which is standard for quarterly data in the literature, according to Grytten and Hunnes (2016, p. 61).

Another well-known challenge of the HP-filter is the problems regarding the end-points (Grytten & Hunnes, 2016). The HP-filter is a two-sided filter designed to use observation t-1 and t+1 to estimate the trend in a period t. Unfortunately, this creates problems in the end-points, where we do not have observations. Lack of observations causes the HP-filter to be more dependent on the actual and the historical values at the end of the time series and more dependent on the actual and future observations in the beginning relative to the other observations.

3.5 Regression with cycle-component

After we detrended the data using a HP-filter, we are left with the cycle component. We will use the cycle component of the detrended variables in our regression analysis.

4 Data

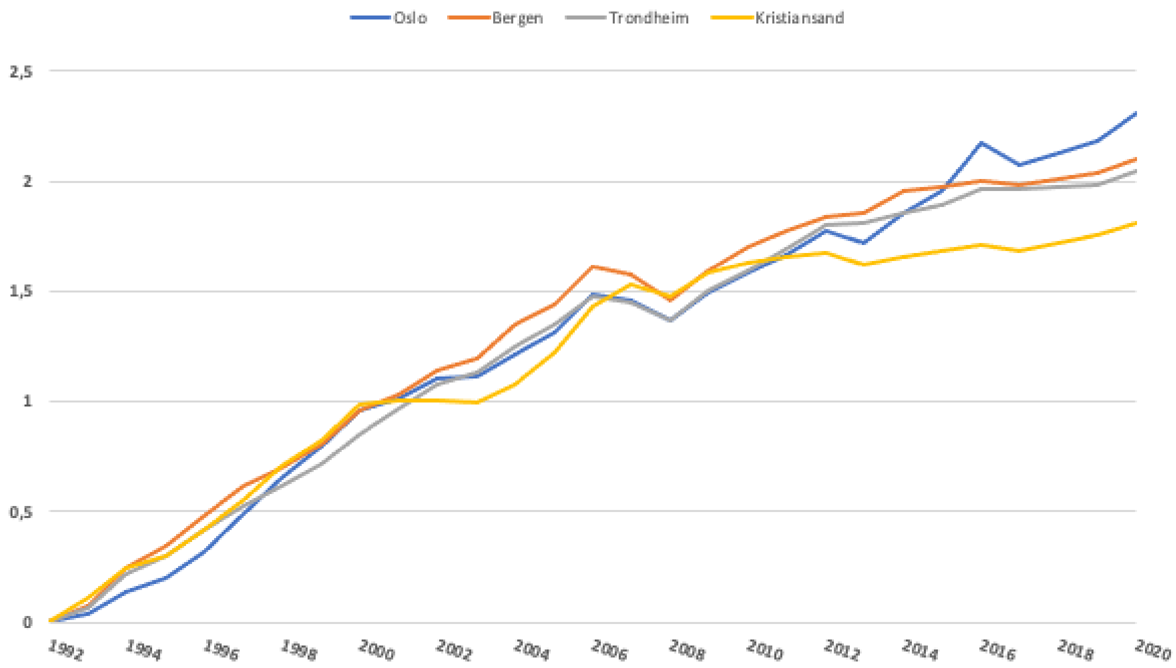
The outspoken "housing policy of property ownership" has led to a high ratio of households who own property compared to those who rent. This ratio, combined with the relatively good availability of historical data collections on housing prices has made the Norwegian housing market a popular research subject. Thus, the Norwegian empirical basis leads to an excellent base for empirical research, and the necessary data is basically adequate for our purpose.

4.1.1 House Price Index

Our y-variable, the Norwegian housing prices is based on two different sources from the Norges Bank and Eiendomsverdi. The data from the Norges Bank, which covers the period 1993-2003, is collected and structured through a collaboration consisting of the Norges Eiendomsmeglerforbund, Eiendom Norge, Pöyry, and Finn.no. The data collection is based on the hedonic price indices (Eitrheim & Erlandsen, 2004). Applying the hedonistic method eliminates the quality differences between houses built in different periods (Osland, 2001). The dataset has a year frequency and covers Oslo, Bergen, Trondheim, and Kristiansand. The 1993-2002-dataset is transformed to quarterly frequency by cubic spline interpolation.

The dataset which covers the period from 2003-2020 is from Eiendom Norge and has a monthly frequency (Eiendom Norge, 2021). The collection covers counties and major cities.
We will change the dataset to quarterly frequency by using the observations at the end of each quarter: March, June, September, and December. For visualization purposes, the housing price indexes are presented with yearly frequency on a log-scale in Figure 3:

Figure 3: *Yearly Development in Housing Price, index, 31.12.1992=0*



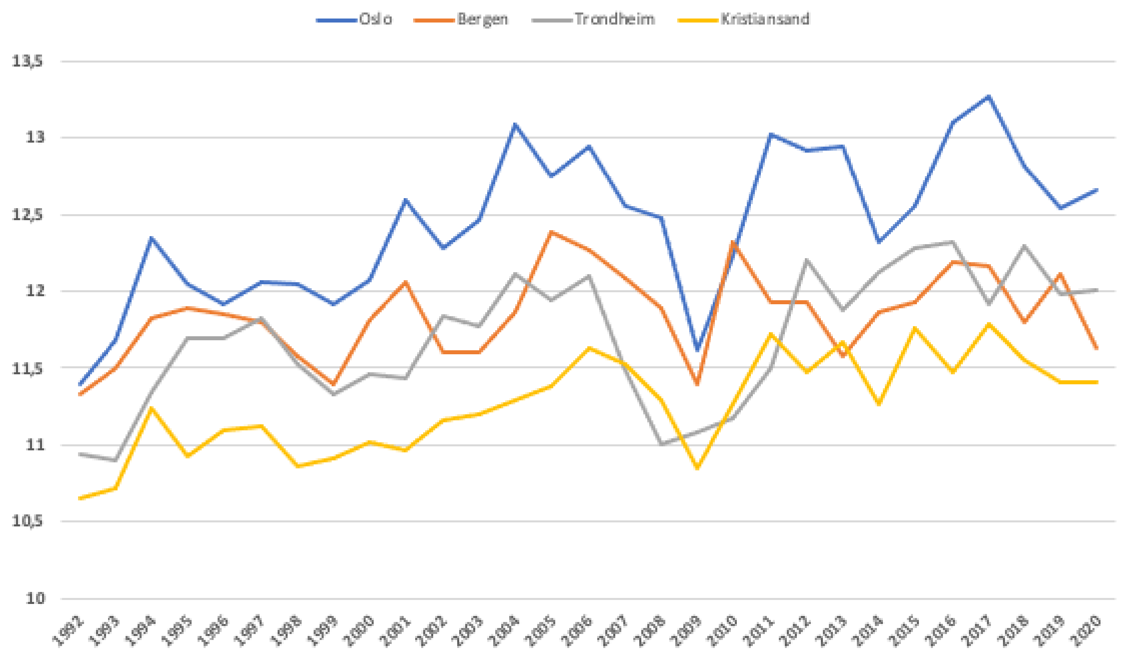
Source: SSB

4.1.2 Housing Completions

To analyze the relationship between construction and housing prices, we will use datasets from SSB that measure buildings completed in utility floor space in dwellings per square meter (SSB; 2020, 2021c). We will use the total of completed square meters for residential purposes as our variable, regardless of the type of housing building it belongs to. Thus, we will assume that the number of square meters completed is the most precise variable for housing completions, not the number of housing units completed. We substantiate this assumption on the growing demand for the opportunity to live in smaller units, in order to enter the housing market.

Housing construction data consists of two datasets provided by SSB, where one covers the period from 1993-1999 and the other the period from 2000-2021. The 1993-1999-dataset is transformed to quarterly by cubic spline interpolation due to its yearly frequency. The 2000-2021-dataset has a monthly frequency, which we will change to quarterly by using the observations at the end of each quarter: March, June, September, and December. For visualization purposes, the data for housing completions are presented with yearly frequency on a log-scale in Figure 4:

Figure 4: *Yearly Development Housing Completions Between 1993-2020*



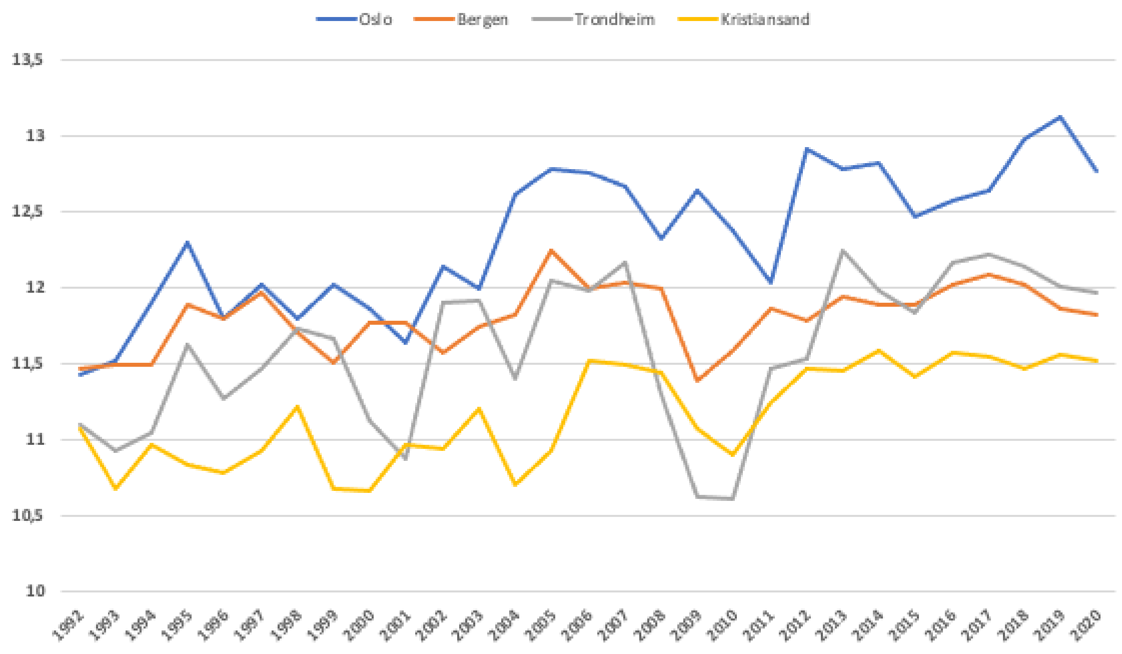
Source: SSB

4.1.3 Available Building Plots and Housing Initiations

We have chosen the square meter of dwellings started as a proxy for available building plots. Behind our proxy is the definition of available building plots as plots where the authorities approve the zoning plan. We selected a proxy due to difficulties obtaining valid information on available plots for housing in each municipality. Furthermore, we argue that our proxy is accurate because of the developers' high alternative cost of binding capital in plots where the zoning plan is finished. Another concern for waiting is the risk of changing business cycles, which can affect demand and construction costs, thereby changing the business case. We seek to understand the relationship between price changes and regulation of new building plots and housing initiations. Therefore, we use housing initiations to measure the short term relationship with housing prices.

Initiated dwellings data is collected from SSB, and measures buildings initiated in utility floor space in dwellings per square meter (SSB; 2020, 2021c). SSB defines initiated as when it has received the project start-up permission. The data comes from the Building's Statistics, the same table as with the data on housing construction. Consequently, this data is collected from the same two datasets, with equivalent characteristics regarding the coverage of period and frequency. Hence, we have done the exact transformation with cubic interpolation as with the construction data from 1993-1999. The 2000-2021-dataset has a monthly frequency, which we will change to quarterly by using the observations at the end of each quarter: March, June, September, and December. For visualization purposes, housing initiation are presented with yearly frequency on a log-scale in Figure 5:

Figure 5: *Yearly Initiations of New Housing Between 1993-2020.*



Source: SSB

4.1.4 Construction Costs

Another interesting supply factor is the relationship between construction costs and housing prices. The dataset we will apply is the construction cost index for residential buildings, updated monthly by SSB (SSB, 2021b). The index measures the prices of input factors on dwellings, consisting of materials and labour costs. We have rebased the index, starting from 1993, and changed the frequency to quarterly by using the observations at the end of each quarter: March, June, September, and December.

4.1.5 Interest rate

In order to examine the relationship between the market rent for the constructors and housing prices, we will apply the rent level of government bonds, plus a constant risk premium of 5 %. We will use a dataset with monthly frequency from the Norges Bank (Norges Bank, 2021). We will change the dataset to a quarterly frequency by using the observations at the end of each quarter: March, June, September, and December.

4.1.6 Capital access

In order to measure the capital access of the supply side, we have constructed a proxy based on the equilibrium of where the demand for capital access meets supply. Our proxy includes the households' total debt because of the challenge of finding valid information over a long period of debt directly related to housing. Nevertheless, Finanstilsynet states that of the total debt to the households, the average fraction of debt related to housing was around 85% in 2011 and 2017 (Finanstilsynet; 2012, 2017). The data is based on a representative portfolio of Norwegian banks. Consequently, we have chosen to multiply total debt by 0.85. Furthermore, due to equity demand by both banks and Finanstilsynet, we need to add an average fraction of equity. Based on numbers from Finanstilsynet, we have chosen an average debt ratio of 63% (Finanstilsynet, 2018; 2020). The data on the total debt is collected from SSB and has a monthly frequency, which we will change to quarterly by using the observations at the end of each quarter: March, June, September, and December (SSB, 2021d). Our proxy is formalized in equation (18) below:

$$Capital\ Access = (Total\ Debt * 0{,}85)\ /\ Average\ Debt\ Ratio \qquad (18)$$

4.2 Data transformation

We test our variables with the ADF-test, and the results are presented in the appendix Table 18. From the results, we find presence of a unit root for the housing price indexes for all cities. We used the Akaike Information Criteria to determine the optimum number of lags. All variables were tested. Based on the test results, we apply HP-filter for the housing price indexes, construction cost index, capital access, and interest rates. Surprisingly, our interest rate shows a negative trend. We believe that this can result from the steadily falling interest rates from 1993 to 2020. Finally, housing completions and housing initiation did not show clear indications of trend.

4.3 Validity

An important aspect regarding the statistical inference is the validity of the research. Validity measures to what extent results from a study are accurate (Lecompte & Goetz, 1982). We can further divide this expression into internal and external validation. Internal validity is the extent to which the results from the study are valid for the measured variable, which in our case is changes in the housing prices. External validity represents to what extent the results can be generalized outside the study.

To examine our study's internal validity, we will investigate whether our statistical analysis violates the OLS assumptions. As mentioned in chapter 3, we have used various techniques to avoid OLS assumption's problems. For a more profound elaboration on possible violations, see Appendix.

In our study, an essential aspect regarding external validity is whether the results from our study can be generalized with other countries. On one hand, you could argue that supply factors are universal for comparable countries, and hence it can have the same impact on housing prices. On the other hand, an essential feature of the housing market is that it is heavily regulated. Non-equivalent regulation and requirements of the housing market can lead to different extents of impact for the supply factors on the housing prices. Hence, we should be careful in applying general inference across countries.

4.4 Reliability

A crucial factor for the degree of validity of the study is the reliability of data. Reliability of the data is measured by its representativeness for the purpose, from how it’s conducted and treated. The data conducted in our analysis is collected from government institutions or the reputable actor Eiendom Norge, whose data has been used in previous research.

A challenge to reliability in our thesis is related to the access of housing market data with a quarterly frequency from 1993-2003. To overcome this challenge, we chose to use cubic interpolation. However, cubic interpolation smooths the variance between the yearly data, making the quarterly variance non-accurate. Nevertheless, we considered the advantages of using quarterly data greater than the disadvantage of using interpolation. This is due to the challenges we could face with a small sample due to the application of annual data.

Another specific challenge to reliability that we need to address is the use of SSB statistics on initiation. The data is conducted from two different datasets with a different definition of initiation. In the period until 1999, initiations were defined as «a building is considered to have been started when the work with piles, formwork of the foundation wall, casting of the sole or foundation wall has begun» (SSB, 2019, p.12). Since 2000, initiation is defined by when it has received the project start-up permission (SSB, 2021c). Different measurements can affect the reliability of our data. However, we do not consider this a significant problem for reliability due to our belief that developers will start construction as soon as they have received the project start-up permission, as argued in chapter 4.1.3.

5. The Norwegian economy and housing market

In this chapter, we will briefly introduce the characteristics of the Norwegian economy and give a historical review of the Norwegian housing market from 1945 until today. Furthermore, we will describe the regulatory environment on both the supply and demand side. The purpose is to get a deeper understanding of the Norwegian housing market specifics in order to make qualified conclusions in the analysis.

5.1 Characteristics of the Norwegian economy

The Norwegian economic system can be described as a coordinated market economy (Hall & Soskice, 2001). "An economy that is set up as a mixture of markets yet contains governmental intervention or centralized institutions to a substantial degree may be called a coordinated market economy", according to Larsen (2001, p. 24; Hall & Soskice, 2001). This is contrary to a liberal market economy, where stakeholders usually adjust their actions solely based on supply and demand. Norway is a constitutional monarchy, where the government is elected every four years. The government plays a relatively large role in the economy with strong state-ownership stakes.

A major driver for the Norwegian welfare state is petroleum and natural resources. After the discovery of Ekofisk in 1969, oil and gas have lubricated the economy. The creation of the Government Pension Fund of Norway and the Fiscal policy rule were made to secure future generations and resist the effects of Dutch Disease. Renewable and reliant hydropower paved the way for energy-intensive industry, and long aquaculture traditions have strengthened the Norwegian welfare state.

5.2 Housing market development until 1993

5.2.1 1945 - 1970

The post-war Norwegian economy can be characterized as a planned economy (Grytten 2018a; Lie, 1995). Stern prices and credit regulations from the pre-war were continued and were combined with measures to keep the interest rate level low. The outspoken goal was to increase housing construction and industrial investments. After the liberation, there was a national housing deficit due to low housing construction under the war and German scorched earth policy in the north (Reiersen et al., 1996). It was also suggested in the Norwegian parliament in 1936 that the state needed public initiatives in the form of a bank to ensure sustainable housing for the working class (Reiersen et al., 1996). However, it got postponed due to the war. To solve the post-war housing deficit, Gerhardsen-administration announced a construction goal of 100 000 new houses within 1949 (Reiersen et al., 1996). To accomplish the goal, the state-owned bank, Husbanken, was created in 1946 (Reiersen et al., 1996).

The purpose of Husbanken was to provide increased quality housing at a low cost and decrease cyclical fluctuations in the construction business (Reiersen et al., 1996). Husbankens mandate ensured cooperation between the state, municipalities, and housing cooperations (Gjerstad et al.; 2018, 2021). To secure long-term quality housing, standards regarding size and quality were introduced (Reiersen et al., 1996). In addition, the government incentivized housing investments by keeping interest rates artificially low, while the borrowers got subsidized by cheap loans from Husbanken with flexible terms (Lie, 2012; Reiersen et al., 1996). According to Sørvoll, Husbanken financed around two-thirds of all the housing in Norway from 1950 to 1995 (2011a).

Another measure to ensure that ordinary citizens could meet the current housing price level was price regulation policies (NOU: 1981). Measures, like price regulation on renting, followed by maximum housing and land prices by appraiser's approval, were introduced to avoid galloping prices (Sørvoll, 2011a; NOU: 1981). The regulations were successful in terms of that the nominal prices only increased by approximately 15 percent from 1940 to 1954 (Eitrheim & Erlandsen, 2004). The regulations slowly diminished towards 1970, resulting in increased growth in housing prices.

5.2.2 1970 - 1993

The discovery of Ekofisk in the North Sea in 1969 led to tremendous optimism for the Norwegian economy in the early 1970s. The Norwegian economy had experienced an explosive production growth after the second world war, with an average growth rate of 4.2 percent from 1950 until 1973 (Grytten & Hunnes, 2016). However, western stagflation with high inflation and high unemployment threatened the Norwegian economy, causing the government to apply a countercyclical fiscal policy (Grytten, 2020b). Subsidies and grants given to exposed industries as well as increased oil revenues and investments in the oil industry counteracted the consequences of western stagflation. The countercyclical policy resulted in low levels of unemployment relatively to other comparable countries (Grytten & Hunnes, 2016).

The stimulus caused inflation to increase, salaries exploded, and the citizens experienced an increased welfare level due to the government's goal of becoming a welfare state (Grytten, 2020b). The countercyclical fiscal policy also influenced housing construction. Both before and under the stagflation in the 1970s, there was an all-time high housing construction, where Husbanken financed the majority (Reiersen et al., 1996). The housing construction was driven by demand in counties with oil activity and expansive policies.

The stagflation caused a political shift in Western countries towards 1980, including Norway, from planned to market-based economies (Grytten, 2020b). The removal of credit rationalization and the high-interest rate deduction on tax and high levels of inflation led to a negative real interest rate which caused a credit boom in Norway (Moe et al., 2004). The political shift also influenced the Norwegian housing market. In order to deregulate the housing market, the government implemented measures like gradual reduction of the earlier price and renting regulations in the 1980s (Sørvoll, 2011b).

The mixture of negative real rents and deregulation of credit and housing markets led to an explosive increase in housing prices (Grytten, 2018a). Before the beginning of the bank crisis in 1987, real housing prices doubled from 1978. At the same time, approximately 31 300 houses were built each year to meet the increased demand (Reiersen et al., 1996).

After years of monetary and credit expansion that resulted in asset bubbles in the stock and housing market, the bubble burst during Black Monday in 1987. Majority of the world's biggest stock exchanges experienced a decrease between 20 to 45% in October (Roll, 1988), which further negatively affected the Norwegian housing market. Real housing prices fell by 43 percent from 1987 to 1992 which was a significant drop in the historical context (Grytten & Hunnes, 2016). The asset price drop caused a domino effect of bankruptcy in the Norwegian banks. This led to shrunken credit availability in the housing market which caused a prolonged period of limited housing financing and construction. Between 1990 and 1995, there were only 17 000 to 22 000 housing units that were initiated yearly (Reiersen et al., 1996). The construction that occurred was almost solely financed by Husbanken.

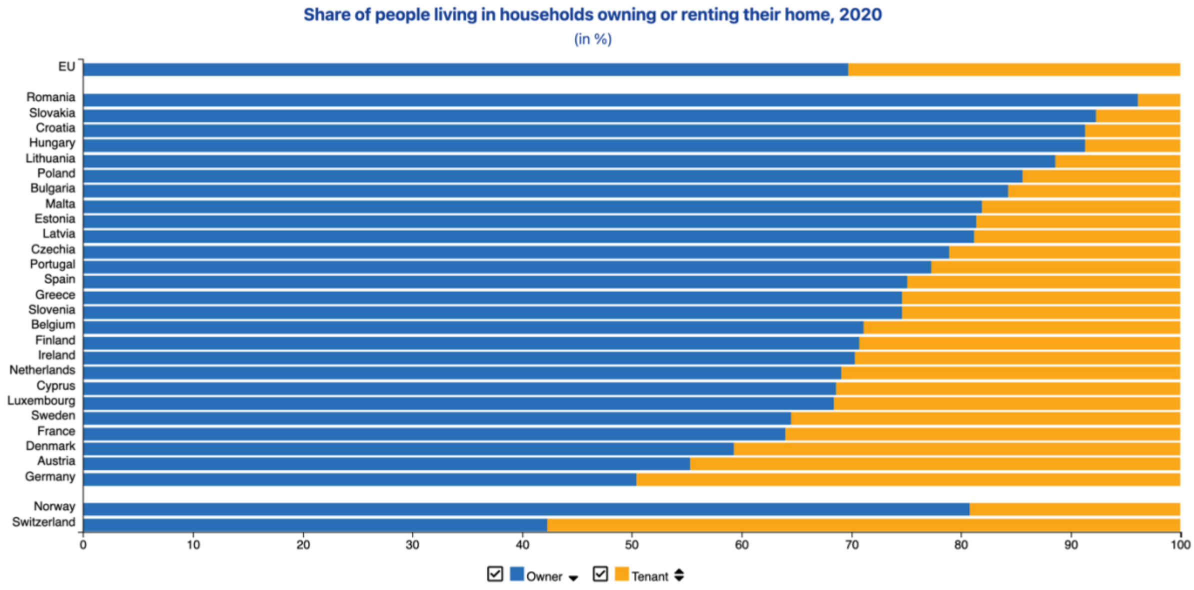
5.2.3 1993 - 2021

The relatively stable housing market after 1993, and increased welfare level for the Norwegian households, led to a change in the housing policy in the middle of the 1990s (Sørvoll, 2011a). Due to the high fraction of ownership, the government concluded in 2003 that the post-war housing policy of holding own property was accomplished and successful (St.Meld. nr.23

(2003-2004)). The healthy housing market was going to be maintained by a low interest rate level and other measures to keep the unemployment low. The government's new political strategy was to fight poverty by securing housing for the less fortunate (Sørvoll, 2021). Consequently, Husbanken also changed its mission from providing housing for the ordinary citizen. Their primary focus is the needy, encouraging sustainable upgrades of already constructed homes, and being a national resource center for housing.

If we measure the Norwegian housing policy by the fraction of holding own dwellings, we can endorse the conclusion made in 2003 by the government. Norwegian households are well above average on the fraction of self-owners within the EU and much higher than comparable Scandinavian countries, as shown in the figure below (Eurostat, 2020).

Figure 6: *Home Ownership rate EU27*



Source: Eurostat.

After the hard landing in the late 1980s, there has been a continuous rise in Norwegian housing prices. The real prices have quadrupled between 1993 and 2021 (Grytten, 2018a). The explosive increase and the increased debt level of households that has followed is a major challenge to Finanstilsynet (Finanstilsynet, 2016). To ensure healthy development in the prices, Finanstilsynet has suggested and implemented several regulations to impede the supply and demand of debt related to housing (Regjeringen, 2016). However, recently the corona crisis pushed interest rates to zero which ultimately resulted in increased housing prices in Norway.

5.3 The regulatory environment of the Norwegian housing market today

In a construction project, several parties are involved, including municipalities, counties, and different private firms. Conflict of interest between the various stakeholders can lead to collaboration challenges which hinders efficiency in the housing market. Therefore, before discussing the aspects of the regulatory environment today, it is necessary to get an overview of the role distribution of the Norwegian housing policy. The role distribution is in principle as follows (St.Meld nr.23(2003-2004)):

State – The state sets the housing policy goals and legal framework conditions, offers financial assistance to particular purposes, and contributes with measures to raise competence.

Municipalities - The municipalities plan and facilitate the construction and improvements of homes and residential areas and are also responsible for ensuring housing for the needy.

Private firms - Private owners build and manage the building complex.

5.3.1 Supply-side

To discuss the Norwegian regulatory environment on the supply-side, we will use a standardized plan for a construction process made by Konkurransetilsynet. Konkurransetilsynet divides a construction process in four phases (Konkurransetilsynet, 2015):

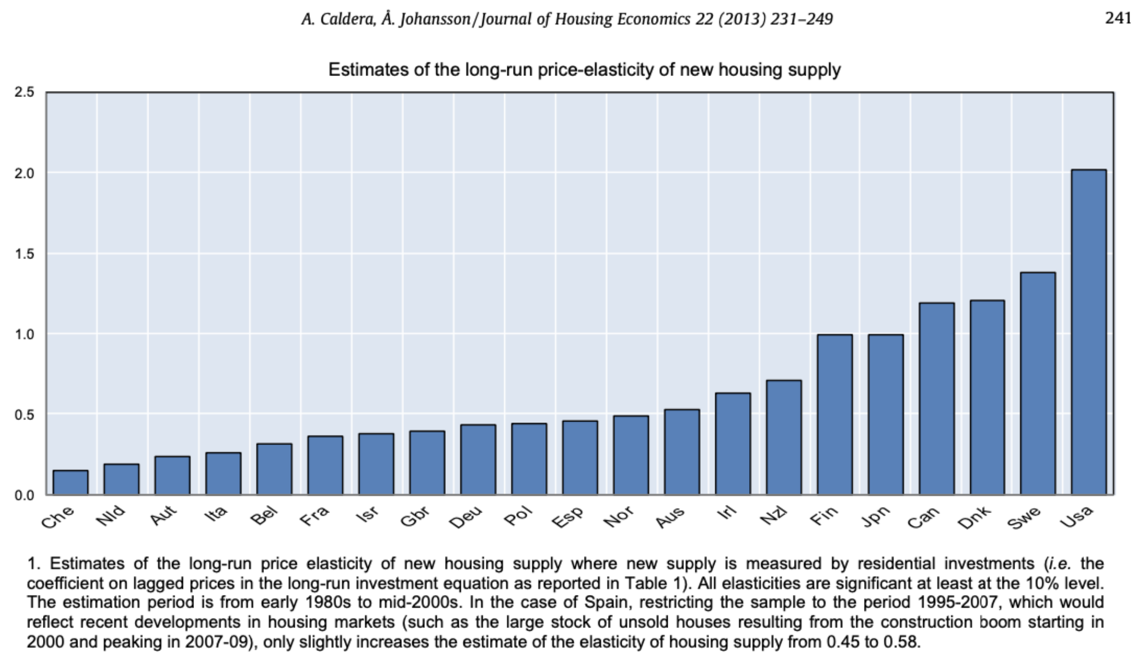
1. The planning
2. The regulatory and building application process
3. Construction
4. Sale process

The first phase, which is planning, is crucial as it is related to building plot planning. There are often substantial risks related to market conditions, technical requirements, and the regulatory environment in this phase (Konkurransetilsynet, 2015). The report states that stakeholders consider location and price as the essential factor for investments in building plots, followed by regulatory status, degree of utilization, developed infrastructure, and order provisions. Order provisions are chronological requirements from the municipality for the purpose of having a comprehensive and long-term infrastructure offer in the local area (Konkurransetilsynet, 2015).

The second phase, the regulatory and building application process involves the entrepreneurs' application and subsequent response from the municipalities. In this phase, the municipality has the last word on when, where, and how the entrepreneurs can build (Konkurransetilsynet, 2015). Conflicts that arise between various stakeholders leading to increased time cost before breaking ground, often occur in this phase. A source of conflict is often related to order provisions because a municipality has the strongest negotiation position, as the authority has the power to disapprove a practically completed project (Direktoratet for byggkvalitet, 2017a). There have been several disputes regarding order provisions in the courts where the entrepreneur has questioned both the proportionality and the late timing of the claim (Løtveit, 2021; Konkurransetilsynet, 2015). Over 75 percent of entrepreneurs have experienced order provisions causing an increase in the investment cost of the project (Konkurransetilsynet, 2015).

Another concern for the entrepreneurs and a source of conflict in the regulatory environment is the national and regional authorities' right to object to a proposed project. The primary purpose of the right to object is to ensure that national and regional interests are followed in municipal planning (Regjeringen, 2014). However, 20 possible objectors with different self-interests have led to complaints of resource-intensive bottlenecks from municipalities and leading business leaders in the housing industry (Meling et al., 2012; Revfem, 2021). Furthermore, Konkurransetilsynet points out that lack of cooperation between the different objectors hinders efficiency in construction (Konkurransetilsynet, 2015, p. 37). Lack of effectiveness is shown in a study on price responsiveness of housing supply (Caldera & Johansson, 2013). The study shows that the Norwegian long-run price elasticity of new supply is quite inelastic relative to other Scandinavian countries, as shown in Figure 7.

Figure 7: *Housing Price Elasticities for Selected Countries. Source: Caldera & Johansson, 2013*



Under the third phase, construction, several requirements, and regulations must be followed. The regulations on technical requirements for construction works, TEK17 gives minimum requirements for approved construction (Direktoratet for byggkvalitet, 2017b). It falls outside this master's thesis to examine the various building technical requirements. Still, it is worth pointing out that several entrepreneurs point out that continuously increasing requirements lead to increased investment costs and hence housing prices (Konkurransetilsynet, 2015).

The sale process is the last step before take-over; however, entrepreneurs can resell a project under all the different construction steps, often after the option value of the project has changed.

5.3.2 Demand side

The demand side has been subsidized since the housing policy of property ownership was introduced and implemented after the second world war. Below in Table 2 are the different measures that subsidize the demand-side today (Skatteetaten, n.da; n.db; n.dc; n.dd; n.de; Sørvoll, 2011a):

Table 2: *Tax Subsidies for Housing Demand*

What	How
Interest deduction	Reduced tax with marginal tax rate * Interest Expenses
Valuation discount on housing	25 % of the tax value on primary dwelling 90 % of the tax value on secondary dwellings
Reduced property tax	Reduced to 70 % of MV and then reduced by an annual basic deduction.
Reduced tax on rental	Tax free rental for renting out a minor part of the primary dwelling.
BSU – Young people's housing savings	Up to 5 500 in tax reduction a year, by saving up to 27 500 for housing purposes.
Subsidized loans from Husbanken	Subsidized loans to families with children, elderly, people with disabilities, or others who live in an unsuitable home and either want to buy or improve their home.

The subsidy has led to increased housing prices, followed by increased debt for Norwegian households. The increased debt level has been a great concern for the Financial Supervisory Authority for many years. The housing market has also concerned the IMF, which has stated that the Norwegian taxation of property is lower than the average OECD country, resulting in a possible distribution of Norway's financial system (IMF, 2017). As an answer, the government introduced stricter regulations in 2016 to decrease the growing debt-level (Regjeringen, 2016).

Today’s regulations have set requirements to liquidity and solidity to ensure long-term stability in the economy (Regjeringen, 2016):

- Total debt should not exceed five times the income of the household.
- Total debt shall not be higher than 85 % of the market value of the house, and 60% for secondary houses in Oslo.
- The household must be able to handle the debt after a five-percentage point increase in interest rates.

In addition to the new requirements, the government introduced a debt register, where previously invisible debt is now visible to potential creditors and must be considered under the calculation of new financing (Regjeringen, 2019). Furthermore, the previous government has suggested in the tentative national budget 2022 that the tax value of secondary housing shall increase by five percentage points from 90 to 95 % to ensure increased property tax on housing speculation (Regjeringen, 2021).

6. Model Estimates

This chapter applies the time-series regressions on the data presented for the supply factors of the housing markets in Oslo, Bergen, Trondheim, and Kristiansand. We test whether housing supply factors affect housing prices in the short run and discuss the relationships based on the results, relevant theory, and previously conducted studies. During the analysis, we will evaluate the validity of our conclusions and regression results found in the associated appendixes. The validity is examined through graphical assessments and statistical tests on normality, autocorrelation, and homoscedasticity in error terms. We apply Newey-West standard error regressions where autocorrelation and heteroscedasticity in the error terms are strongly present.

In addition, we analyze how housing initiations are affected in the short run by changes in housing prices, construction costs, and access to capital. We are interested in the responsiveness of housing investments and compare them within the Norwegian cities.

The finite distributed lag model is used to measure the influence of the explanatory variables with time lags. This is to account for the time effect the materialization of supply factor changes will have on prices. Furthermore, we will also test for joint significance where it is reasonable. A variable might be insignificant individually but may have a significant effect when tested jointly with several lags. The insignificance might occur because of the explanatory variable and its lagged values. By testing the cumulative effect of the last four quarters, we obtain the effect a permanent change in the explanatory variable will have on the dependent variable. The joint significance and its coefficients are reported in the regression tables.

6.1 Expectations for the Model estimates

The estimate for the Norwegian cities is dependent on the reliability of the data. We utilized the same data source for each variable in each city to generate comparable results as much as possible. The framework for the estimations of the supply variable's effect on housing prices builds on the empirical approach of OLS time-series regressions. The explanatory variables for the regressions on price includes the construction cost index, housing completion, housing initiations, capital access, and interest rate. All variables are in logarithmic form. Furthermore, the independent variables are in lagged form to reflect the nature of pricing, which typically lags to changes in determinant factors. This also reduces the endogeneity problems. Table 3 shows an overview of the expected signs of estimated coefficients on housing prices as illustrated below.

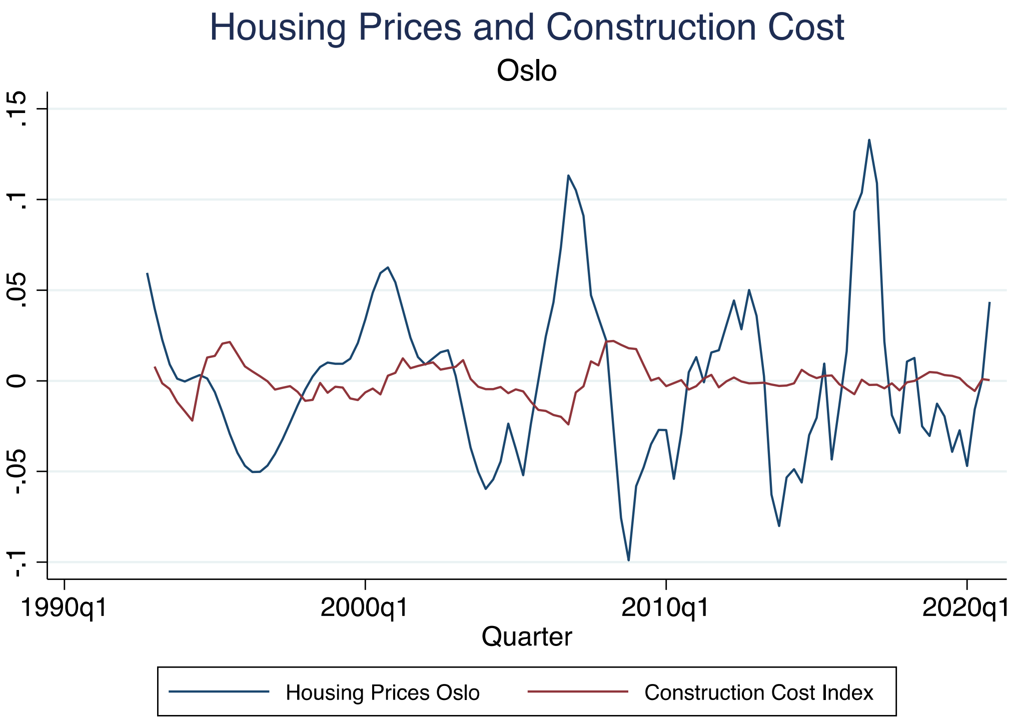
Table 3: *Expected Signs of Estimated Coefficients*

	Expected sign of estimated coefficients on housing prices			
	Oslo	Bergen	Trondheim	Kristiansand
Construction cost	+	+	+	+
Housing Completion	-	-	-	-
Housing Initiations	+	+	+	+
Capital Access	+	+	+	+
Interest rate	-	-	-	-

6.2.1 Model for Housing Price and Construction cost

In this section, we will examine whether shocks in construction costs impact housing prices in the short run. Our hypothesis is a positive relationship between construction cost increases and housing prices. As stated in chapter 2.2.2, there is a complementary relationship between the markets for new construction and existing housing, thus it is reasonable that construction costs will affect housing prices (Grytten, 2009). Figure 8 below presents the cyclical relationship between housing prices for Oslo (blue) and construction costs (red) lagged by one quarter.

Figure 8: *Relationship Between Housing Prices and Construction Cost 1993-2020*



We observe that for several years until 2010, a cyclical appreciation in construction cost seems to be associated with a contraction in housing prices. The variation in the construction cost index also seems to decrease in the years following the financial crisis.

Regressions are done on quarterly data on Oslo, Bergen, Trondheim, and Kristiansand to examine the relationship. The OLS time series regression is formalized in equation 19:

$$cP_t = \beta_0 + \beta_1 CCI_{t-1} + \epsilon_t \tag{19}$$

where

$$cP_t = Cyclical\ component\ of\ the\ housing\ price\ index$$

$$CCI_{t-1} = Lagged\ cyclical\ component\ of\ construction\ cost\ index$$

AIC is used to determine the optimal number of lags, and a lag of one quarter seems to fit the model best. The validity test from the regression is found in the Appendix. Newey-West standard errors are applied due to suspicion of autocorrelation and heteroscedasticity. The results are presented in Table 4.

6.2.2 Model for Housing Completions

In this section, we will examine the relationship between the cyclical component of the housing prices and the completion of new houses. The goal is to understand whether housing completions affect prices in the short run. Our hypothesis aligns with conventional economic theory that completions affect prices by changing housing supplied in the market. An increased supply of new housing will result in lower housing prices, and vice versa.

Regressions are done on quarterly data on Oslo, Bergen, Trondheim, and Kristiansand to examine the relationship. The OLS time series regression is formalized in equation 20:

$$cP_t = \beta_0 + \beta_1 Completion_{t-1} + \epsilon_t \tag{20}$$

where

$$cP_t = Cyclical\ component\ of\ the\ housing\ price\ index$$
$$Completion_{t-1} = Lagged\ quarterly\ housing\ completion$$

Results from AIC suggest a lag of 1 to best fit the model in all cities. The validity test from the regression can be found in the Appendix. Due to conflicting results of autocorrelation and heteroscedasticity, we have applied the Newey-West standard errors. The regression results are presented in Table 5.

6.2.3 Model for Housing Initiations

In this section, we will examine the relationship between the cyclical component of the housing price index and the housing initiations. Our hypothesis is a positive relationship as we believe initiations are driven by housing price expectations. However, we question whether this effect is significant and if it will materialize in the short run.

Regressions are done on quarterly data on Oslo, Bergen, Trondheim, and Kristiansand to examine the relationship. The OLS time series regression is formalized in (21):

$$cP_t = \beta + \beta_1 Initiation_{t-1} + \epsilon_t \tag{21}$$

where

$$cP_t = Cyclical\ component\ of\ the\ housing\ price\ index$$
$$Initiations_{t-1} = Lagged\ quarterly\ housing\ initiations$$

A lag of one fits the model best for all cities according to AIC. The validity test from the regression can be found in the Appendix. Due to conflicting results of autocorrelation and heteroscedasticity we have applied the Newey-West standard errors. The regression results are presented in Table 6.

6.2.4 Model for Capital Access

This section examines the relationship between the short-term relationship between housing price index and capital access. The hypothesis is a positive coefficient for capital access as increased housing prices encourages housing investments. Capital access is dependent on the financial regulatory environment, and periods with capital access liberalization are expected to be followed by periods of appreciation.

Regressions are done on quarterly data on Oslo, Bergen, Trondheim, and Kristiansand to examine the relationship. The OLS time series regression is formalized in (22):

$$cP_t = \beta + \beta_1 CapAc_{t-1} + \epsilon_t \tag{22}$$

where

$$cP_t = Cyclical\ component\ of\ the\ housing\ price\ index$$
$$CCI_{t-1} = Lagged\ cyclical\ component\ of\ capital\ access$$

A lag of one fits the model best for all cities according to AIC. The validity test from the regression can be found in Appendix. Newey-West standard errors are applied, and the regression results are presented in Table 7.

6.2.5 Model for Interest Rate

This section will examine the relationship between the cyclical component of housing prices and the interest rates. Interest rates are both a demand and supply factor in the housing market. We believe the relationship to be negative as lower interest rates improve financial conditions resulting in price appreciation. We believe all cities will show the same effect.

Regressions are done on quarterly data on Oslo, Bergen, Trondheim, and Kristiansand to examine the relationship. The OLS time series regression is formalized in (23):

$$cP_t = \beta_0 + \beta_1 Int_{t-1} + \epsilon_t \tag{23}$$

where

$$cP_t = Cyclical\ component\ of\ the\ housing\ price\ index$$
$$Int_{t-1} = Lagged\ cyclical\ component\ of\ interest\ rates$$

Results from AIC suggest a lag of 1 to best fit the model in all cities. The validity test from the regression can be found in the Appendix. Newey-West standard errors are applied and the regression results are presented in Table 8.

6.3 Combined Model for Housing Prices

In this section, we will perform the regression with multiple variables. As the Gauss-Markov assumptions for time series regression state, omitted variable bias is a problem when error terms are correlated with included variables. We include multiple variables to improve precision, reduce bias, and increase explanatory power.

We suspect that some of our independent variables correlate with omitted variables that we cannot control. Inclusion of the lagged cyclical price component can serve as a proxy for omitted variables and serve as a control variable. An example is price expectations, as we believe current cyclical housing price changes to be affected by previous periods. Simply put, it is likely that the price change deviation from the trend in the last quarter affects housing price change deviations in the next quarter. The performed regression is formalized in (24).

$$\begin{aligned} cP_t = \delta_0 + \delta_1 CCI_{t-1} + \delta_2 Initiations_{t-1} + \delta_3 Completions_{t-1} \\ + \delta_4 Interest_{t-1} + \delta_5 CapAc_{t-1} + \gamma cP_{t-1} + \epsilon_t \end{aligned} \tag{24}$$

where

$$\gamma cP_{t-1} = lagged\ cyclical\ component\ of\ price$$

The coefficient for the lagged dependent variable is expected to be positive. The validity test from the regression can be found in Appendix and Newey-West standard errors are applied, and results are presented in Table 9.

6.4 Combined Model for Housing Initiations

This section examines short-run effects on the housing Initiations. The framework for the estimations builds on the same empirical framework as presented in section 6. Explanatory variables included in the model for housing initiations are the cyclical component of housing prices, construction cost, and capital access. All included variables are in logarithmic form. The goal is to understand the how changes in housing prices, construction cost and capital access affect housing supply through initiations. Our hypothesis is in line with the theory presented in chapter 2, and we expect the coefficients of price and capital access to be positive and the construction cost to be negative. The equation for the short-term effects on housing initiations is expressed in equation (25):

$$I_t = \delta_0 + \delta_1 P_{t-1} + \delta_2 CCI_{t-1} + \delta_3 CA_t + \epsilon_t \tag{25}$$

where

$$I = Initiations$$

$$P = Price$$

$$CCI = Construction\ cost$$

$$CA = Capital\ access$$

The regression results are presented in Table 10.

7. Empirical Results

In this section, we will present the results from the estimated models. Furthermore, we analyze and discuss the results in relation to presented theory and expectation.

7.1.1 Model Estimates for Construction Cost

Table 4: *Estimates for Construction Cost by Cities*

	Dependent varialbe: Cyclical component of log housing prices			
	Oslo	**Bergen**	**Trondheim**	**Kristiansand**
Construction cost (t-1)	-1,32	-1,58	-1,23	0,03
	(0,602***)	(0,651**)	(0,547**)	(0,545)
Constant	-0,001	-0,002	0,000	0,000
	(0,007)	(0,004)	(0,004)	(0,008)
Observations	112	112	112	112
R-squared	0,071	0,169	0,149	0
Adj R-suqared	0,063	0,161	0,141	0,009
Root MSE	0,04272	0,03139	0,0264	0,03909
F-statistic	4,83 (df=1;110)	5,87 (df=1;110)	5,06 (df=1;110)	0 (df=1;110)
Note:				**p<0,1; **p<0,5; ***p<0,01*

The construction cost coefficients show negative coefficients for Oslo, Bergen, and Trondheim with a significance at 5%-level. Kristiansand showed no significant relationship. The regression results indicate that an appreciation in the cyclical component of construction cost is followed by depreciation in housing prices. This relationship challenges the hypothesis that increased construction costs materialize in increased housing prices in the short run. We tested several lags, and the results indicated the same pattern.

A potential explanation of these results is that increased housing prices lead to new housing initiations, which puts pressure on construction input factors. As short-term construction demand increases, construction costs rise due to increased construction activity. Therefore, reverse causality might be prevalent where housing price appreciation drives construction cost. Reverting the regression, we found support for the relationship; appreciation in housing prices was followed by an increase in construction costs. Due to demand shocks, increased cost inputs are often met by contractive monetary policy, which might result in decreased housing prices. Therefore, the results might be affected by omitted variable bias, where variables in error terms like policy measures are correlated with construction cost.

We do not find evidence that increased construction costs lead to increased housing prices in the short run we expected. Hence, it can be inferred that the housing market does not price in construction cost shifts in the short run. However, in the long run we believe that increased prices for input factors for construction affect housing prices. This is due to the need for developers to protect their margins. Hence increased construction cost over the long run can materialize in increased housing prices. In chapter 7.3, we examine whether construction cost impacts initiation of new housing in the short run.

7.1.2 Model Estimates for the Housing Completions

Table 5: *Estimates for the Housing Completions by Cities*

	Dependent varialbe: Cyclical component of log housing prices			
	Oslo	**Bergen**	**Trondheim**	**Kristiansand**
Log Completions (t-1)	0,004	0,023	0,014	0,010
	(0,005)	(0,010**)	(0,005**)	(0,013)
Joint relationship (q/4)	-0,003	0,053	0,015	0,007
	(0,010)	(0,015***)	(0,005***)	(0,012)
Constant	-0,009	0,241	-0,141	-0,100
	(0,009)	(0,100**)	(0,056**)	(0,135)
Observations	112	112	112	112
R-squared	0	0,0559	0,0868	0,0108
Adj R-suqared	-0,0091	0,0473	0,0785	-0,0018
Root MSE	0,04433	0,03345	0,02734	0,03888
F-statistic	0 (df=1;110)	5,50 (df=1;110)	6,46 (df=1;110)	0,55 (df=1;110)
Note:				***p<0,1; **p<0,5; ***p<0,01**

We observe no significant short-term relationship between completions and housing prices in Oslo and Kristiansand. Trondheim and Bergen indicate a positive relationship. From the joint relationship, we observe that the cumulative effect of a 1% increase in housing completions across four consecutive quarters is associated with a 0.05% appreciation in housing prices.

The conflicting result from the cities indicates a weak relationship between housing completion and housing prices in Norway in the short run. There are several reasons why housing prices might not react to completion in the short term. Houses depreciate slowly, and the total housing stock that changes between the quarters is relatively low. Implying that new housing construction will have a relatively small impact on the prices as it accounts for a low fraction of the total housing stock. This effect is somewhat surprising, but other studies have shown the same pattern with a weak relationship between housing stock changes and housing prices in the short run (Caldera & Johansson, 2013).

The positive relationship between Trondheim and Bergen seems counterintuitive. As explained in the theory section, increased completions should reduce prices due to the positive supply shift. A possible explanation is the endogeneity problems in the regression where increased housing completions are associated with population movements.

Furthermore, housing price appreciation might affect housing completions as well. In that case, we are affected by a reverse causation problem. It is rational to believe that housing developers would like to build in locations where prices are expected to appreciate. Therefore, housing projects can be accelerated when housing prices rise. There is also likely a simultaneity problem as new housing construction is more attractive for households and demands a price premium. As a result, new construction in each period would result in an appreciation housing price index for the given area, all else equal. Overall, the low explanatory power of the regression does not provide evidence for a causal interpretation.

7.1.3 Model Estimates for the Housing Initiations

Table 6: *Estimates for the Housing Initiations by Cities*

	Dependent varialbe: Cyclical component of log housing prices			
	Oslo	**Bergen**	**Trondheim**	**Kristiansand**
Log Initiations (t-1)	0,017	0,033	0,020	0,005
	(0,009*)	(0,009***)	(0,008**)	(0,010)
Joint relationship (q/4)	0,028	0,073	0,035	0,002
	(0,103***)	(0,011***)	(0,006***)	(0,014)
Constant	-0,189	-0,345	-0,205	-0,053
	(0,102*)	(0,097***)	(0,080**)	(0,106)
Observations	112	112	112	112
R-squared	0,0422	0,1512	0,1438	0,0027
Adj R-suqared	0,0335	0,1435	0,1360	-0,0064
Root MSE	0,04339	0,03172	0,02648	0,03903
F-statistic	3,29 (df=1,110)	12,42 (df=1;110)	6,72 (df=1;110)	0,25(df=1;110)
Note:				****p<0,1; **p<0,5; ***p<0,01***

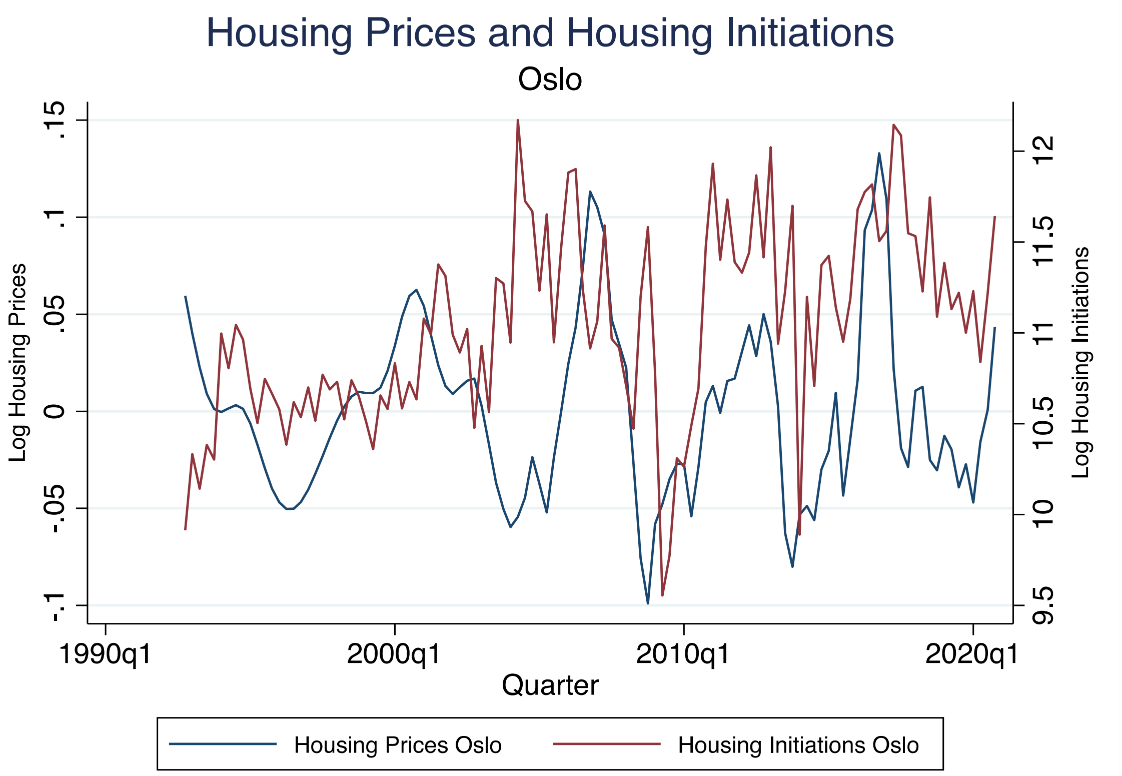
The coefficients show a positive relationship between initiations and the cyclical component of housing prices. Across four consecutive quarters, we observe the cumulative effect of a 1%

increase in housing initiations is associated with a 0.027%, 0.073%, and 0.035% increase in the cyclical component of housing prices in Oslo, Bergen, and Trondheim respectively. This can indicate that expected price appreciation leads to initiations in the short term.

Housing initiations as a determinant for housing prices in the short run can be due to future expectations. On the other hand, prices might be a determinant for housing initiations itself, introducing a causation problem. Furthermore, it is likely that initiations are also driven by financial conditions such as capital access for developers, hence we are likely to be affected by endogeneity bias. Controlling for the other factors that might be determinants for initiations can solve the problem. Therefore, we cannot causally interpret that housing initiations serve as a determinant for housing prices in the short run.

Further graphical examination between 1993 and 2020 can help us understand the relationship. Figure 9 shows the cyclical component of price and quarterly initiations in Oslo, both in logarithmic values.

Figure 9: *The relationship Between the Cyclical Component of Housing Prices and Initiations*



From 2004 we observed a substantial increase in housing initiations where housing prices fell, followed by a steep price appreciation. This period supports the hypothesis of housing initiations as a proxy for price expectations. The steep decline in housing prices in 2008 is followed by a collapse in initiations. From regression results and graphical examination, we find support that initiations are both driven by future housing price expectations and current housing price changes. We will further examine and quantify this relationship in chapter 7.3.

7.1.4 Model Estimates for Capital Access

Table 7: *Estimate for Capital Access by Cities*

	Dependent varialbe: Cyclical component of log housing prices			
	Oslo	**Bergen**	**Trondheim**	**Kristiansand**
Capital access (t-1)	*0,230*	0,117	-0,012	0,829
	(0,559)	(0,530)	(0,461)	(0,531)
Constant	*0,005*	-0,000	0,000	0,000
	(0,007)	(0,003)	(0,004)	(0,007)
Observations	*112*	112	112	112
R-squared	*0,0034*	0,0015	0,0000	0,0567
Adj R-suqared	*-0,0057*	-0,0076	-0,0091	0,0481
Root MSE	*0,04426*	0,0344	0,02861	0,03796
F-statistic	*0,5411 (df=1;112)*	0,16 (df=1;110)	0,97 (df=1;110)	2,43 (df=1;110)
Note:				****p<0,1; **p<0,5; ***p<0,01***

The regression results do not find a significant relationship between lagged variables of capital access and housing prices. This is not surprising as capital access shifts take time to materialize in increasing housing prices. Another reason for the low explanatory power of the regression results might be due to data reliability of capital access. The proxy used for developers' capital access is influenced by the regulatory environment and capital access for housing demand, as the total debt level is a variable in the equation for capital access. As housing prices increase, debt levels are also likely to increase. This results in a reverse causation problem where part of the capital access proxy is driven by housing prices making it hard to assess a clear short-term relationship.

The results show no clear short-term relationship. However, it is likely for capital access shifts to affect housing developers' behavior in the long run. Demand factors will also be determinants of developers' capital access through demand category 1 (owners) and category 2 (investment objects) as explained in chapter 2.1.

7.1.5 Model estimates for Interest Rates

Table 8: *Estimate for Interest Rate by Cities*

	Dependent varialbe: Cyclical component of log housing prices			
	Oslo	**Bergen**	**Trondheim**	**Kristiansand**
Interest rate (t-1)	-0,043	-0,024	-0,025	0,025
	(0,022*)	(0,013*)	(0,012**)	(-0,021)
Joint relationship (q/4)	-0,087	-0,060	-0,069	0,035
	(0,260***)	(0,021***)	(0,017***)	(0,025)
Constant	0,000	0,000	0,000	0,000
	(0,006)	(0,005)	(0,004)	(0,006)
Observations	112	112	112	112
R-squared	0,0470	0,0249	0,0381	0,0522
Adj R-suqared	0,0383	0,0160	0,0293	0,0062
Root MSE	0,04328	0,034	0,02806	0,03932
F-statistic	3,72 (df=1;110)	3,36 (df=1;110)	4,31** (df=1;110)	1,34 (df=1;110)
Note:				****p<0,1; **p<0,5; ***p<0,01***

We observe a negative coefficient with significance for Oslo, Bergen, and Trondheim, but not for Kristiansand. All cities show significance for the cumulative relationship. The significant joint relationship can be interpreted as a one percentage point increase in interest rates across the four consecutive quarters are associated with a decrease in the cyclical component of housing prices of 0.09%, 0.06%, 0.07%, for Oslo, Bergen, and Trondheim respectively. Changes in interest rates affect housing prices through the supply and demand sides. We cannot causally interpret the results due to weak explanatory power and insignificant F-statistics for Oslo and Bergen.

7.2. Combined Model Estimates for Housing Prices

Table 9: *Estimated Supply Model by Cities*

	Dependent varialbe: Cyclical component of log housing prices			
	Oslo	**Bergen**	**Trondheim**	**Kristiansand**
Construction Cost (t-1)	-0,8930228	-0,872314	-0,5509817	-1,047465
	(0,2349106***)	(0,2347541***)	(0,1531776***)	(0,1381732***)
Initiations (t-1)	0,0026717	0,0068592	0,0045771	(0,000862)
	(0,0037374)	(0,0036656*)	(0,0021419**)	(0,0031149)
Completions (t-1)	0,003477	-0,0056182	-0,0056494	-0,0007057
	(0,0035652)	(0,0031047*)	(0,0015769***)	(0,0029536)
Interest Rate (t-1)	-0,0336534	0,0005062	-0,009588	-0,0002441
	(0,0102257***)	(0,0058524)	(0,004171**)	(0,0050673)
Capital Access (t-1)	0,420632	-0,0091058	0,0377353	0,2005883
	(0,1846398**)	(0,1812246)	(0,1446148)	(0,0956591)
C.housing price (t-1)	0,8174986	0,8573822	0,901068	0,9888394
	(0,0553132***)	(0,0494513***)	(0,0532064***)	(0,0333216***)
Constant	-0,0334479	-0,0130926	0,0104252	0,0155638
	(0,0491798)	(0,0474173)	(0,0208549)	(0,0338759)
Observations	112	112	112	112
R-squared	0,8028	0,8974	0,9151	0,9484
Adj R-suqared	0,7916	0,8916	0,9102	0,9455
Root MSE	0,02015	0,01128	0,00853	0,00701
F-statistic	48,70*** (df=6;105)	80,65*** (df=6;105)	72,79*** (df=6;105)	236***(df=6, 105)
Note:				****p<0,1; **p<0,5; ***p<0,01***

The coefficients for the lagged variables of construction cost show a significant negative effect, as previously observed. We find that the coefficients for housing Initiations are positive for Bergen and Trondheim at 10% and 5% levels. This relationship aligns with expectations and what we found in chapter 7.1.3. However, the coefficient for Oslo does not show significance anymore. A notable change from previous tests is the coefficients for completion. We noted that we expected completions to affect price negatively, but in chapter 7.1.2, we found a weak but positive relationship hence questioning our hypothesis. The coefficients for completions in Bergen and Trondheim indicate that a 1% increase in housing completions in the previous quarter is associated with a 0.006% decline in the cyclical component of housing prices where

Trondheim shows significance at the 1% level. This is in line with our theoretical predictions. We believe the marginal effect is due to the relatively stable level of housing completions over time, making short-term fluctuations less impactful.

Furthermore, positive changes to interest rates are associated with price depreciation in Oslo and Trondheim. The effect of interest rate changes is relatively modest, considering that a 1% interest change is associated with a 0.034% change in the cyclical component of housing prices in Oslo. Lack of significance in Bergen and Kristiansand is surprising and might indicate that the regional price responsiveness to interest changes is lower. Possible explanations are demography and income level compared to housing prices. Young adults or first-time buyers are likely more sensitive to interest rate changes as debt is their primary financing source for housing in the starting phase. Another explanation can be that other factors offset the effects of interest rate changes in the measured period. The coefficient for capital access shows positive significance only in Oslo, while no effects were observed when measured independently in chapter 7.1.4. The conflicting results make it hard to conclude whether this variable has a meaningful impact on housing prices or not in the short run.

7.3 Combined Model Estimates for Housing Initiations

Table 10: *Model for Housing Initiations by Cities*

	Dependent varialbe: Log Housing Initiations			
	Oslo	**Bergen**	**Trondheim**	**Kristiansand**
Housing Price (t-1)	2,316	3,182	6,135	0,695
	(1,380*)	(1,114***)	(1,956***)	(1,176)
Construction Cost (t-1)	-8,288	-10,05639	-3,395	-9,420
	(6,271)	(4,872**)	(5,430)	(4,650*)
Capital Access (t-1)	-2,212	7,412	-7,569	4,526
	(6,207)	(3,864*)	(4,802)	(4,586)
Constant	11,049	10,379	10,278	9,867
	(0,061)	(0,035***)	(0,062***)	(0,356***)
Observations	112	112	112	112
R-squared	0,0689	0,1657	0,1368	0,0410
Adj R-suqared	0,0430	0,1425	0,1128	0,0144
Root MSE	0,513	0,37073	0,50696	0,37677
F-statistic	1,79 (df=3;108)	7,15*** (df=3;108)	7,45***(3;108)	1,39 (3;108)
Note:				**p<0,1; **p<0,5; ***p<0,01*

The regression result shows that price change deviations from trends in the previous quarter positively affect housing initiations in Bergen and Trondheim. Our model fails to provide overall significance for Oslo and Kristiansand as the F-tests are not statistically significant. The significant short-run coefficients for Bergen and Trondheim are in line with expectations and presented theory. In the previous quarter, a 1% increase in the cyclical component of housing prices is associated with 3.18% and 6.14% increased housing initiations. Changes in the construction cost index are negative for both Bergen and Trondheim, but significance at 5%-level is only achieved in Bergen, where a 1% change is associated with a 10% decrease in housing initiations. Lastly, the coefficient for capital access shows a weak relationship at 10% significance for Bergen. However, the regression's conflicting result and low explanatory power makes it hard to conclude that capital access for developers significantly affects initiations in the short run.

8. Conclusions

This master thesis aimed to identify the impact of supply factors in the property market on the housing prices in the short run for the selected Norwegian Cities. With the following research question:

How do Supply Factors in the Property Market Affect House Prices in the Short Run?

The supply variables applied in the analysis stem from an overview of housing price determinants in the article, *Historisk blikk på eiendomsmarkedet: prisdrivere for boliger*, by Grytten (2018a). We applied data for the relevant variables for Oslo, Bergen, Trondheim, and Kristiansand on quarterly frequency from 1993 to 2020.

We applied a quantitative analysis using the time series regressions to answer our question. Our findings indicate that construction costs, housing completions, and interest rates are the most important determinants as they all showed a negative relationship on housing prices in the short run. The findings were in line with the theory and expectations, except for construction cost, which we expected to have a positive relationship to prices in the short run. This could be due to reverse causality where housing prices drive initiations that increase construction costs due to higher activity. Following this reasoning, construction cost has a positive lead relationship to housing prices.

From the results, we observed a weak relationship between housing initiation and price. We believe the positive coefficient of initiation is driven by the developer's expectations rather than initiations itself directly impacting prices. Thus, initiations increase in periods prior to the price growth as developers expect a cyclical price appreciation. Our model for housing initiations further supports this positive price relationship with initiations. The model results indicated that housing prices were the primary determinant for housing initiation activity in the short run.

Our results indicated several regional differences. We found no short-term relationship for housing completions on prices in Oslo from the combined model, contrary to Bergen and Trondheim. A reasonable explanation can be the low level of new completions relative to demand. However, for Oslo, we found a significant relationship for capital access and interest rates on short term housing prices. The results indicate that financing conditions are the primary determinants for short term price changes. Hence, we argue that new completion is absorbed in Oslo at a given price level determined by the possible financing level for households.

As expected, we found prices to positively affect housing initiations in Bergen and Trondheim. However, we found no valid significant relationship for Oslo. This indicates a market where conventional economic theory for supply and demand does not apply due to limited supply of regulated plots from authorities. Thus, for housing supply to be more responsive in Oslo, the regulatory policy should change to create a more responsive market.

We believe that our findings provide useful contributions to current research on supply mechanisms in the short run for the Norwegian housing market. The difference in regional results can provide valuable knowledge to regulatory authorities when designing new housing policy. Much of the existing literature primarily focuses on short run demand effects on housing prices. Hence, our research contributes by providing literature on supply mechanisms and thus strengthening our understanding of market dynamics for the short run for Norway.

In summary, our findings are mostly in line with the presented theory and expectations. Our analysis finds support for short term relationships between housing prices and the discussed supply variables for Norwegian cities. The notably most significant supply variables are construction cost, housing completions, interest rates, and capital access. Additionally, we find that housing price development affects supply factors as it is an interconnected relationship between demand and supply.

Future research should consider investigating the remaining supply factors as determinants for price in the overview by Grytten (2018a). A qualitative approach regarding how developers' short term expectations can affect housing prices would have been an interesting extension. Moreover, it can be of value to test our models on rural regions to observe whether our research is applicable outside the cities. The findings can provide important insight for the authorities regarding supply mechanisms in relation to housing price changes. Additionally, testing the models outside Norway, more precisely on other large European Cities could be of interest to observe potential differences. Other studies could also test time periods prior to 1993 to observe whether previous periods yield the same results.

Finally, it would be interesting to examine how supply factors affect housing prices in the long run. An interesting factor to examine is plot regulation, which we believe has a major long-term impact on housing prices, especially in high demand areas. A possible approach to the suggested research would have been to examine the relationship between different political regimes' effects on access to building plots and hence the development in price.

9. References

Blackley, D. M. (1999). The Long-Run Elasticity of New Housing Supply in the United States: Empirical Evidence for 1950 to 1994. *Journal of Real Estate Finance and Economics*, *18*(1), 25-42. https://link.springer.com/content/pdf/10.1023/A:1007781228328.pdf

Brooks, C. (2008). *Introductory Econometrics for finance*. (2nd ed). Cambridge.

Eurostat. (2020). House or flat – owning or renting. https://ec.europa.eu/eurostat/cache/digpub/housing/bloc-1a.html

Caldera, A. & Johansson, Å. (2013). The price responsiveness of housing supply in OECD countries. *Journal of Housing Economics*, *22*(3), 231-249. https://doi.org/10.1016/j.jhe.2013.05.002

Direktoratet for byggkvalitet. (2017a). *Steg 8. Skaffe ferdigattest*. DIBK. https://dibk.no/verktoy-og-veivisere/atte-steg-fra-ide-til-ferdig-soknad/stegene-fra-ide-til-ferdig-soknad/steg-8-skaffe-ferdigattest/

Direktoratet for byggkvalitet. (2017b). *Byggteknisk forskrift (TEK17) med veiledning*. DIBK. https://dibk.no/regelverk/byggteknisk-forskrift-tek17/

Finanstilsynet. (2012). *Finansielt utsyn 2012*. Finanstilsynet. https://www.finanstilsynet.no/contentassets/c284766bf68f4dc9933e9e10b49d7bda/finansielt_utsyn_2012.pdf

Finanstilsynet. (2016). *Finanstilsynet foreslår innstramminger i boliglånsforskriften.* (Pressemelding 18/2016). Finanstilsynet. https://www.finanstilsynet.no/nyhetsarkiv/pressemeldinger/2016/finanstilsynet-foreslar-innstramminger-i-boliglansforskriften/

Finanstilsynet. (2017). *Finansielt utsyn: November 2017*. Finanstilsynet. https://www.finanstilsynet.no/publikasjoner-og-analyser/finansielt-utsyn/#3190

Finanstilsynet. (2018). *Finansielt utsyn: Desember 2018*. Finanstilsynet. https://www.finanstilsynet.no/publikasjoner-og-analyser/finansielt-utsyn/#3188

Finanstilsynet. (2020). *Boligmarkedsundersøkelsen 2020.* Finanstilsynet. *https://www.finanstilsynet.no/contentassets/283fc01171fb41a3bb618d2ee664ebc4/boliglansundersokelsen_2020.pdf*

Gjerstad, J., Grytten, O. H., Solem, O. R. & Nyberg, J. (2018). *Tuftet på fortiden – bygger for fremtiden: BOB gjennom 75 år*. Bodoni. https://www.researchgate.net/publication/331891744_Tuftet_pa_fortiden_-_bygger_for_fremtiden_BOB_gjennom_75_ar

Gjerstad, J., Grytten, O. H., Østerbø, K. & Gaasemyr, M. (2021). *Rom for alle: Vestbo gjennom 75 år*. Bodoni.

https://www.researchgate.net/publication/352372993_Rom_for_Alle_Med_Vestbo_gjennom_75_ar

Gran, B. (2021). *Boligbyggingen fra 2000-2020 i et historisk perspektiv* (Notat 2). Samfunnsøkonomisk analyse AS. https://www.regjeringen.no/contentassets/b4821864e02647839e12881a335d0700/notat-2-2021-boligbygging-i-et-historisk-perspektiv.pdf

Grytten, O. H. (2009). Boligboble? Empiriske indikatorer i historisk perspektiv. *Magma*, *12*(5), 26-39. https://www.researchgate.net/publication/331993274_Boligboble_Empiriske_indikatorer_i_historisk_perspektiv

Grytten, O. H. (2018a) Historisk blikk på eiendomsmarkedet: prisdrivere for boliger. Kristoffersen, Ø, R. & Røsnes, A. E. (Eds.), *Eiendom og Eierskap: Om forståelsen av fast eiendom og dens betydning i verdiskapning og samfunnsbygging* (72-88). Universitetsforlaget.

Grytten, O. H. (2018b). Eiendomsbobler før og nå? Kristoffersen, Ø, R. & Røsnes, A. E. (Eds.), *Eiendom og Eierskap: Om forståelsen av fast eiendom og dens betydning i verdiskapning og samfunnsbygging* (136-154). Universitetsforlaget.

Grytten, O. H. (2020a). *Tidsserieanalyse*. FIE431 Krakk og Kriser. Norwegian School of Economics.

Grytten, O. H. (2020b). *Stagflasjon*. FIE431 Krakk og Kriser. Norwegian School of Economics.

Grytten, O. H. & Hunnes, A. (2016). *Krakk og Kriser i historisk perspektiv*. Cappelen Damm.

Hall, P. A. & Soskice, D. (2001). *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford.

Hendry, D. F. (1984). Econometric Modelling of House Prices in the United Kingdom. David F. Hendry & Kenneth F. Wallis (Eds.), *Econometrics and Quantitative Economics.* Basil Blackwell Publisher Ltd.

Reiersen, E., Thue, E. & Jensen, L. A. (1996). *De tusen hjem: Den norske stats husbank 1946-96*. Gyldendal Norsk Forlag.

IMF. (2017). *Norway: 2017 Article IV Consultation-Press Release; and Staff Report* (IMF Country Report 17/182). International Monetary Fund.

https://www.imf.org/en/Publications/CR/Issues/2017/07/05/Norway-2017-Article-IV-Consultation-Press-Release-and-Staff-Report-45027

Jacobsen, D. H. & Naug, B. E. (2004). Hva driver boligprisene? *Penger og Kreditt, 32*(4), 229-240. https://www.norges-bank.no/globalassets/upload/publikasjoner/penger_og_kreditt/2004-04/jacobsen.pdf

Jansen, E. S. (2011). Hva driver utviklingen i boligprisene? *Samfunnsspeilet, 25*(5-6), 89-96. https://www.ssb.no/a/samfunnsspeilet/utg/201105/ssp.pdf

Kahn, James (2008). *What drives housing prices* (Federal Reserve Bank of New York Staff Reports 345). Federal Reserve Bank of New York. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1264048

Kenny, G. (1998). *The Housing Market and the Macroeconomy: Evidence From Ireland* (Research Technical Papers 1/RT/98). Central Bank of Ireland. Available at: https://www.centralbank.ie/docs/default-source/publications/research-technical-papers/1rt98---the-housing-market-and-the-macroeconomy-evidence-from-ireland-(kenny).pdf?sfvrsn=4

Konkurransetilsynet. (2015). *Konkurransen i boligutviklermarkedet.* https://konkurransetilsynet.no/publications/konkurranseproblemer-for-boligutvikling/

Kurlat, P. & Stroebel, J. (2014). *Testing for information asymmetry in real estate markets* (NBER Working Paper 19875). National Bureau of Economic Research. https://pages.stern.nyu.edu/~jstroebe/PDF/RFS_Kurlat_Stroebel.pdf

Larsen, E. R. (2001). The Norwegian Economy 1900-2000: From Rags to Riches A brief history of economic policymaking in Norway. *Economic Survey, 4*, 22-27. https://www.uio.no/studier/emner/hf/iln/NORINT0500/h08/undervisningsmateriale/The_Norwegian_Economy_1900-2000.pdf

Larsen, E. R. & Mjølhus, J. (2009). *Finanskrise! Lånefest, boligboble – og dagen derpå.* Gyldendal Akademisk.

Larsen, J. H. (2015). *Finansielle kriser og resesjoner*. Cappelen Damm.

Lecompte, M. D. & Goetz, J. P. (1982). Problems of Reliability and Validity in Ethnographic Research. *Review of Educational Research, 52*(1), 31-60. https://www.researchgate.net/publication/255615696_Problems_of_Reliability_and_Validity_in_Ethnographic_Research

Lie, Einar. (1995). *Ambisjon og tradisjon: Finansdepartementet 1945-1965*. Universitetsforlaget. https://www.nb.no/nbsok/nb/dd52b21da57e3c4cbf40a24c014bacd5?lang=no#3

Lie, Einar. (2012). *Norsk Økonomisk Politikk etter 1905*. Universitetsforlaget.

Løtveit, H. (2021, 28.may). Høyesterett tar ikke i Entra - kan få store konsekvenser. *Finansavisen*.

https://finansavisen.no/nyheter/naeringseiendom/2021/05/28/7680945/hoyesterett-avviser-anke-fra-entra

NOU 1981: 5. (1981). *Fast eiendom: prisregulering og ekspropriasjonserstatning*. Forbruker- og administrasjonsdepartementet. https://www.nb.no/statsmaktene/nb/f595a6d6a9cb2b1dd1627175065aac2f?index=2#33

Meling, S. V., Omland, I. Ø. & Christoffersen, J. F. (2012, 20.aug). Boligbygging stoppes av myndighetene. *Tv2*.
https://www.tv2.no/a/3855568/

Moe, T. G., Solheim, J. A. & Vale, B. (2004). *The Norwegian Banking Crisis* (Occasional Papers 33). Norges Bank.
https://www.norgesbank.no/contentassets/ed5dd397dce345338046a22c7e07f959/hele_heftet.pdf?v=03/09/2017122240&ft=.pdf

Osland, L. (2001). Den hedonistiske metoden og estimering av attributtpriser. *Norsk Økonomisk Tidsskrift 115(1)*, 1-22.
https://www.researchgate.net/publication/258092733_Den_hedonistiske_metoden_og_estimering_av_attributtpriser

Regjeringen. (2014). *Retningslinjer for innsigelse i plansaker etter plan- og bygningsloven* (Rundskriv H-2/14). Kommunal- og moderniseringsdepartementet. Rundskriv.
https://www.regjeringen.no/no/dokumenter/retningslinjer-for-innsigelse-i-plansaker-etter-plan--og-bygningsloven/id751295/

Regjeringen. (2016). *Forskrift om krav til nye utlån med pant i bolig (boliglånsforskriften).* Finansdepartementet. https://www.regjeringen.no/no/dokumenter/forskrift-om-krav-til-nye-utlan-med-pant-i-bolig-boliglansforskriften/id2523973/

Regjeringen. (2019). *Gjeldsinformasjonsloven.* Barne og familiedepartementet.
https://www.regjeringen.no/no/tema/forbruker/gjeldsinformasjonsloven/id2510537/

Regjeringen. (2021). Lavere formueskatt.
https://www.regjeringen.no/no/dokumentarkiv/regjeringen-solberg/aktuelt-regjeringen-solberg/fin/pressemeldinger/2021/lavere-formuesskatt/id2875194/

Revfem, J. (2021, 09.feb). Boliglegenden advarte i 2012 om utviklingen. Siden er det blitt mye verre. *Nettavisen*.
https://www.nettavisen.no/okonomi/boliglegenden-advarte-i-2012-om-utviklingen-siden-er-det-blitt-mye-verre/s/12-95-3424084715

Rohrer, M. (2021). *Assumptions and biases*. FIE401 Financial Econometrics. Norwegian School of Economics.

Roll, R. (1988). The International Crash of October 1987. *Financial Analysts Journal*, *44*(5), 19-35.
https://www.jstor.org/stable/pdf/4479142.pdf

Shapiro, S. S. & Wilk, M. B. (1965). An Analysis of Variance Test for Normality (Complete Samples). *Biometrika, 52*(3/4), 591–611. https://doi.org/10.2307/2333709

Skatteetaten (n.da). *Loans and interest rates*. Skatteetaten. https://www.skatteetaten.no/en/person/taxes/get-the-taxes-right/bank-and-loans/loans-and-interest-rates/

Skatteetaten (n.db). *Glossary*. Skatteetaten. https://www.skatteetaten.no/en/person/taxes/get-the-taxes-right/property-and-belongings/houses-property-and-plots-of-land/tax-value/your-own-home-primary-dwelling/glossary/

Skatteetaten (n.dc). *How much property tax must I pay*. Skatteetaten. https://www.skatteetaten.no/en/person/taxes/get-the-taxes-right/property-and-belongings/houses-property-and-plots-of-land/property-tax/how-much-tax-must-i-pay/

Skatteetaten (n.dd). *Tax rules – letting part of your own home*. Skatteetaten. https://www.skatteetaten.no/person/skatt/hjelp-til-riktig-skatt/bolig-og-eiendeler/bolig-eiendom-tomt/utleie/utleie-av-del-av-egen-bolig/skatteregler/

Skatteetaten (n.de). *BSU - Young people's housing savings.* Skatteetaten. https://www.skatteetaten.no/person/skatt/hjelp-til-riktig-skatt/bank-og-lan/bsu/

Solvang, F. (2020). Eie eller leie? Larsen, T. M (Produksjonsleder), *Debatten*. NRK. https://tv.nrk.no/serie/debatten/202010/NNFA51101520/avspiller

SSB. (2019). *Registrerbasert byggstatistikk (Documents 2019/27)*. https://ssb.brage.unit.no/ssb-xmlui/bitstream/handle/11250/2625445/NOT2019-27_web.pdf?sequence=1&isAllowed=y

St.meld. nr. 23 (2003-2004*). Om boligpolitikken.* Kommunal- og regionaldepartementet. https://www.regjeringen.no/contentassets/89610455593354fa5ac91f93b8f3b3c3b/no/pdfs/stm200320040023000dddpdfs.pdf

Stock, J. H. & Watson, M. W. (2019). *Introduction to Econometrics, Global editon.* (4th ed). Pearson Education Limited.

Studenmund, A. H. (2014). *Using Econometrics: A Practical Guide*. (6th ed). Pearson education limited.

Sørvoll, J. (2011a). *Den boligsosiale vendingen. Norsk boligpolitikk fra midten av 1990-tallet i historisk perspektiv* (Attachment to NOU 2011:15, 171-180). Kommunal- og regionaldepartementet. https://www.regjeringen.no/globalassets/upload/krd/vedlegg/boby/rapporter/den_boligsosiale_vendingen.pdf?id=2260849

Sørvoll, J. (2011b). *Norsk boligpolitikk i forandring 1970-2010. Dokumentasjon og debatt* (NOVA Rapport 16/2011). Norsk institutt for forskning om oppvekst, velferd og aldring.

http://biblioteket.husbanken.no/arkiv/dok/Komp/Norsk%20boligpolitikk%20i%20forandring.pdf

Sørvoll, J. (2021). *Husbanken og boligpoltikken 1996-2021: En jubileumsbok.* Cappelen Damm.

Wooldridge, J. M. (2012). *Introductory Econometrics: A Modern Approach*. (5th ed). Cengage Learning.

Datasets:

Norges Bank. (2021). Interest rates, GBON - 5 years. [Data set]. https://app.norges-bank.no/query/#/no/interest

Eiendom Norge. (2021). *Housing price index from 2003-2021 (closed file)*. [Data set].

Eitrheim, Ø. & Erlandsen, S. K. (2004). House price indices for Norway 1819-2003. Eitrheim, Øyvind, Jan T Klovland og Jan Qvigstad (Eds.), *Historical monetary statisics for Norway 1819-2003* (349-375). Norges Bank.

SSB. (2020). Building statistics. [Data set]. https://www.ssb.no/en/statbank/table/01751/

SSB. (2021a). Price index for existing dwellings. [Data set]. https://www.ssb.no/en/statbank/table/07221

SSB. (2021b). Construction cost index for residential building. [Data set]. https://www.ssb.no/en/statbank/table/08651/

SSB. (2021c). Building statistics. [Data set]. https://www.ssb.no/statbank/table/03723/

SSB. (2021d). Credit indicator. [Data set]. https://www.ssb.no/en/statbank/table/06718/

10. Appendix

In this chapter, we perform various tests and graphical assessments presented in chapter 3 to evaluate the validity of our models. The test's primary focus is to evaluate the time series regression assumptions of homoscedasticity, autocorrelation, and normality. Violations of these assumptions affect the reliability of the estimated coefficients presented in our models.

Testing for heteroscedasticity is done by the Breusch-Pagan test, as well as residual plots against fitted values and time. Autocorrelation is tested through the Durbin Watson test and autocorrelation plots of residuals. Normality is tested through the Shapiro-Wilk test and Jarque-Bera test, as well as histograms and Q-Q plots of residuals.

We present and comment on the validity for model 7.2 and 7.3, while the validity results from model 7.1.1-7.1.5 are presented without comments further down in the appendix.

Assessment of Heteroskedasticity for Model 7.2 and 7.3

We look for patterns in the plots where residuals are plotted against fitted values. Figure 10 and Figure 11 display the residuals against fitted values for housing price model 7.2. While Figure 12 and Figure 13 display the residuals against time model 7.3 on housing initiations.

In the housing price model 7.2, we observe that the residuals seem to be evenly distributed for Oslo, but there appears to be some increased variation over time. An indication that homoscedasticity is not present. For Bergen and Trondheim, we observe some clustering of the residuals, and further, we observe increased spread during the period 2008 to 2010. This is likely due to the impact of the financial crisis. In this period, our models might be less accurate compared to other periods in the time series. For model 7.3 on housing initiations, we observe overall very well distributed residuals both against fitted values and against time. Our Breusch-Pagan test is presented in Table 11 and Table 12 for the models. We observe that all P-values from the BP-tests on model 7.3 are well above the 5% significance level, but not for the model on housing prices.

Figure 10: Residuals vs Fitted values for Model 7.2

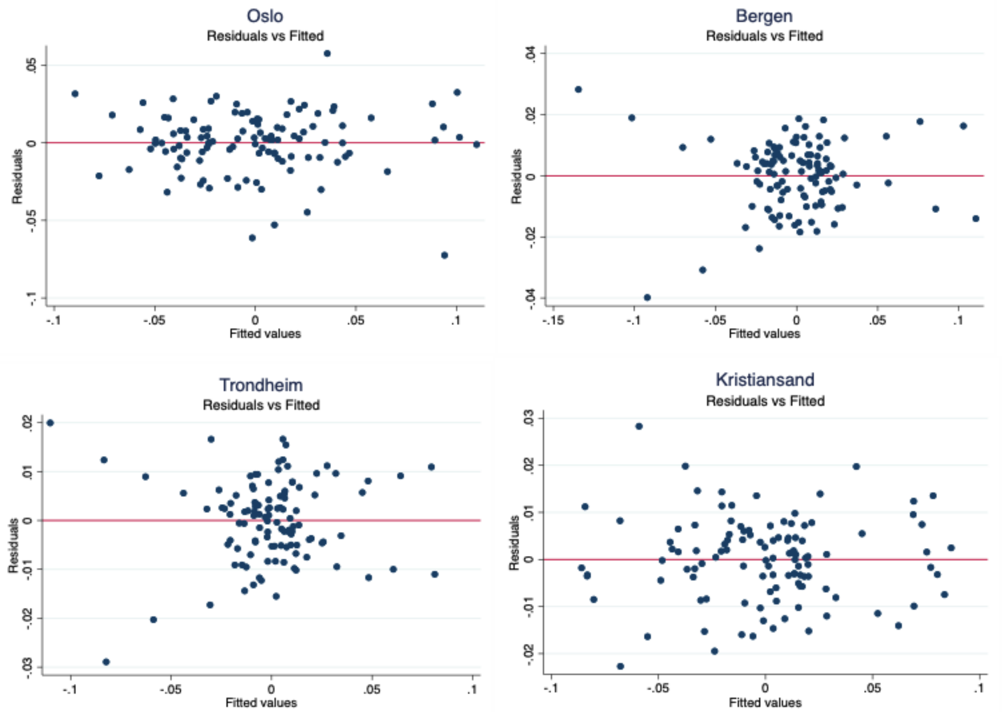


Figure 11: Residuals vs Time for model 7.2

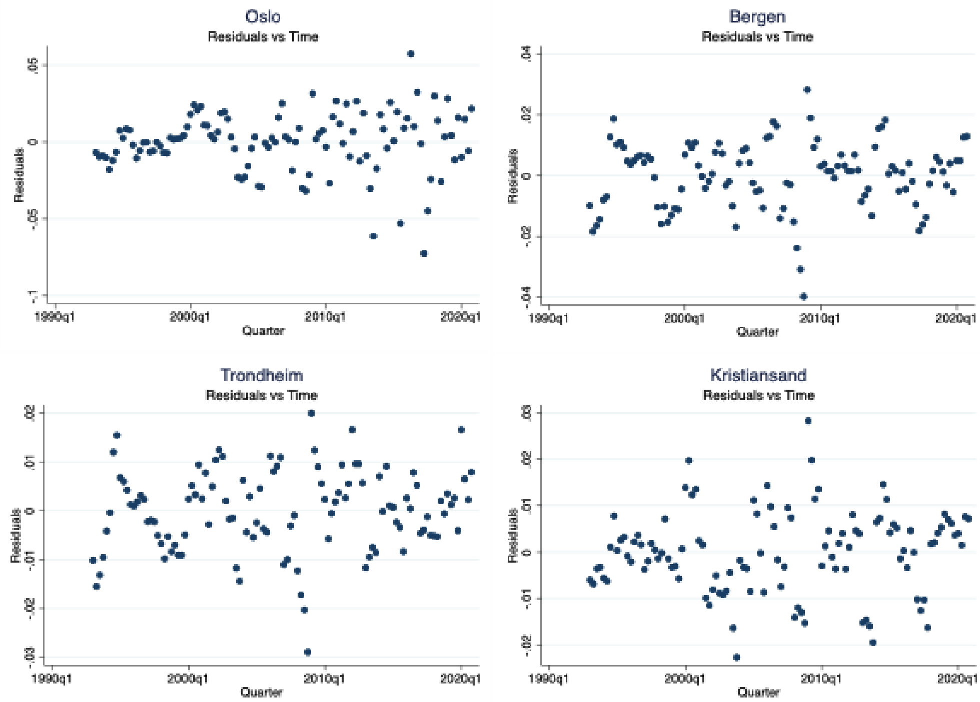


Figure 12: Residuals vs Fitted Values for Model 7.3

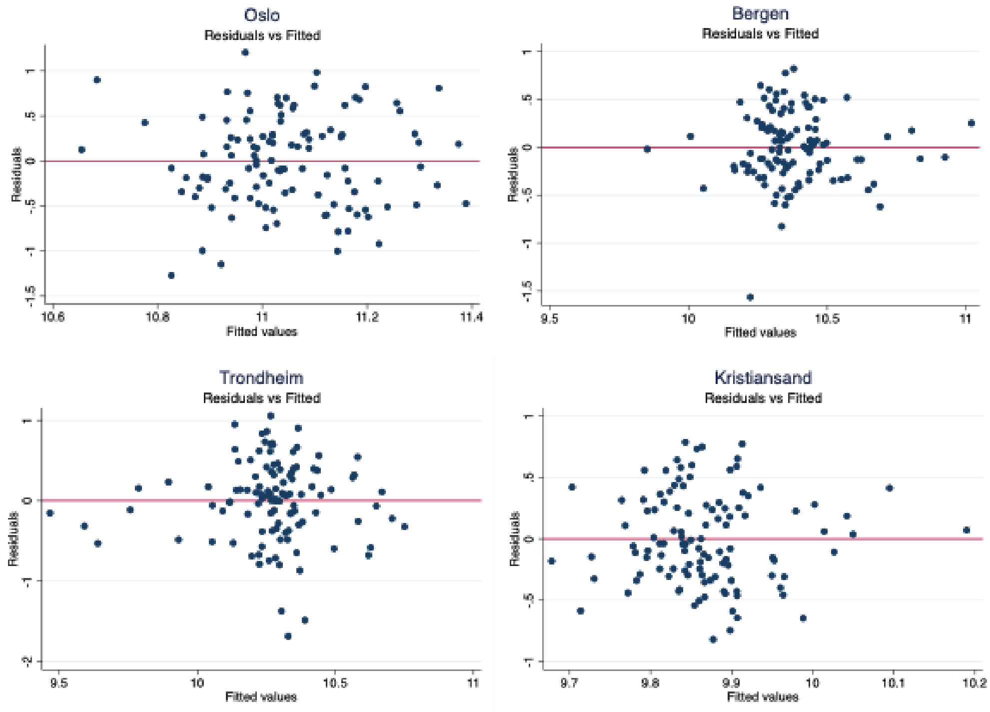
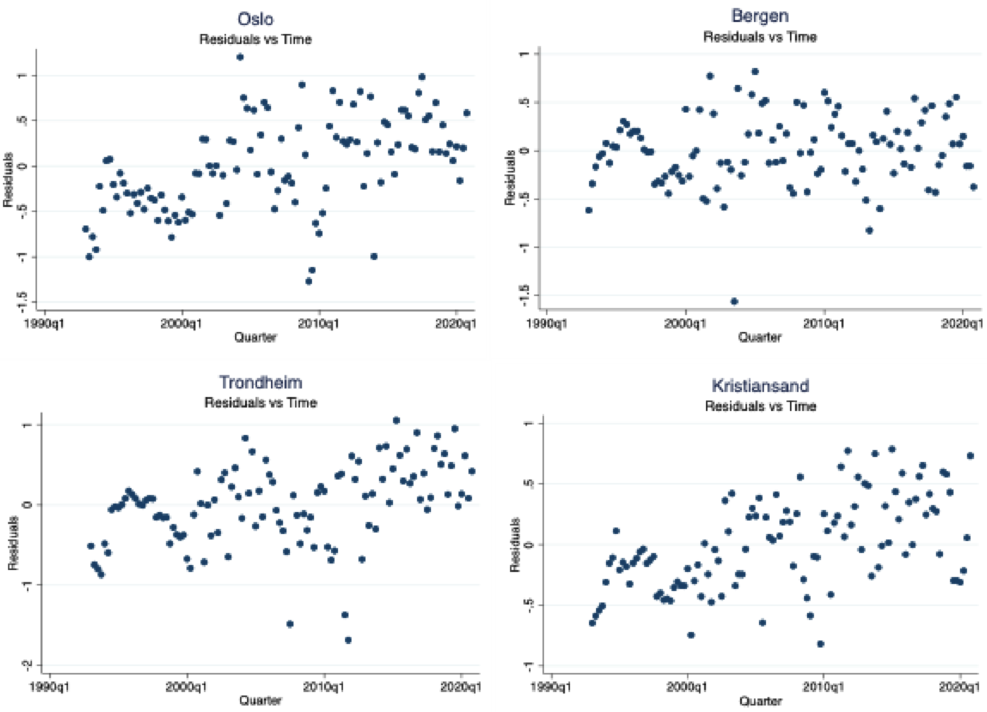


Figure 13: Residuals vs Time for Model 7.3



Assessment of Normality for Model 7.2 and 7.3

Histogram density plots and Q-Q normal plots of the residuals for model 7.2 and 7.3 are presented in Figure 14 and Figure 15. For model 7.2, we observe that the residuals in the histograms are evenly distributed around a mean of zero, but there seem to be some outliers for Oslo and Bergen and some skewness in the histograms. Trondheim and Kristiansand look well distributed and without any clear skewness. The normal Q-Q plots of the residuals also show some outliers for Oslo and Bergen, and we cannot conclude that the normality assumption holds for those cities. While Trondheim and Kristiansand's Q-Q plots look well distributed with few outliers. The residuals for model 7.3 look overall well distributed for all cities with few outliers, but some skewness for Oslo and Kristiansand.

To further examine whether the normality assumption is violated, the Shapiro-Wilk test and the Jarque-Bera test are performed. Results for the validity test are presented in Table 11 and Table 12. For model 7.2, we find that the null hypothesis of normality is rejected for Oslo and Bergen, while Trondheim and Kristiansand the null hypothesis is not rejected at the 5% significance level. If the normality assumption is violated, our coefficients can still be unbiased, but the standard errors are likely affected and are not accurate.

Figure 14: *Normal QQ and Residual Histograms for Model 7.2*

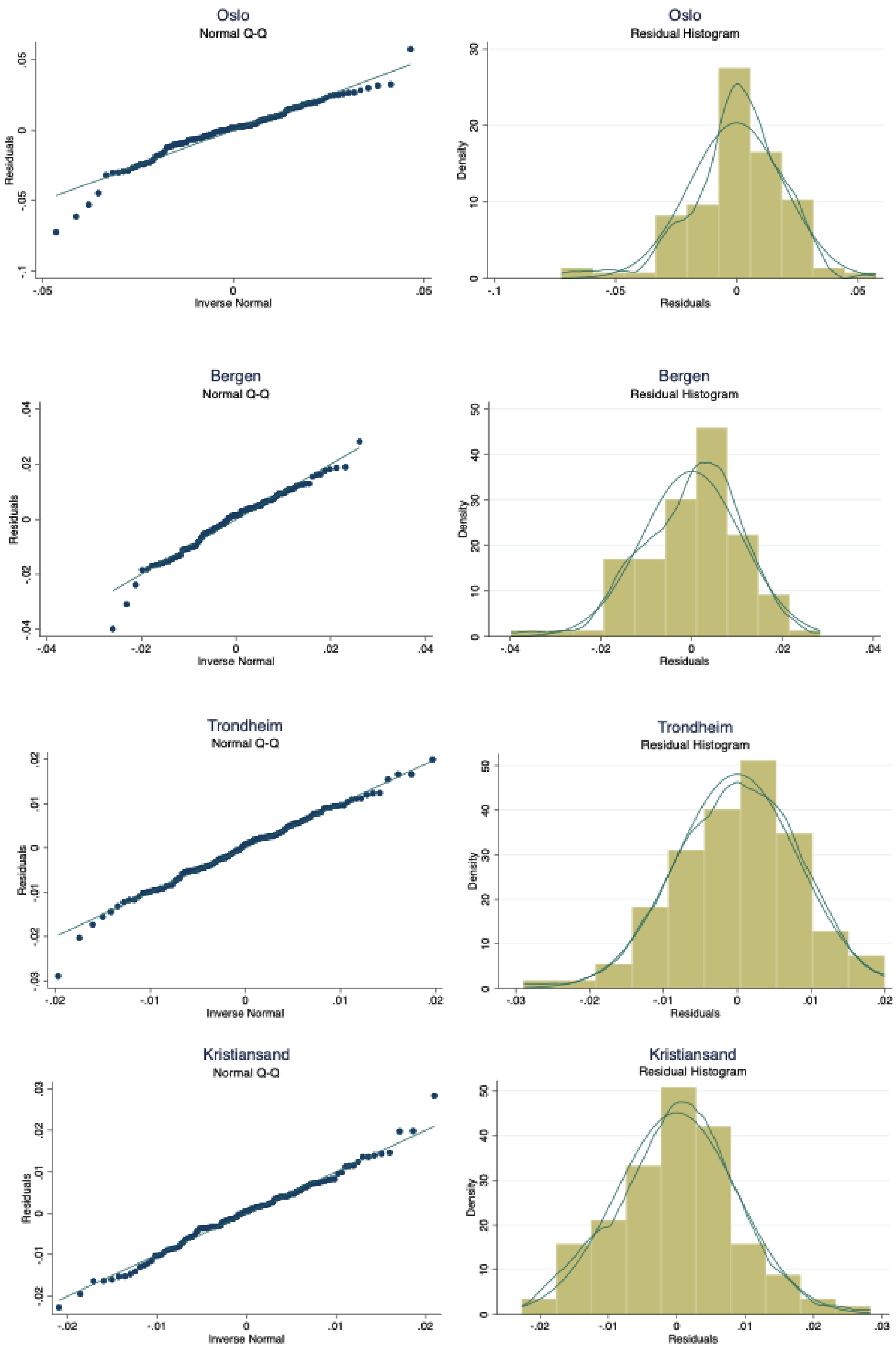
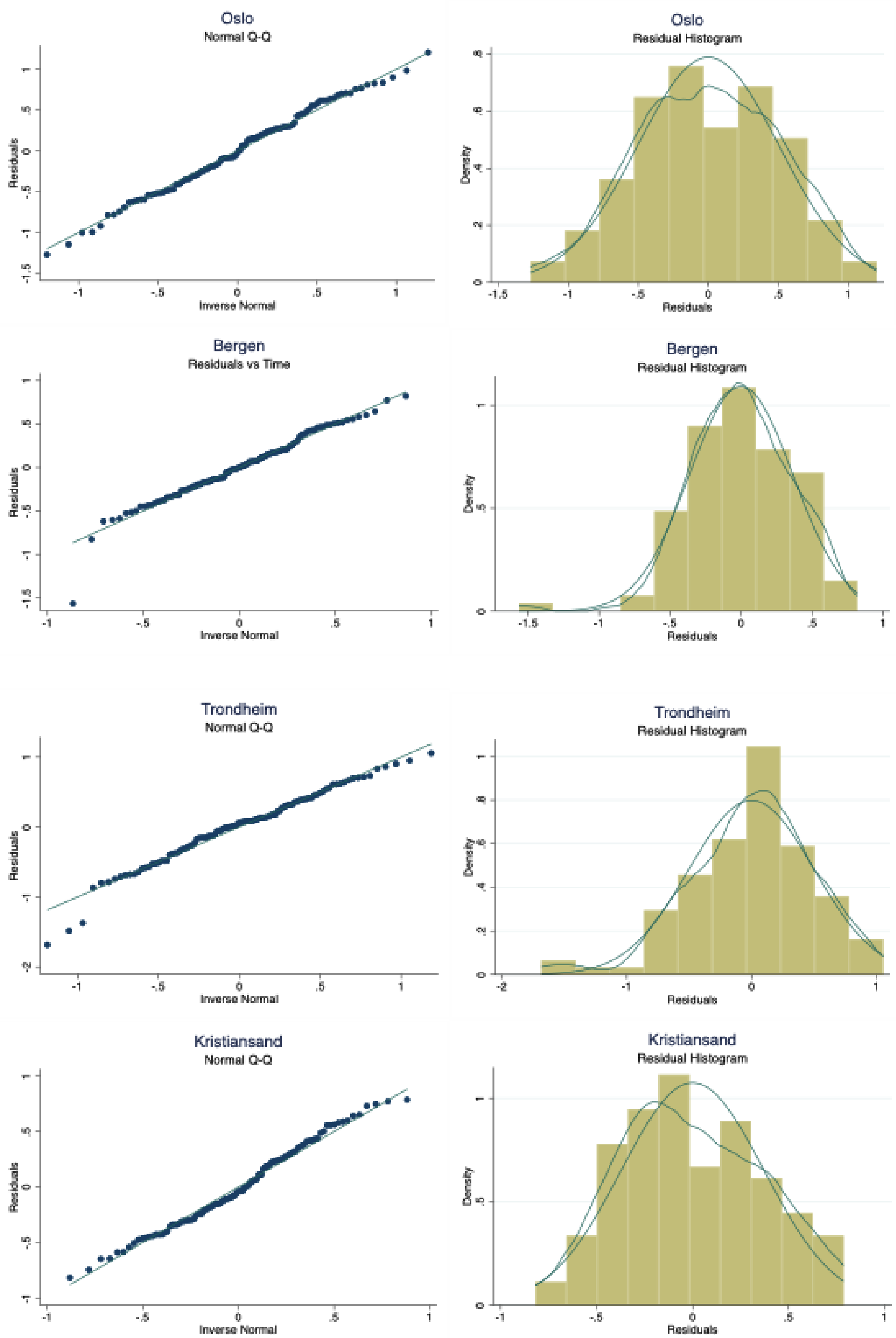


Figure 15: *Normal QQ and Residual Histograms for Model 7.3*



Assessment of Autocorrelation for Model 7.2 and 7.3

We create autocorrelation plots of the residuals to examine whether autocorrelation is present in the residuals. The autocorrelation function (ACF) is a visual way to examine autocorrelation in our time series. In Figure 16 and Figure 17, we present the ACF plots for model 7.2 and 7.3.

For model 7.2, we observe some significant autocorrelation for several of the first lags for all cities. Overall, the ACF plots with 95% confidence interval indicate some level of autocorrelation, and for Bergen, we observe that the mark is passed at around lag 20. This could be random and does not necessarily pose a problem, but we cannot conclude that there is no autocorrelation. Furthermore, we observe some patterns where there is a presence of autocorrelation in Bergen, Trondheim, and Kristiansand. However, Oslo shows no clear pattern.

We perform the Durbin-Watson test to examine if there is a presence of autocorrelation. Results are presented in the validity Tables 11-17. We do find presence of some autocorrelation and cannot conclude that the assumption of no autocorrelation holds. When autocorrelation is present, our standard errors can be underestimated, and thus the significance of our coefficients might not be accurate. In that case, we must be careful regarding inference of the results as we might conclude that a coefficient is significant even when it is not significant. Newey-west standard errors can reduce the problem.

Figure 16: *ACF plot Model 7.2*

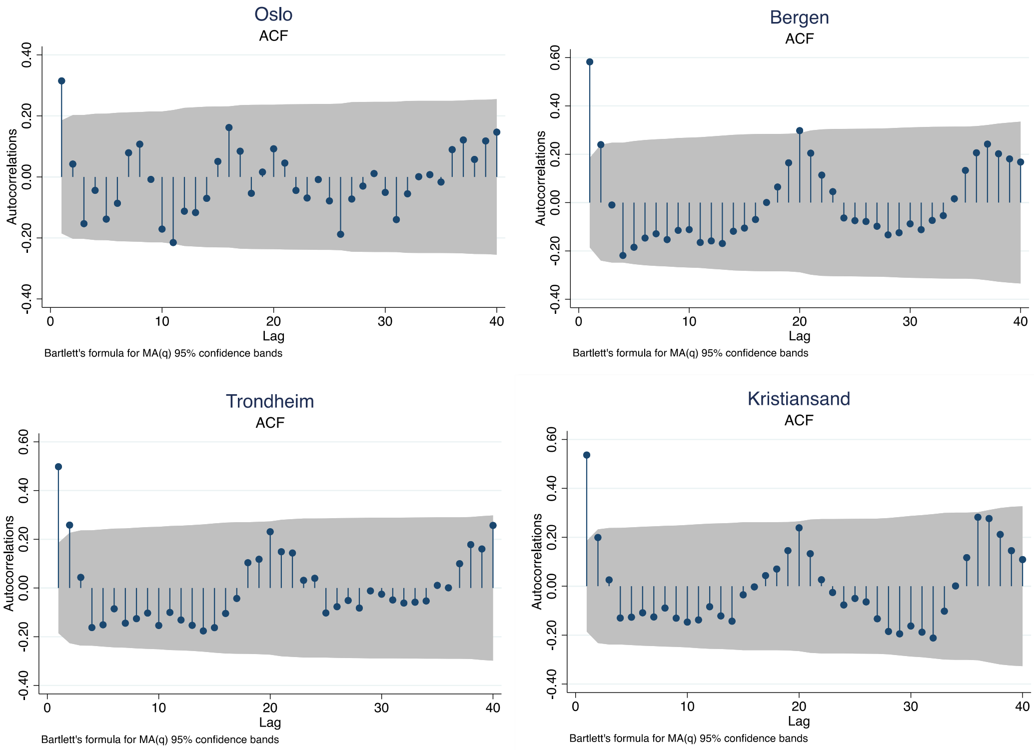


Figure 17: *ACF plot Model 7.3*

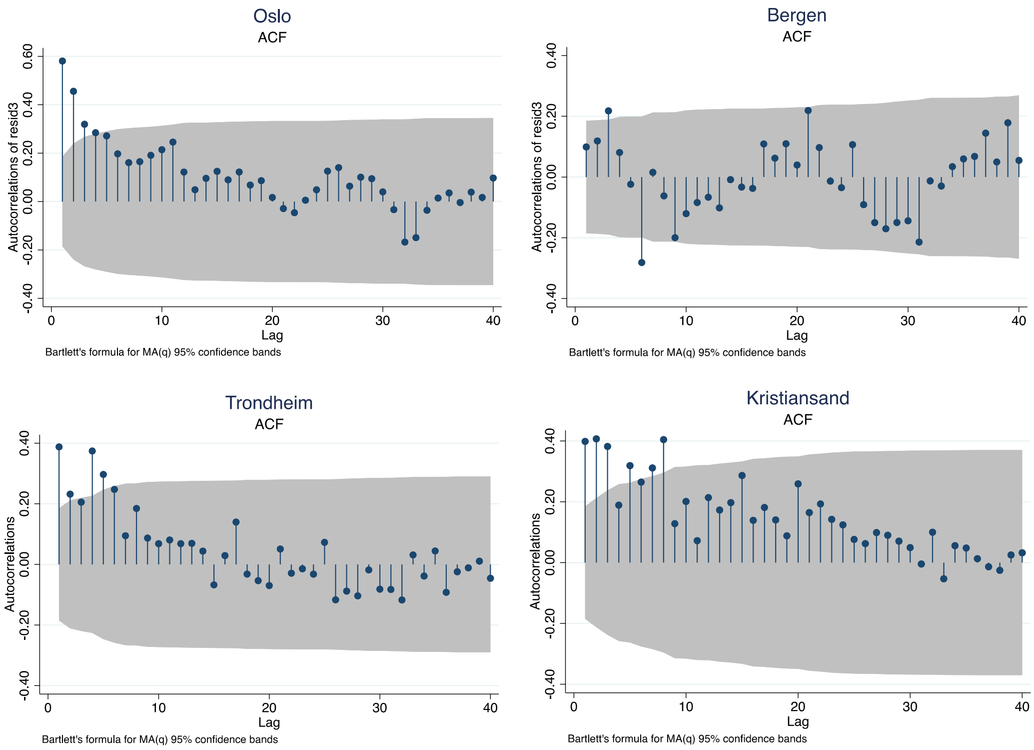


Table 11: *Model 7.2 Validity tests*

	Oslo	Bergen	Trondheim	Kristiansand
Homoscedasticity				
Breusch-Pagan	0,147	0,000	0,000	0,259
Serial correlation				
Durbin Watson	1,358	0,815	0,982	0,917
Normality				
Shapiro-Wilk	0,001	0,049	0,566	0,745
Jarque-Bera	0,000	0,007	0,177	0,711

Table 12: *Model 7.3 Validity tests*

	Oslo	Bergen	Trondheim	Kristiansand
Homoscedasticity				
Breuch-Pagan	0,187	0,805	0,919	0,998
Serial correlation				
Durbin Watson	0,809	1,166	1,209	1,141
Normality				
Shapiro-Wilk	0,533	0,013	0,036	0,154
Jarque-Bera	0,702	0,000	0,010	0,227

Table 13: *Model 7.1.1 Validity tests*

	Oslo	Bergen	Trondheim	Kristiansand
Homoscedasticity				
Breusch-Pagan	0,470	0,396	0,117	0,510
Serial correlation				
Durbin Watson	0,310	0,228	0,197	0,099
Normality				
Shapiro-Wilk	0,012	0,082	0,284	0,004
Jarque-Bera	0,026	0,049	0,101	0,673

Table 14: *Model 7.1.2 Validity tests*

	Oslo	Bergen	Trondheim	Kristiansand
Homoscedasticity				
Breusch-Pagan	0,230	0,058	0,358	0,024
Serial correlation				
Durbin Watson	0,287	0,271	0,249	0,102
Normality				
Shapiro-Wilk	0,005	0,000	0,000	0,025
Jarque-Bera	0,012	0,000	0,000	0,570

Table 15: *Model 7.1.3 Validity tests*

	Oslo	Bergen	Trondheim	Kristiansand
Homoscedasticity				
Breusch-Pagan	0,013	0,140	0,053	0,589
Serial correlation				
Durbin Watson	0,317	0,430	0,320	0,098
Normality				
Shapiro-Wilk	0,005	0,000	0,000	0,006
Jarque-Bera	0,095	0,000	0,004	0,677

Table 16: *Model 7.1.4 Validity tests*

	Oslo	Bergen	Trondheim	Kristiansand
Homoscedasticity				
Breusch-Pagan	0,115	0,000	0,001	0,328
Serial correlation				
Durbin Watson	0,283	0,157	0,141	0,124
Normality				
Shapiro-Wilk	0,007	0,000	0,000	0,325
Jarque-Bera	0,020	0,000	0,000	0,887

Table 17: *Model 7.1.5 Validity tests*

	Oslo	Bergen	Trondheim	Kristiansand
Homoscedasticity				
Breusch-Pagan	0,609	0,341	0,472	0,937
Serial correlation				
Durbin Watson	0,287	0,173	0,157	0,113
Normality				
Shapiro-Wilk	0,005	0,000	0,000	0,089
Jarque-Bera	0,018	0,000	0,000	0,958

Figure 18: *Residuals vs Fitted values and Time for Model 7.1.1*

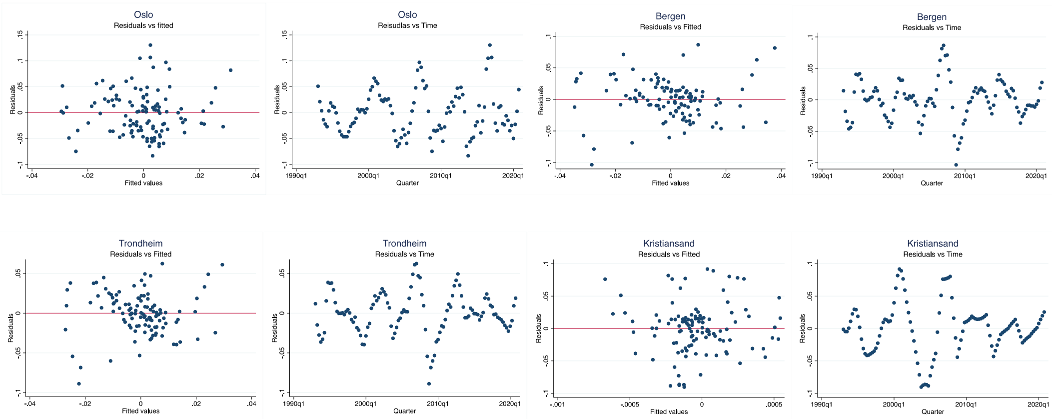


Figure 19: *Residuals vs Fitted values and Time for Model 7.1.2*

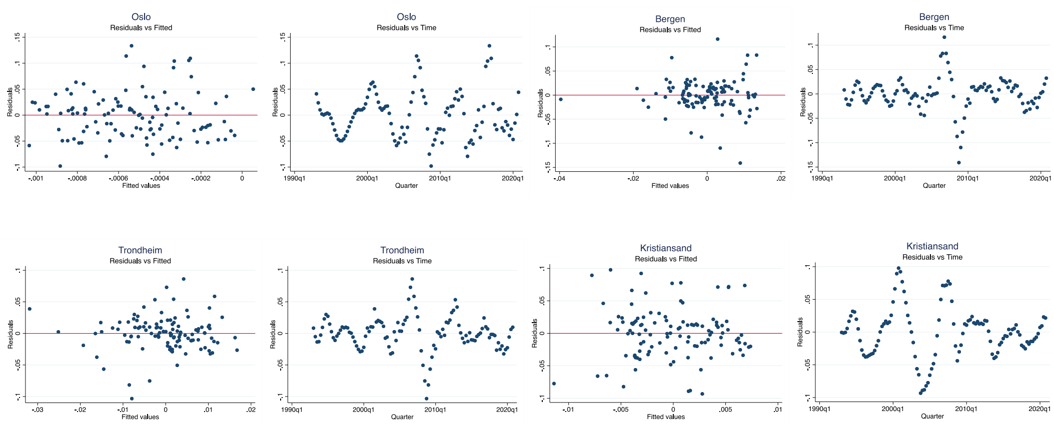


Figure 20: *Residuals vs Fitted values and Time for Model 7.1.3*

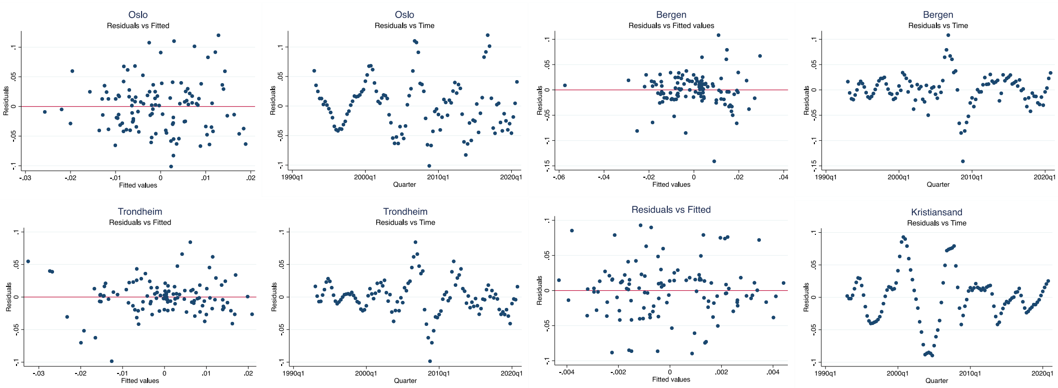


Figure 21: *Residuals vs Fitted values and Time for Model 7.1.4*

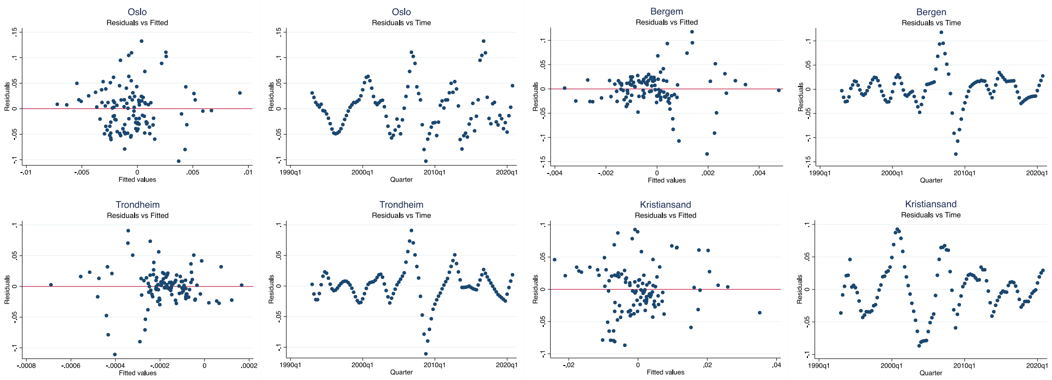


Figure 22: *Residuals vs Fitted values and Time for Model 7.1.5*

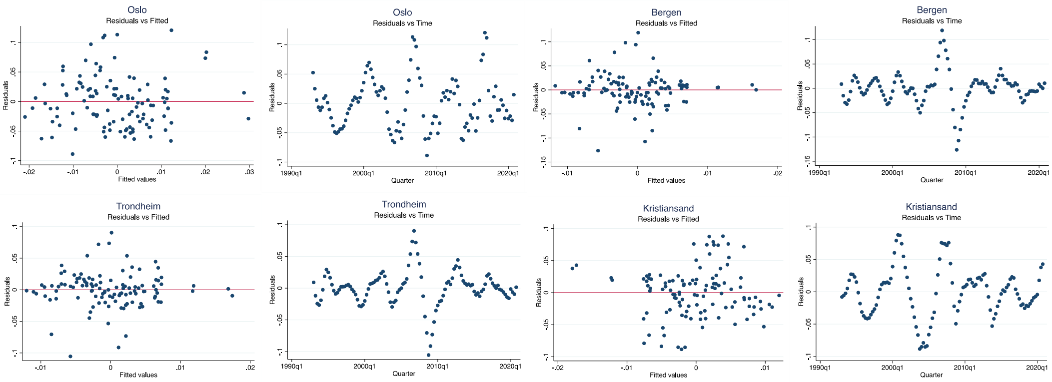


Figure 23: *Normal QQ and Residual Histograms for Model 7.1.1*

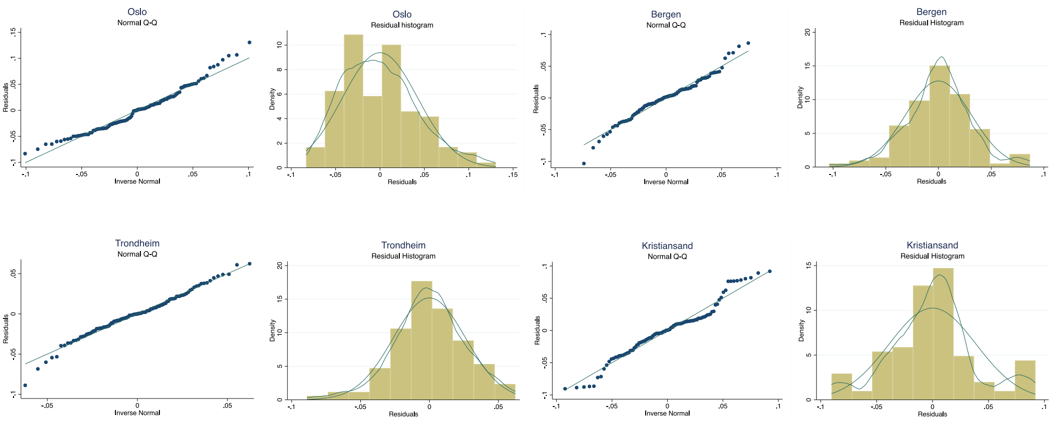


Figure 24: *Normal QQ and Residual Histograms for Model 7.1.2*

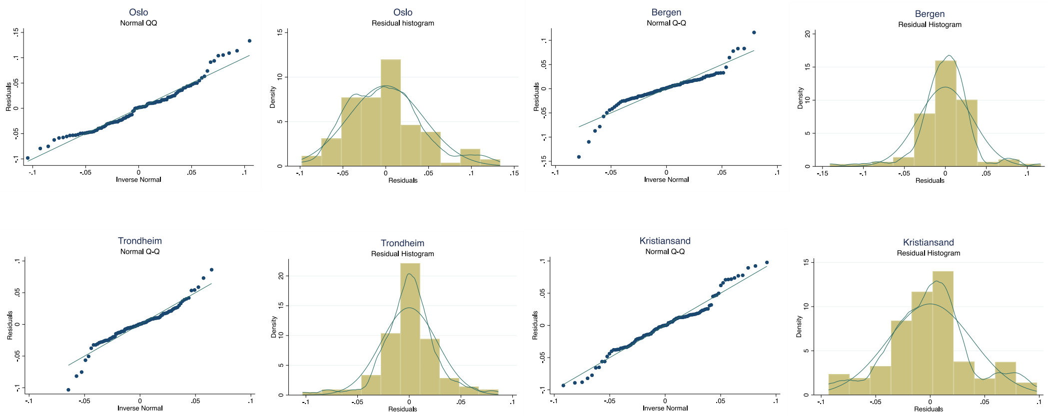


Figure 25: *Normal QQ and Residual Histograms for Model 7.1.3*

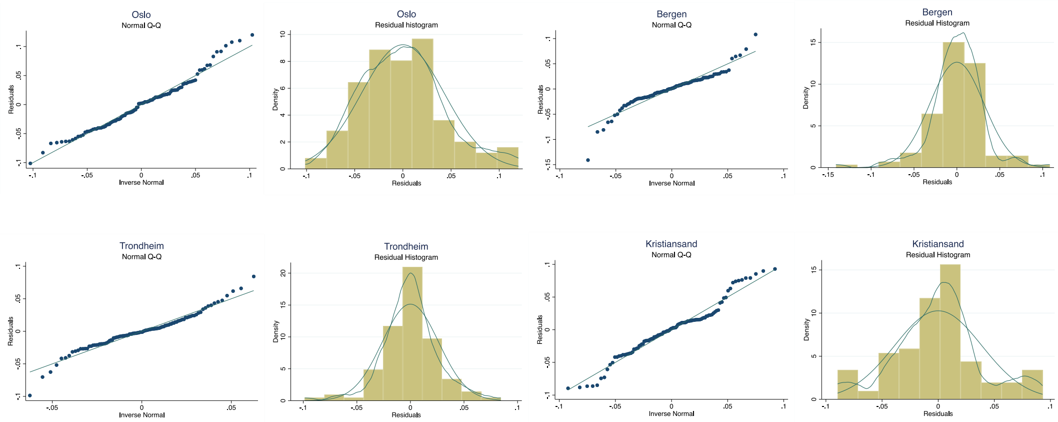


Figure 26: *Normal QQ and Residual Histograms for Model 7.1.4*

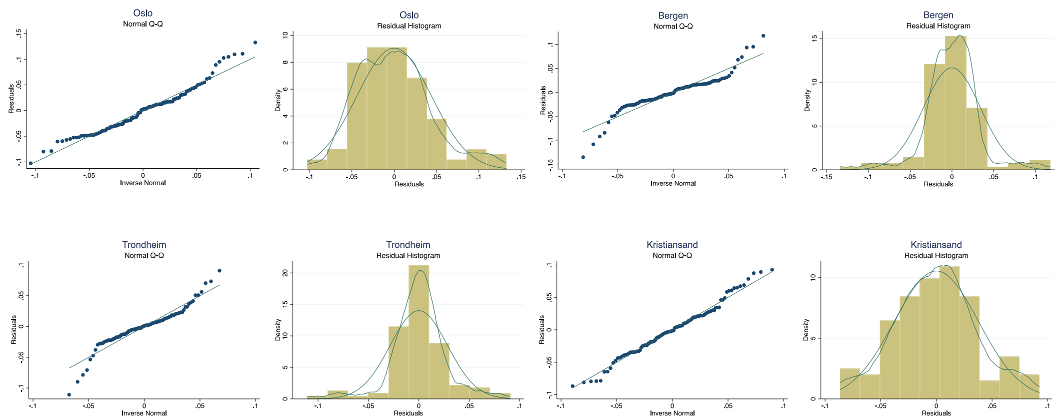


Figure 27: *Normal QQ and Residual Histograms for Model 7.1.5*

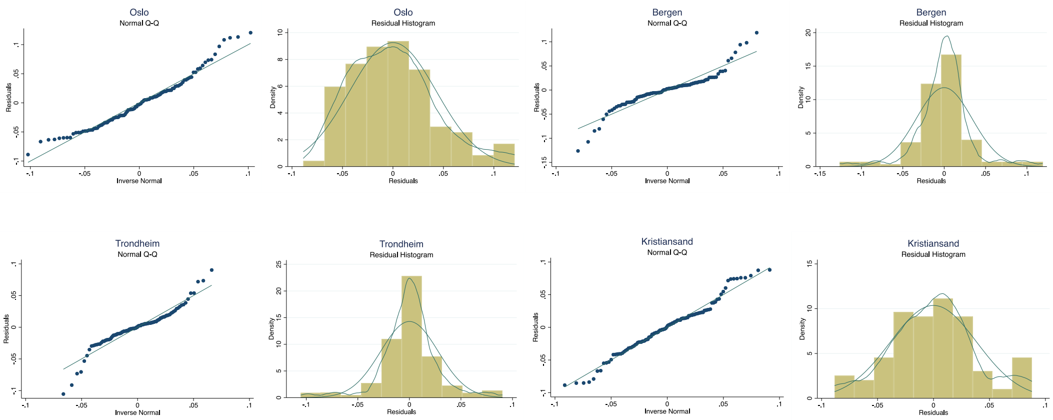


Figure 28: *ACF plot Model 7.1.1*

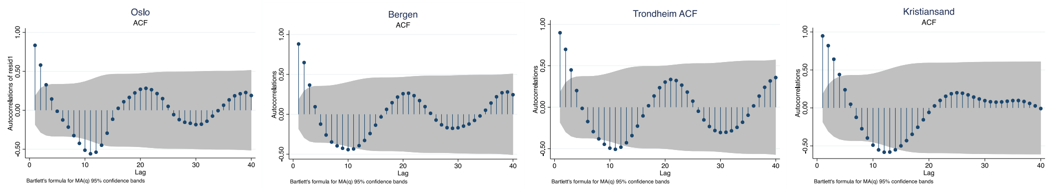


Figure 29: *ACF plot Model 7.1.2*

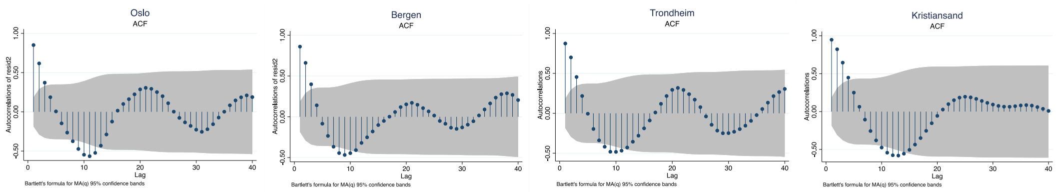


Figure 30: *ACF plot Model 7.1.3*

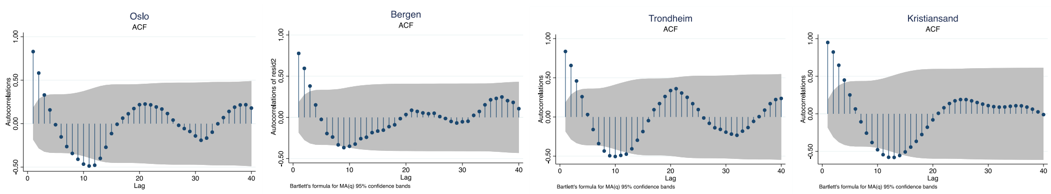


Figure 31: *ACF plot Model 7.1.4*

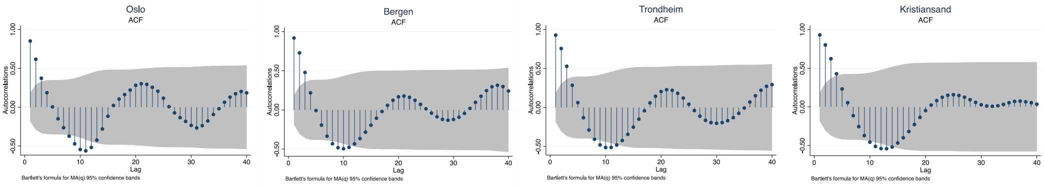


Figure 32: *ACF plot Model 7.1.5*

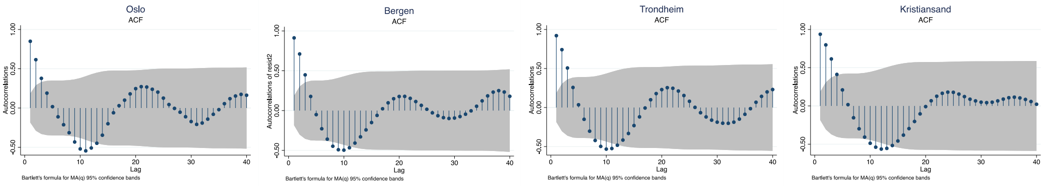


Table 18: *Augmented Dickey-Fuller Test Results*

ADF - Tests	**No Trend**			**With Trend**		
Variable	lag (k)	Critical Value (5%)	T-statistics	lag (k)	Critical Value (5%)	T-statistics
Price Index Oslo	4	-2,889	1,607	4	-3,449	-1,154
Price Index Bergen	4	-2,889	0,091	4	-3,449	-2,918
Price Index Trondheim	4	-2,889	0,385	4	-3,449	-2,794
Price Index Kristiansand	4	-2,889	-0,841	4	-3,449	-1,610
Construction Cost Index	4	-2,889	1,099	4	-3,449	-1,916
Capital Access	4	-2,889	1,355	4	-3,449	-1,942
Interest Rate	3	-2,889	-0,825	3	-3,449	-3,669
Initiations Oslo	2	-2,889	-3,532	2	-3,449	-4,314
Initiations Bergen	3	-2,889	-3,423	3	-3,449	-3,351
Initiations Trondheim	4	-2,889	-2,373	4	-3,449	-2,667
Initiations Kristiansand	4	-2,889	-2,787	4	-3,449	-4,165
Completions Oslo	4	-2,889	-2,553	4	-3,449	-4,215
Completions Bergen	4	-2,889	-3,425	4	-3,449	-3,380
Completions Trondheim	4	-2,889	-2,384	4	-3,449	-2,758
Completions Kristiansand	3	-2,889	-2,400	3	-3,449	-4,074