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Commercial Real Estate in Norway: Determinants of Rental Prices

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Summary

In this master's thesis, we present a study with logistic regression. We want to find out which macroeconomic variables that affect the rental price growth on commercial real estate in Norway. Through a literature review and a theory part, we arrive at the relevant variables that we believe can influence the rental prices. The variables we end up using are GDP, policy rate, unemployment rate, building costs, inflation, and squaremeters total floor space within commercial real estate.

Through the analysis- and results section, we process the data so we could create a regression model that is valid and reliable. This allows us to draw valid statistical conclusions in the study.

The result is a model where we use differenced variables in the form of time series regression. In our preferred model, we use the policy rate, building costs, square meter total mass and inflation as independent variables. In the study, we find that the policy rate is statistically significant at the 10% level, while square meter total mass and inflation are statistically significant at the 5% level. Therefore, this is the variables that we validly and reliably can say have influenced the rental prices for commercial real estate in the period from January 2012 to December 2019 in Norway. At the same time, we have some assumptions that may affect our results.

Preface

In this assignment we are going to look at the rental prices for commercial real estate in Norway and the different factors surrounding it. We chose this subject because we thought the real estate market was not only highly relevant, but also very interesting. We also found out that the residential real estate market had been written about and researched to a much greater extent than the commercial market. This made us more curious about the market for commercial real estate and we decided to focus exclusively on that instead of the whole real estate market.

The process has been challenging at times, but also interesting and stimulating, when comes to collecting data, looking at prior research and relevant theoretical concepts. We think it has been a very useful experience on working with a subject where there is a little bit lesser previous assignments written. We want to thank our advisor Tapas Kundu for help with the assignment, finding source material that was useful to us and for giving us encouragement during our writing process. We would also like to thank Statistics Norway for the amount of data and statistics that was critical to our assignment, and last to Erik Smith Meyer for giving us some very helpful guidance on the tests and data analysis in Stata.

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1. Introduction

The real estate market is one of the most dynamic markets that we have in society and there is always a high interest and curiosity around it, regarding the changes and developments that occur within it. No matter what activities we are participating in or what we choose to do with our time we always need a place to do it. This goes for both working and spare time activities. That's why the market for real estate is, always have been and probably always will be such a fundamental part of the economy as a whole. In a way you can look at it as the market for space.

We mainly separate the market for properties into two parts. The housing market which includes houses, apartments, condos, and cabins etc. and the market for commercial real estate. This market is about the types of property that is used mostly for work related, income generating activities. It includes a wide variety of categories such as offices, retail stores, industrial complexes, warehouses, and shopping malls (Esajian, u.å). The demand for the two categories of property is in many ways similar but also differ to a certain degree. On one hand, as people will always need a place to live, there will always be a strong demand for housing, which will increase as the population grows. People move to more populous places, or people generally earn more money and have more purchasing power. However, the market for commercial real estate can be a little bit different based on the fact that the labor market is in a transition of change where more jobs can be done from home. Some developments make certain jobs require less space and of course automatization and technological advancement even makes some types of jobs obsolete and replaceable. This can easily result in the growth in prices being more varying and less linear compared to the housing prices and this might be the biggest difference between these two. However, even though there are a slight difference in the development of prices in the two categories, we will still see that there has been a significant increase in the prices for both of them the last years. A price increase that has been significantly higher compared to normal inflation (Statistics Norway, u.å.).

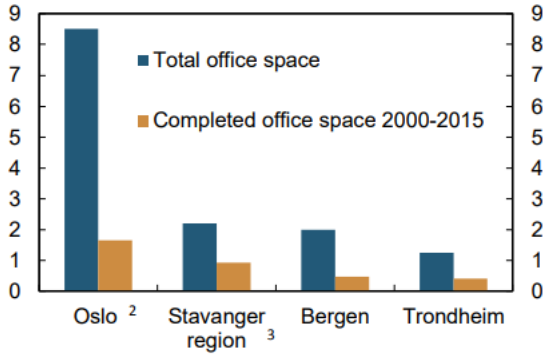
Since regional factors often play a significant role in the supply and demand development of commercial real estate, we have chosen to focus solely on the market in Norway for a 10-year period. While both markets have had an increase in average prices over the years, we can see that there are still differences in the sense that the increase have been a bit lesser in the commercial real estate market, compared to the housing market. We would like to look more closely at the specific factors that influence the prices of commercial real estate in Norway, their level of impact, and which factors are more unique to the commercial real estate market than those that influence prices in the housing market. To further understand this, we want to employ a number of data sources, previously published research articles, and statistical tests to identify some of the various factors influencing market pricing and the extent to which they are doing so.

2. The market for commercial real estate in Norway

Commercial real estate is basically all forms of real estate except private homes, cabins and vacation properties. Most commercial real estate in Norway is found within the four biggest cities Oslo, Bergen, Trondheim and Stavanger. The capital, Oslo, is by far the city with the most constructed office space (Hagen, 2016). The numbers show that Oslo has more constructed office space than the three other largest cities Bergen, Trondheim, and Stavanger together. Despite being the smallest of the 4 cities, Stavanger has the second largest amount of office space. In the period from 2000 - 2015, they had almost as much new construction of office spaces as Oslo. This is probably because Stavanger is a city with a big industry, particularly within the oil and gas sector (Hagen, 2016).
However, the statistics shows that while office space is mainly concentrated within the bigger cities and particularly in Oslo, other forms of commercial real estate such as industrial buildings, public buildings etc. is mostly located in other parts of the country.

Figure 2.1. Office space both total and completed 2000 - 2015. (Hagen, 2016).

Chart 2.
Total[1] and office building completions 2000 – 2015 in the largest Norwegian cities. In millions of square metres.

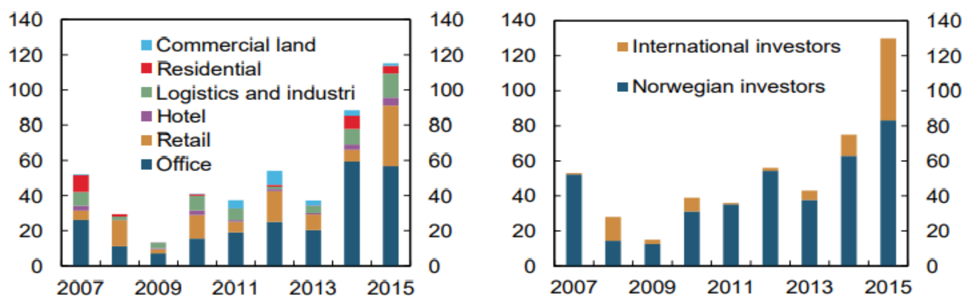


We can also use data on transactions of different commercial real estate in Norway to get a look at the different proportions at this time. When we look at the total transaction volume of different categories of commercial buildings in Norway, we can see that most of the volume is in the form of office space. Office space in total represents about half of the total transactions on average within commercial real estate for the last few years. The second largest category in the same period is retail while the third largest is the category for industry and logistics.

Figure 2.2. Different transactions of commercial real estate by category and investors (Hagen, 2016).

Chart 3.
Transaction volume in CRE market.[1, 2] Annual figures. In billions of NOK. 2007 – 2015.

a) By type of commercial property b) By investor, Norwegian/ international

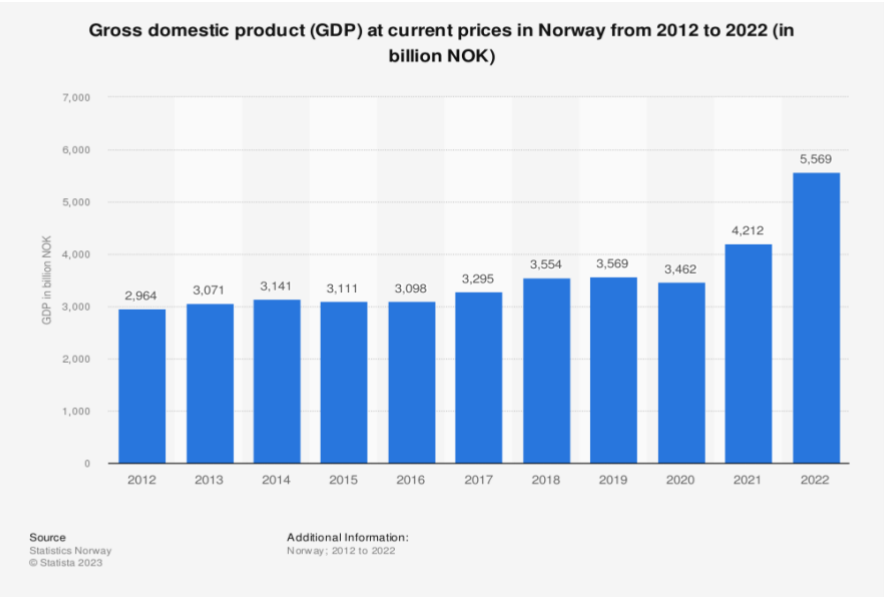


3. Theory

3.1 GDP

GDP or gross domestic product can be described as the total monetary sum of goods and services produced within a country during a specific period (Britannica Kids, u.å). The period is often set to a year and GDP is therefore often used on an annual basis. GDP will give us some indication of the country’s current economic situation and is a useful tool in comparing the economy to earlier time periods. Among the variables considered to calculate GDP are public consumption, private consumption, investments, construction payments and balance of trade (exports minus imports). GDP can possibly affect the rental prices of commercial property in several different ways. GDP often works as an indicator of the country's economic situation as a whole and comparing it to earlier years will often give us a picture of whether the economy is in a growing/expanding or shrinking/contracting face. When the GDP is higher than in prior years, it may be a sign that the economy is expanding. This usually means an increase in transactions and investments, overall higher economic activity, and returns. When the economic activity is higher in general, that will often result in a higher demand for office and other commercial spaces. The increase in demand will allow the suppliers to increase the rental prices.

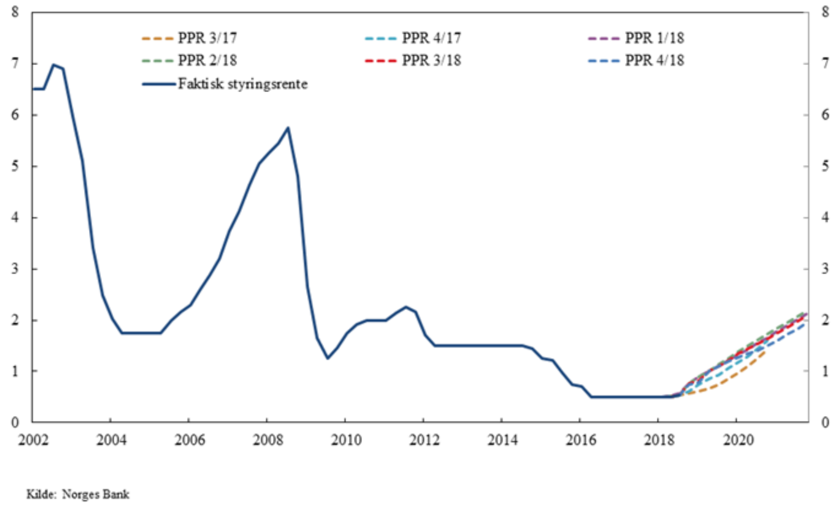
Figure 3.1. GDP for Norway 2012-22 (Statista, 2023).



3.2 Interest rates

Interest rates and especially the bank rate probably has significant effect on the prices of commercial real estate. When the interest rates increase, it means that it will be more profitable for people and businesses to save their money and get a higher return on it (Ross, u.å.). On the other hand, when the interest rates fall, people are incentivized to spend more of their money and invest it different ways. A high level of interest rates will therefore most likely make businesses having less money available to spend on office and workplaces in general and therefore could lower the demand for commercial properties over a period. Businesses will be more motivated to spend and invest their money when rents are cheaper as opposed to saving it. It will also be more favorable to borrow money and that can have a significant effect on the demand for commercial spaces, especially in the cases where businesses are using borrowed funds to finance their rental expenses.

Figure 3.2. Norwegian policy rate 2002 - 2020 (Erlandsen & Langbraaten, 2018).

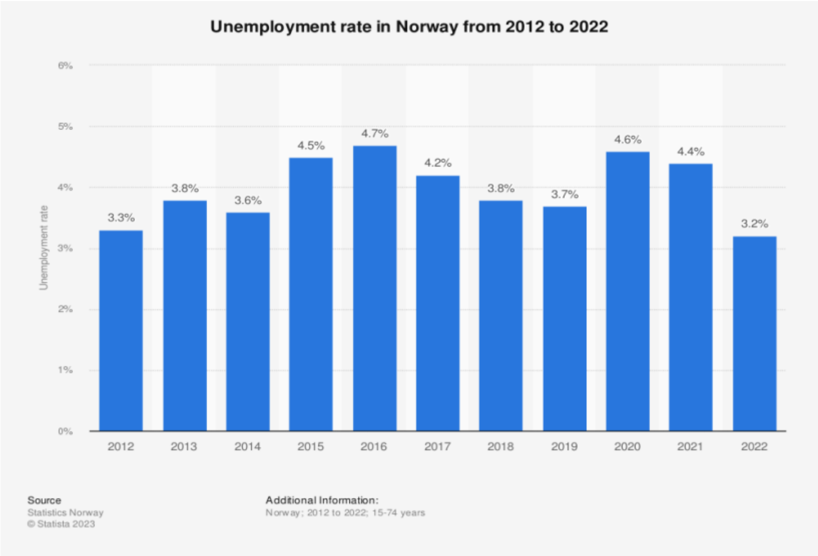


3.3 Unemployment level

Unemployment rates are usually published each month and shows the part of the population that is currently out of work. The unemployment rate only considers the part of the population that is able to work, but who are currently unemployed. Therefore, people who are officially out of the workforce are not included in the statistic. Unemployment rates can affect the demand and supply for workspace in different ways.

When a larger part of the population is employed, there will frequently be a greater need for workspace, which might increase demand. This can cause the providers to raise their renting rates once more. On the other side, when unemployment is high, there may be less of a market for commercial real estate, which might lead to a decline in rental prices. A lower unemployment rate may be linked to a higher wage level due to the inverted connection between unemployment rates and wage levels. This is brought on by the decline in the labor pool.

Figure 3.3. Norwegian unemployment rate 2012 - 2022 (Statista, 2023).



3.4 Building costs

Building costs is another variable that can have a significant effect on the commercial real estate market on both the supply and demand side.

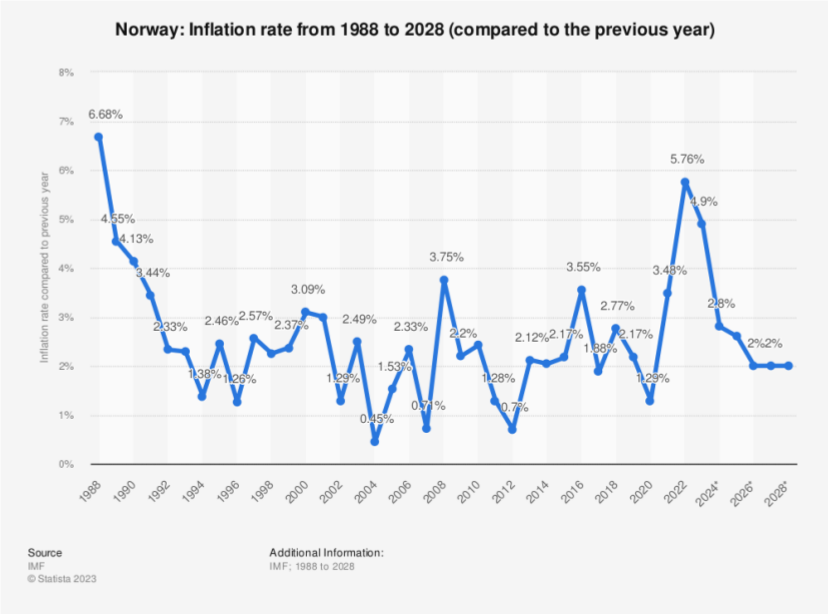
When we are talking about building costs in general, there are different parts that make up the total costs. We have the costs of the materials used and the costs of the workers who perform the work. These can be referred to as the labor and material costs. We also have the costs of creating and designing the buildings both interior and exterior. These are the architect and engineering costs. And then there is the costs referred to the buying and selling of the property. There are a lot of different people involved in this process. This could be management, salespeople, brokers, marketing etc. These costs are sometimes referred to as overhead costs and they are defined as the costs that are not directly connected to the building or construction process (Hayes, 2023).

When construction costs increase, it means that less new properties will be built because its more expensive and hence it will create a negative effect on the supply side. In turn, this can result in a situation where the shift drives up the rental rates. Additionally, it is possible that rates would rise to make it profitable for the providers to rent out this real estate. When it becomes more expensive to build, the easiest way to improve the results for the owners will be to increase the rental prices.

3.5 Inflation

Inflation is the general increase in prices for goods and services over a period. Inflation is also the decrease of purchasing power which is the value of money measured in the amount of goods and services the amount can buy.
Inflation is measured in the so-called Consumer Price Index (CPI) which is a weighted average of the prices that consumers pay for a basket of goods (Statistics Norway, 2023). The change in prices over time through the CPI is on a percentage basis. When inflation is high and the general costs of all goods and services are at a high level it can potentially lead to a decrease in demand for commercial properties. This is because the firms and individuals looking to acquire commercial real estate will have experienced a decrease in their purchasing power. This happens regardless of whether they have had an increase or decrease in revenue and profits. The money that they have made have lost some of its value and therefore there will be less to spend on commercial real estate. When we look at the connection between inflation and what we want to observe the effect of it on, it’s important that we use adjusted inflation to see if the prices have increased or decreased. Based on that observation we will have an opportunity to observe the effects of inflation in general. The question is whether rental costs rise faster or slower than the average level of prices in society.

Figure 3.4. Inflation rate in Norway 1988 - 2028 (O'Neill, 2023).



4. Literature Review

In this part we will go deeper into theories and earlier research within this area. As mentioned, commercial real estate is largely based on how the people who owns the venue, rents it out, and approximately, a stock-based company always rents out to other stock-based companies. This signifies that the income for the property owner only consists of the income they receive from the property. Additionally, they might calculate any added value on the property as profit, since this has been a reason for the bigger wins within commercial real estate the last decade. We will through this literature review find the variables that have the most extensive influence on the renting prices in the commercial real estate market in Norway by going through earlier research on the field. It exists very little research on what influences the renting prices on commercial property in Norway, even though the banks, financial newspapers and such do have some articles on the theme, it is still only speculations and just a few specific research. Therefore, we will concentrate on the small amount of research that is already out there from abroad.

Foo Ng & Higgins (2015) made an article with the purpose of making the best rental price determination model as possible, which would apply for office commercial real

estate in central parts of Singapore. Thus, they had to find out which variables that affected the rental price the most, thereafter make a model based on that. Based on earlier research, they wished to utilize GDP, unemployment rate, squaremeters total mass, building costs, vacancy rate and lending rate.
They think that the two first variables represent the demand in the market, and the four last ones, except lending rate, represents the supply in the market. They utilized these variables based on what countries around the world had gathered from earlier research that influenced the office renting prices. Arguments through earlier research says that BNP should join as a variable because the financial activity will influence the renting market heavily, simultaneously as to when the economy is strengthened, the trust within the economy will grow and that will cause an increase in offers and demand. Relative to unemployment rate, its argued that with the findings they have collected, have found out that the variable is reverse when related to rent. This means that the higher unemployment rate, the lower the rent is. They also mention employment figures, however this will be the opposite of the unemployment rate and therefore be expected to have the opposite effect. There is not a lot of arguments for the other variables, other than they have been used and found statistically significant in earlier research.

In their own analysis, they utilized tests to reassure that the data set gives the most reliable answer as possible, and that the data is proper, and to see if they were statistically significant. They used, among other things, Augmented dickey-fuller test, VI test and a breakpoint test. After the variables were checked with every criterion, they were left with vacancy rate, building costs, unemployment rate in the financial sector, unemployment in the insurance sector and real estate, and the lending rate. These four variables were data that could be utilized, and they were also within the requirements for the tests that were done and became statistically significant. They got R2 on 0.72, that is a degree of explanation on 72%, which tells us that the variables they chose to use, explains a high proportion of the variation to the renting prices on office properties in central parts of Singapore. However, they found out that GDP were not statistically significant, and therefore omitted this from their model. If we assume that this is transferable to our analyses of commercial real estate in Norway, then the variables that has been used here, can be an essential share of those variables that we should use in our model.

Chin (2023) studied macroeconomic variables which influenced the renting prices on office real estate in cities in Southeast-Asia, respectively Singapore, Hong Kong, Taipei, Kuala Lumpur and Bangkok from 1988 to 2001. He was supposed to study the variables for inflation-adjusted GDP, rents, lending interest, consumer price index, service production, unemployment, and changes in volume of office areas. In his analysis, he found that changes in volume in office areas and the bank´s lending interest rates was the two variables that had the highest effects on the rental prices in these cities, except Bangkok, which was not found statistically significant with these variables. He could not either find that the GDP adjusted for inflation, the policy rate, consumer price index, service production and unemployment was statistically significant variables in any of the cities. Chin had indeed some weaknesses in his analysis, amongst them that he could not get the data with a lot of the variables he saw was current, and he had to modify some of the data by adjusting them from monthly data to semi-annually data.

In the two articles mentioned, no one seems to find that employment rate or unemployment rate have any statistically significance. Bjørland and Hagen (2019) published in 2019 an article from the bank of Norway, where they made error correction models to find the main factors for the renting prices with data from the office property in Oslo and found that unemployment was one of the most important and statistically significant variables in their analysis. They also found that the total stock of office area was statistically significant and an important explanatory variable as to what could influence the renting prices on office real estate in Oslo.

The existing literature consist of variables that influences the renting prices on commercial real estate in different ways. A big share of the variables that is being studies are local variables, for example the properties' location and if the property is old or new. We do not study these variables, because we put a spotlight on macroeconomic variables that will influence the rental market, such as unemployment or GDP. Fuerst (2007) found in his studies about renting prices on Manhattan that the higher vacancy rates the buildings have, the lower the renting prices will be. This tells us that the vacancy rate correlates negatively with the prices, as expected. He found a clear connection, but it was not significant on every level in the analysis from Fuerst. We cannot use the data on vacancy rate for the commercial real estate in Norway in this assignment, however, we can assume that a high vacancy rate within commercial real estate, which is a lot of empty premises, correlates with a lower degree of unemployment in the society.

5. Hypotheses

When we look at unemployment as a factor there are some strong arguments for it to be included as a variable in our analysis. Not only can the unemployment rate be a healthy indicator for the economy as a whole, but it is also logic to assume that more people working, there will be a greater demand for workspace. Combined this with the fact that Foo Ng and Higgins found support for this variable to be significant in their study, we believe that the unemployment rate is statistically significant.

The same people also found statistically significancy for the variable interest rate. Based on this and the fact that there are good arguments for the interest rates having an effect, we believe that the policy rate level is statistically significant.

Also, since a higher unemployment rate means more people unemployed, it can therefore be a negative effect on the demand for working spaces. Therefore, we believe that unemployment rate has a negative effect on the rental prices.

Even though there are some strong arguments for GDP having a significant effect on the rental prices from a theoretical standpoint, others who have tested it before us, like Foo and Higgins, did not find any support for it. Therefore, we believe that GDP is not statistically significant.

Because inflation influences the purchasing power of both individuals and businesses, and therefore can be directly linked to the increase in rental prices, we believe that the inflation is statistically significant.

The total area of commercial real estate space is another factor that can affect the price index in different ways. We know that when there is a shortage of space, prices can be pushed upwards due to high demand. In opposite, when there are a lot of available space, the price will probably be pushed upward. But, when the total commercial real estate market builds a lot, we can also think that the demand is high, and therefore higher building rate will lead to higher prices. Because of this, it is hard for us to say which way we think the variable will affect the price index. But since it can have an effect in different ways, and that both Chin (2003) and Bjørland & Hagen (2019) found significancy in their studies, we believe that the amount of commercial real estate space is statistically significant.

When it comes to building costs, it is possible that it can influence the supplier side because of the higher cost that it will need to be compensated for. However, it is not certain that it will have any effect on the demand side of the equation because businesses that need office space doesn't really care about how much it cost to build the office spaces. Neither Chin (2003) nor Bjørland & Hagen (2019) had building costs included in their analysis, and from this background we don't believe that building costs is statistically significant.

Therefore, our hypotheses are:

H_1: Policy Rate is a statistically significant variable that affect the Rental Price index.

H_2: Inflation is a statistically significant variable that affect the Rental Price index.

H_3: Commercial Real Estate space is a statistically significant variable that affect the Rental Price index.

6. Data

From the literature review and the theory part, we have found and discussed a lot of interesting variables that can affect the rental prices over time on commercial real estate in Norway. Our data will start January 2012 and ending in December 2019. Our data will contain of rental price index of commercial real estate as the dependent variable, and the policy rate, building costs index, unemployment rate, total mass of Squaremeters, Gross Domestic Product (GDP), and inflation as independent variables. The final dataset will contain of monthly data with a total of 96 observations for each variable. All our data will be with a macroeconomic direction on national level, and it will not include anything that is affected by local conditions. We have chosen to use this data after an overall assessment from the literature review and the theory part. There were also some other variables that we could have included, but we were not able to find the data on it.

Table 6.1 The summarize of the dataset:

Variable	Obs	Mean	Std. dev.	Min	Max
priceindex	96	116.8515	6.050284	105.9	124.9
policyrate	96	1.044271	.4472059	.5	1.75
buildingco~s	96	101.7437	6.282068	91.4	112.6
unemployme~e	96	4.130208	.4583999	3.4	5
inflation	96	101.9906	5.736937	92.9	111.6
squaremete~s	96	1.04e+08	1.11e+07	8.56e+07	1.23e+08
gdp	96	222360.2	25582.4	158920	278870

This table shows that every variable have 96 observations and we can see mean and standard deviation for the variables.

6.1 Rental Price Index Commercial Real Estate

We use the rental price index on commercial real estate in Norway from Statistics Norway. The index we use includes all types of commercial real estate. SSB got this data from the tax returns, the form RF-1098 (Statistics Norway, 2017). Originally, the

index is stated on annually basis, but a lot of the other variables are stated on monthly basis. Therefore, we have changed the index from yearly to monthly basis. We distributed the annual index evenly over each month with interpolation since we know the data from each turn of the year. Because we did that, this can be a weakness of the data and give some bias in the results we will get. However, we concluded to do this, because if we did not, we would get only yearly data, and that would be too few observations in total.
Data source: (Statistics Norway, u.å.).

6.2 The Norwegian Policy Rate from Norges Bank

In Norway, it is Norges Bank that determines the policy rate. This interest rate is the one that affects all other interest rates, because the banks must lend at these interest rates and thus Norges Bank's policy rate will affect the entire interest rate level in the country. Most people who own commercial property have debt, and since their biggest cost is interest costs, the interest rate will probably have a lot to say about the value of the property. We have chosen to use the policy rate, since this interest rate affects lending rates for commercial property to a very large extent. This was also the interest rate where we were able to find a good, reliable source for within a reasonable time. We got the data on the policy rate from Norges Bank (Norges Bank. u.å.).

6.3 Building Costs Index

In Norway, Statistics Norway prepares various indices for building costs. Since we focus on commercial property, we have chosen to use the index "Multi dwelling houses total". This index includes an entire building with the materials that are largely used for commercial buildings and residential blocks. This index points out the pricing level for building commercial real estate in Norway and through the index we can see how this changes monthly. Commercial buildings may have a slightly different weighting in relation to material use, for example in recent years it has become significantly more popular to build with wood. This index will not take this into account to any greater extent than it uses the national average, which we think is correct in this context (Statistics Norway, u.å.).

6.4 Unemployment Rate

The unemployment rate, an index that has also been compiled by Statistics Norway, shows how many unemployed people there are in Norway between the ages of 15 and 74 (Statistics Norway, u.å.). This index state something about the total level of activity in Norway, and since it mentions the number of available jobs, it will probably also affect the demand for commercial property. The index only considers unemployment as a percentage of the workforce. This means that students, pensioners, and people with disability benefits are not included in the statistics. The statistics are created by contacting 21,000 people and with such a large sample, the probability that the answers will be correct on average will be very certain.

6.5 Total Squaremeters of Commercial Real Estate

In 2011, Statistics Norway and Multiconsult prepared an overview of how much building stock there is in Norway. For this variable, we have used this data (Byggordboka, 2017) as a starting point and then we have used Statistics Norway's statistics (Statistics Norway, u.å.). Statistics Norway states how much completed usable space which has been completed per month on all property in Norway other than housing, and added this to the starting sum we had. This data can probably be influenced since it also includes public buildings, which can affect the statistics. The most important thing for us is to have data where we can see the development. That is not whether the number of finished usable area is 100 or 200 square meters per month, but to see the development of completed usable area in relation to the rental price index.

6.6 Gross Domestic Product for mainland Norway

Gross domestic product is the sum of all goods and services produced in a country during a year, minus inputs. In Norway, we have an industry which accounts for a broad part of the value creation, but which is managed very differently to the rest of the value creation, namely oil and gas. “Handlingsregelen” in Norway states that we can only use a small proportion of the surplus from oil and gas production in the state budget through the Government Pension Fund (Regjeringen, 2022). At the same time, the Government Pension Fund has grown massively, and in a bad year for oil and gas you will be able to spend more than the actual surplus from oil and gas. Thus, in our analyses, we have chosen to use Gross Domestic Product for mainland Norway and thereby exclude influence from oil and gas production. The main reason why we choose to do this, is that oil and gas prices are very variable, and this could give us spurious connections and much higher variance to a much greater extent than mainland GDP. Our data is taken from Statistics Norway (Statistics Norway, u.å.) and they reported quarterly up to and including 2015, however they started reporting monthly from 2016. Thus, we have interpolated the data up to and including 2015. We have also made a monthly calculation of the percentage of production from 2016 - 2019 which we have used in the interpolation, so that the years from 2011 - 2015 have the same trend as 2016 - 2019, an example, holiday closures affect production in July.

A weakness of this variable that can affect our results is that it is not seasonally adjusted, which can give a false relationship linked to periods with a greater number of holidays than others, for example July and December. It should be seasonally adjusted, but it does not show in our analyzes and models.

6.7 Inflation

The inflation index we use here is called the consumer price index in Norway. A statistic on a selection of goods and services in demand from private individuals, which is prepared by Statistics Norway (Statistics Norway, u.å.). The index we use will include tax changes and energy prices. This index will also be a measure of activity in a country, while it probably will have a certain correlation with GDP and possibly also unemployment rate over time.

7. Methods

In this part we will go through which methods and tools we will use through the analysis part. Our goal is to make the statistical model as reliable as possible, to find out which of the determinants affecting the rental prices the most and if it has statistically significance. We will use statistical regression, to estimate the relationship between the dependent and the independent variables. Rental price will be the dependent variable and all other variables, for example gross domestic product and inflation, will be the independent variables, also named explanatory variables. With this statistical regression, it will show us which way the independent variables are affecting the dependent variable, how much they affect and if it has statistically significance.
A multiple least squares regression (OLS) model in Stata will be noted like this:

$$Y_t = \hat{\beta}_0 + \hat{\beta}_1 X_1 t + \hat{\beta}_2 X_2 t + \epsilon$$

In this notation, Y is the dependent variable we want to explain, here: rental prices on commercial real estate, and X is the independent explanatory variables that affecting Y, the other variables in the dataset. β_0 is the constant term and β_1 is the slope of the coefficient. ε is the residual term. T is the time.

7.1 Time series

Our dataset consists of variables who measures the same entity over multiple time periods. Therefore, we use the time series regression. When we use time series regression, stationarity is one of the key assumptions, because if we don't have stationarity, we can get an unreliable model where the hypothesis tests and confidence intervals are not making reliable results (Stock & Watson, 2020). When we have achieved stationarity, we can with certainty say that the results are reliable.

7.2 Stationarity

Time series data will measure the same entity over multiple time periods, and since we have economic data like gross domestic product, the past value will affect the future value. The data is stationary when the probability distribution does not change over time (Stock & Watson, 2020). In other words, the future must be predictable on the basis from the past, in a probabilistic sense. Stationarity can be expressed in this way:

$E(X_t)$ = constant = μ , constant average

Var (X_t) = constant = σ^2 , constant variance

If these conditions are not met, we have non-stationarity.

7.3 Trends

Trend is when a variable has a long-term movement in the same direction (Stock & Watson, 2020). There are two types of trends in time series, and that is deterministic trends and stochastic trends. Deterministic trends are a predictable trend that is a nonrandom function of time, and stochastic trend is a random function of time. However, these trends raise three main problems due to their nonstationarity. The coefficients can be biased toward zero and we will get a wrong distribution of the t-statistic, that will cause invalid confidence intervals and hypothesis tests. In addition, we can get spurious relationships between the variables, which means that we find relationships that are false but can seem to be true.

7.4 Tests for stationarity

7.4.1 Dickey-Fuller test

The Dickey-Fuller test is a test to find out if there is stationarity in the dataset. It is testing for unit root and the result gives us information if there is a stochastic trend in the dataset. The null hypothesis is that the time series has a stochastic trend (unit root), and the alternative hypothesis is that the time series is stationary (Stock & Watson, 2020).

If the time series follows an AR(1) model with B = 1 = stochastic trend, testing for unit root have this hypothesis:

$$H_0 : \beta_1 = 1, H_1 : |\beta_1| < 1$$

In the regression model:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t.$$

In practice, we implement a modified version of this equation by subtracting Yt-1 from both sides of the AR(1) model to get this:

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + u_t$$

Where:

$$\delta = \beta_1 - 1.$$

Then we will get this hypothesis:

$$H_0 : \delta = 0, H_1 : \delta < 0.$$

One of the poor factors with the Dickey-Fuller test is that this test is not taking care of possible autocorrelation in the residual term. Therefore, we can use the Augmented Dickey-Fuller test.

7.4.2 Augmented Dickey-Fuller test

The Augmented Dickey-Fuller test is a test for stationarity that is applied to an AR(p) model. The biggest difference between this test and the Dickey-Fuller test is that this test also uses lags, so we can get the lowest variance as possible (Stock & Watson, 2020). As the Dickey-Fuller test, it has the null hypothesis that says stochastic trend and the alternative hypothesis that says stationarity. The regression become:

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \gamma_2 \Delta Y_{t-2} + \ldots + \gamma_p \Delta Y_{t-p} + u_t.$$

If the alternative hypothesis says deterministic trend instead of stochastic trend, we must add an additional regressor and the regression alter to:

$$\Delta Y_t = \beta_0 + \alpha t + \delta Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \gamma_2 \Delta Y_{t-2} + \ldots + \gamma_p \Delta Y_{t-p} + u_t$$

In the Augmented Dickey-Fuller test it is important to get the right number of lags.

7.4.3 Optimal lag length

It is important to choose the right number of lags, because if we choose wrong number of lags, we are at risk for getting the wrong results. If the number of lags is too low, it may happen that we are missing potentially useful information from lags that are further away. If the number of lags is too high, we may risk estimating more coefficients than necessary, which may lead to higher estimation error in the forecasts (Stock & Watson, 2020). So, to get this optimal length we have a few choices. For example, we can use Schwarz Bayesian information criterion (SBIC), or we can use Akaike's information criterion (AIC). These tests are notated as:

SBIC(p) = ln (SSR(P) / T) + (p + 1) * ln(T)/T.

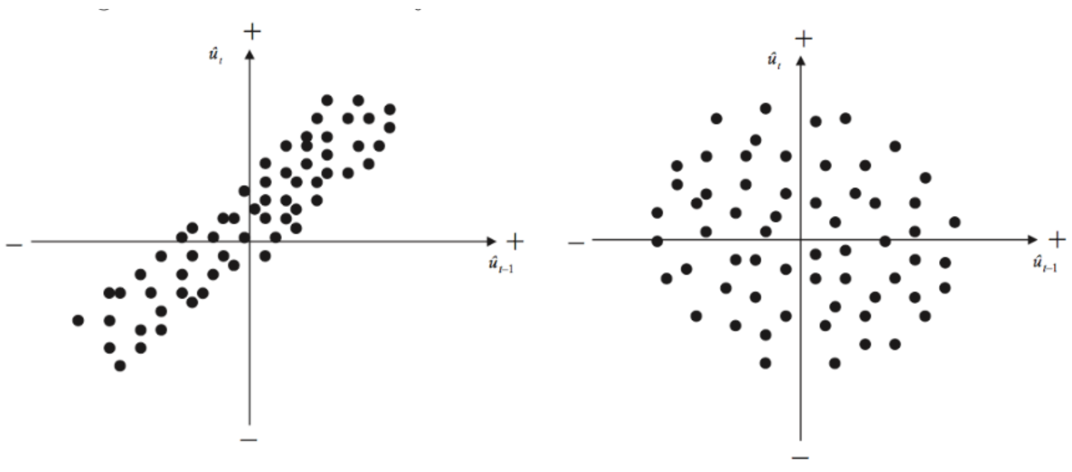
AIC(p) = ln (SSR(p) / T) + (p + 1) * 2/T

These tests will tell us how many lags we should use in the Augmented Dickey-Fuller test. As you can see, these tests are almost similar, but with a slight difference at the end. If these tests choose the same number of lags, everything is great, but if they choose different number of lags, we must make a decision. The difference between SBIC and AIC is not tremendous, but it is a difference in the last term. The difference is, among other things, that with very large samples, SBIC will estimate the number of lags more correctly than AIC (Stock & Watson, 2020). In addition, we can also use the Hannan and Quinn information criterion (HQIC) as a last alternative, if SBIC and AIC estimate different numbers of optimal lags.

7.4.4 Autocorrelation

Autocorrelation is normal within time series data because the time series data is based on previous period data. Autocorrelation means that there is correlation between the periods. With autocorrelation, we violate the assumption that the error terms are independent and uncorrelated. Therefore, we must get rid of autocorrelation. Autocorrelation can be seen in the residual plot, but we can also test for it in Stata with the Durbin Watson test or the Portmanteau test.

Figure 7.1. autocorrelation plot:



On the first figure you can see positive autocorrelation, which will say that we violate the assumption that the error terms are independent and uncorrelated. On the second figure you can see a plot without autocorrelation.

The Durbin Watson test:

$$d = \frac{\sum(\hat{u}_t - \hat{u}_{t-1})^2}{\sum(\hat{u}_t^2)}$$

With a positive autocorrelation the d will get a low value and with negative autocorrelation the d will get a high value. With no correlation, we will get a value between low and high. The value d is always between 0 and 4. The closer to the outer edges the numbers are, the more autocorrelation there is, either the negative or the positive way.

Portmanteau / Ljung box test:

$$Q = n\sum_{k=1}^{m}\hat{\rho}_k^2$$

This is also a test for autocorrelation. This test is also checking for groups of autocorrelations that is different from zero. The null hypothesis in this Portmanteau test explains that the data is distributed independently without autocorrelation and the alternative hypothesis explains that it is autocorrelation.

7.4.5 Log

When using financial data, we often have a lot of data which is growing exponentially. Because many economic variables are growing in percentage, they will get an exponential growth. If we use logarithmic variables, these will grow approximately linearly, even though they initially grew exponentially (Stock & Watson, 2020). Logarithmic variables can also be a key to get rid of non-stationarity.

7.4.6 Differencing

When we use time series data, we often struggle with trends and non-stationarity. One possibility to get rid of this is to use difference. First Difference is noted this way:

$$Y_t - Y_{t-1}$$

This notation explains that the first difference is the change in Y between periods t and t – 1 (Stock & Watson, 2020). Sometimes, a first differencing does not get rid of non-stationarity, and then we can difference one more time to get stationarity.

7.4.7 Multicollinearity and VIF test

Another assumption for reliable time series is that we can't have any perfect multicollinearity (Stock & Watson, 2020). Multicollinearity is when the different variables in the dataset correlates too much. In real life, almost no variables will have perfect multicollinearity over time, and if we try to find this, we will most likely insert the same variable twice. However, a lot of the variables can have high multicollinearity that can cause problem for the results.
We can do a test for multicollinearity, called the Variance Inflation Factor test (VIF). In this test a VIF value at 1 tells us that there is no multicollinearity in the data. A value between 1 and 5 inform us that there is some multicollinearity in the data, and values over 5 can cause some problems for the results (Statology, 2020).

8. Analysis

In this part we should analyze through the dataset we presented in the Data part. Due to the theory, it is crucial to get the data as stationary data. Therefore, we will use log on every variable before the first tests and see if we can reach stationarity with the logged data.

8.1 Plots

Figure 8.1 Price Index plot

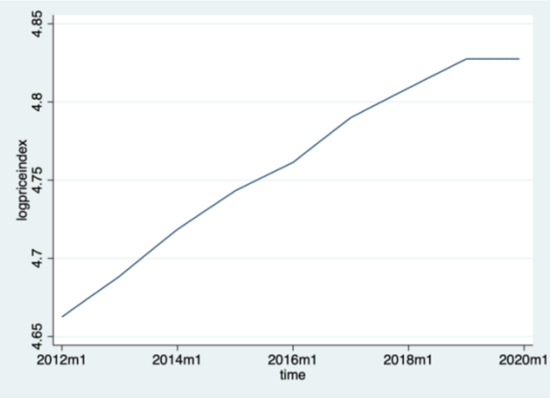


Figure 8.2 Policy Rate plot

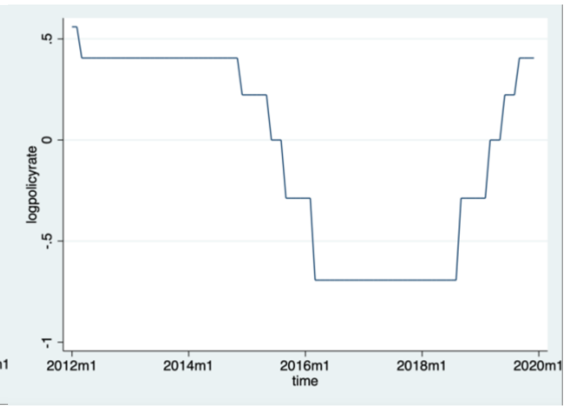


Figure 8.3 Unemployment Rate plot

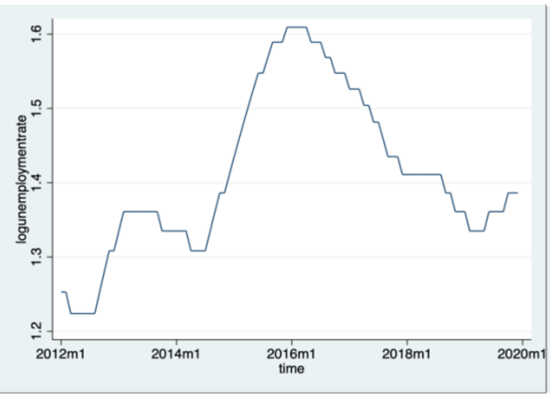


Figure 8.4 Building Costs plot

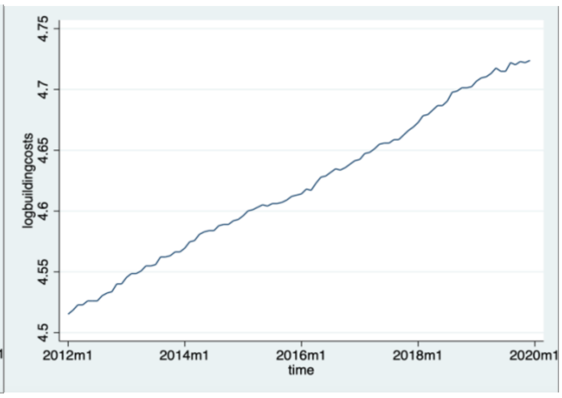


Figure 8.5 Inflation plot

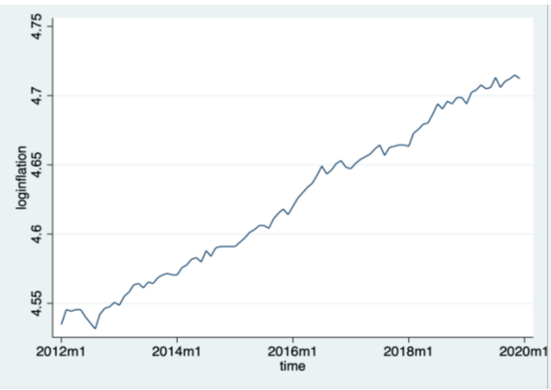


Figure 8.6 Squaremeters total mass plot

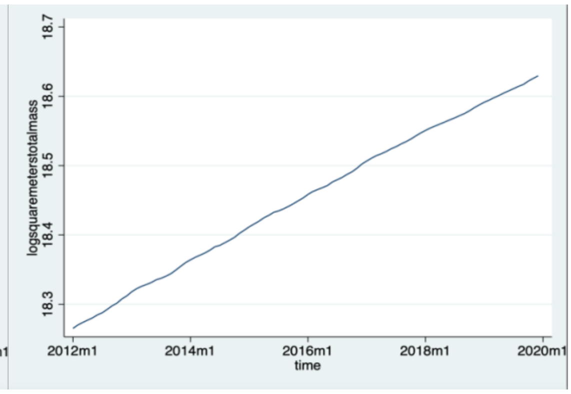
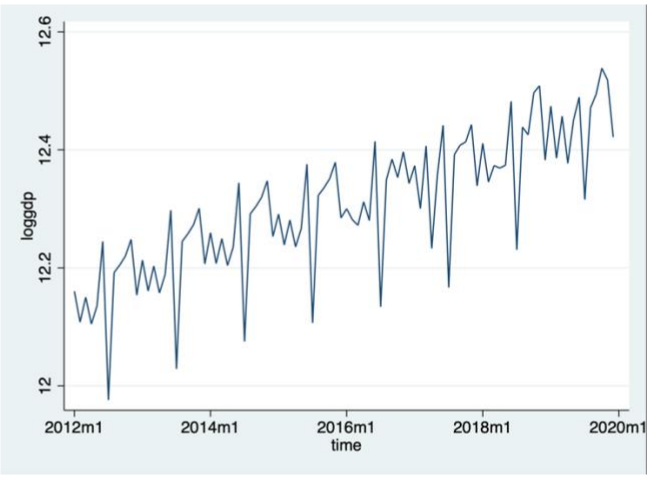


Figure 8.7 GDP plot



Here we can see the different variables in the plots. We listed it up the different plots so we can see if they contain trends or shocks. It may seem that all the variables contain a trend, except the policy rate and unemployment rate. Another assumption for time series is that the dataset has zero large outliers, and it does not appear that any of the variables contain any form of shock or outliers that will affecting the results, and therefore we have satisfied this assumption. Thus, we have a small dataset, so it is also easy to check for outliers in the dataset.

8.2 Optimal lag length

We will take the Augmented Dickey Fuller test, but first we must choose the right number of lags with using the Schwarz Bayesian Information Criterion and Akaike Information Criterion.

Table 8.2.1 AIC / SBIC - Price Index

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	146.81				.00246	-3.16978	-3.15872	-3.14237
1	563.618	833.62	1	0.000	2.9e-07	-12.2091	-12.187	-12.1543
2	644.904	162.57*	1	0.000	5.1e-08*	-13.9544*	-13.9212*	-13.8722*
3	644.919	.02968	1	0.863	5.2e-08	-13.933	-13.8888	-13.8234
4	644.919	3.7e-05	1	0.995	5.3e-08	-13.9113	-13.856	-13.7742

Table 8.2.2 AIC / SBIC - Policy Rate

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-62.3797				.232223	1.37782	1.38888	1.40523
1	96.9109	318.58	1	0.000	.007438	-2.06328	-2.04115*	-2.00846*
2	96.9138	.00583	1	0.939	.007601	-2.0416	-2.00842	-1.95937
3	96.9155	.00338	1	0.954	.007768	-2.0199	-1.97565	-1.91026
4	100.116	6.4016*	1	0.011	.007406*	-2.06775*	-2.01243	-1.93069

Table 8.2.3 AIC / SBIC - Building Costs

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	130.139				.003534	-2.80738	-2.79631	-2.77997
1	438.768	617.26	1	0.000	4.4e-06	-9.49497	-9.47284	-9.44014
2	442.443	7.3488	1	0.007	4.2e-06	-9.5531	-9.51992	-9.47087
3	444.534	4.1825	1	0.041	4.1e-06	-9.57683	-9.53257	-9.46718
4	448.472	7.8755*	1	0.005	3.8e-06*	-9.64069*	-9.58538*	-9.50364*

Table 8.2.4 AIC / SBIC - Unemployment Rate

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	77.1063				.011194	-1.65448	-1.64342	-1.62707
1	260.355	366.5	1	0.000	.000213	-5.6164	-5.59428	-5.56158
2	267.562	14.415	1	0.000	.000186	-5.75135	-5.71816	-5.66911
3	271.965	8.8056	1	0.003	.000173	-5.82532	-5.78107	-5.71568
4	277.84	11.75*	1	0.001	.000155*	-5.9313*	-5.87599*	-5.79425*

Table 8.2.5 AIC / SBIC - Inflation

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	137.278				.003026	-2.96256	-2.9515	-2.93515
1	382.627	490.7	1	0.000	.000015	-8.27451	-8.25238	-8.21969
2	384.908	4.5614*	1	0.033	.000015*	-8.30235*	-8.26916*	-8.22012*
3	385.222	.62696	1	0.428	.000015	-8.28743	-8.24317	-8.17778
4	385.793	1.1426	1	0.285	.000015	-8.27811	-8.22279	-8.14105

Table 8.2.6 AIC / SBIC - Squaremeters total mass

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	79.5856				.010607	-1.70838	-1.69732	-1.68097
1	519.825	880.48	1	0.000	7.6e-07	-11.2571	-11.2349	-11.2022
2	524.416	9.1824*	1	0.002	7.0e-07*	-11.3351*	-11.3019*	-11.2529*
3	524.826	.8205	1	0.365	7.1e-07	-11.3223	-11.2781	-11.2127
4	526.124	2.5956	1	0.107	7.0e-07	-11.3288	-11.2735	-11.1917

Table 8.2.7 AIC / SBIC - GDP

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	70.5522				.012908	-1.512	-1.50094	-1.48459
1	83.104	25.104	1	0.000	.010042	-1.76313	-1.741	-1.70831
2	96.5891	26.97	1	0.000	.007655	-2.03455	-2.00136	-1.95231
3	104.616	16.053*	1	0.000	.006571*	-2.1873*	-2.14305*	-2.07766*
4	104.874	.517	1	0.472	.006678	-2.17118	-2.11587	-2.03413

As we can see, both price index, building costs, unemployment rate, inflation, squaremeters total mass and GDP have all the same lags, if we compare the AIC, SBIC and HQIC. The policy rate, however, has gotten different results, where we can see that the SBIC and HQIC shows 1 lag and AIC show 4 lags. Since both SBIC and HQIC have 1 lag, we choose to use 1 lag.

8.3 Testing for stationarity – Augmented Dickey Fuller

Table 8.3.1 – Augmented Dickey-Fuller test

Variable	Lags	With constant, without trend and drift	With trend	With drift	Without constant
Price Index	2	-1.986	0.702	-1.986**	0.027
Policy Rate	1	-1.072	-1.072	-1.072	-1.036
Building Costs	4	-0.068	-1.952	-0.068	4.324
Unemployment Rate	4	-2.728*	-2.454	-2.728***	0.350
Inflation	2	0.198	-3.643**	-0.198	4.895
m2 total mass	2	-1.505	-1.810	-1.505*	4.706
GDP	3	-1.569	-6.520***	-1.569*	1.213

***= Significance on 1% level **= Significance on 5% level *= Significance on 10% level

In this test, we are starting with the dataset with log variables, to see if we have stationarity with this dataset. We can see in the column with constant, but without trend and drift, that unemployment rate has statistically significance at 10% level. This is the column where we want every variable to get statistical significance at. We have also tested with trend and drift, and we can see that inflation is statistically significance at 5% level with trend, and that GDP have statistically significance at 1% level with drift. We can also see that price index have statistically significance at 5% level with drift, while unemployment rate is at 1% level and squaremeters total mass and GDP have statistically significance with drift at 10% level.

8.4 Differencing variables

Regarding to theory, we choose to difference the variables to see if we can get rid of the non-stationarity.

First, we difference the variables, and then we choose the number of lags before we take the new Augmented Dickey-Fuller test.

Table 8.4.1 AIC / SBIC - First Difference Price Index

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	527.355				5.5e-07	-11.5682	-11.5571	-11.5407
1	635.179	215.65*	1	0.000	5.3e-08*	-13.916*	-13.8938*	-13.8608*
2	635.237	.11684	1	0.732	5.4e-08	-13.8953	-13.8619	-13.8125
3	635.251	.0281	1	0.867	5.5e-08	-13.8737	-13.8291	-13.7633
4	635.302	.1017	1	0.750	5.6e-08	-13.8528	-13.7971	-13.7148

Table 8.4.2 AIC / SBIC - First Difference Policy Rate

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	94.9995				.007418*	-2.06592*	-2.05479*	-2.03833*
1	94.9995	0	1	.	.007583	-2.04394	-2.02168	-1.98876
2	94.9995	0	1	.	.007752	-2.02197	-1.98857	-1.93919
3	97.9745	5.95*	1	0.015	.007423	-2.06537	-2.02085	-1.95501
4	97.9745	4.8e-06	1	0.998	.007588	-2.0434	-1.98774	-1.90544

Table 8.4.3 AIC / SBIC - First Difference Building Costs

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	433.605				4.3e-06	-9.5078	-9.49667	-9.48021
1	437.149	7.0887	1	0.008	4.1e-06	-9.56372	-9.54146	-9.50854
2	439.285	4.2722	1	0.039	4.0e-06	-9.58869	-9.5553	-9.50592
3	443.107	7.6422*	1	0.006	3.8e-06*	-9.65069*	-9.60617*	-9.54033*
4	443.605	.99744	1	0.318	3.8e-06	-9.63968	-9.58402	-9.50172

Table 8.4.4 AIC / SBIC - First Difference Unemployment Rate

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	255.214				.000219	-5.58711	-5.57598	-5.55952
1	262.483	14.54	1	0.000	.000191	-5.72491	-5.70265	-5.66973
2	266.482	7.9978	1	0.005	.000179	-5.79082	-5.75743	-5.70805
3	271.004	9.0432*	1	0.003	.000166*	-5.86822*	-5.82369*	-5.75785*
4	271.178	.34868	1	0.555	.000169	-5.85007	-5.79441	-5.71211

Table 8.4.5 AIC / SBIC - First Difference Inflation

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	378.082				.000015	-8.28753	-8.27639	-8.25993
1	380.368	4.572*	1	0.032	.000014*	-8.31579*	-8.29353*	-8.2606*
2	380.709	.68215	1	0.409	.000015	-8.30131	-8.26791	-8.21853
3	381.149	.87856	1	0.349	.000015	-8.28898	-8.24446	-8.17862
4	381.393	.48791	1	0.485	.000015	-8.27237	-8.21671	-8.13441

Table 8.4.6 AIC / SBIC - First Difference Squaremeters total mass

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	510.925				7.9e-07	-11.2071	-11.196	-11.1796
1	516.702	11.553	1	0.001	7.2e-07	-11.3121	-11.2899*	-11.2569*
2	517.371	1.3383	1	0.247	7.2e-07	-11.3049	-11.2715	-11.2221
3	518.056	1.3705	1	0.242	7.3e-07	-11.2979	-11.2534	-11.1876
4	520.51	4.9078*	1	0.027	7.0e-07*	-11.3299*	-11.2742	-11.1919

Table 8.4.7 AIC / SBIC - First Difference GDP

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	67.7026				.013516	-1.46599	-1.45486	-1.4384
1	91.0763	46.747	1	0.000	.008266	-1.95772	-1.93546	-1.90254
2	101.41	20.668	1	0.000	.006733	-2.16286	-2.12946	-2.08008
3	101.971	1.1224	1	0.289	.006799	-2.15321	-2.10869	-2.04285
4	109.746	15.55*	1	0.000	.005858*	-2.30211*	-2.24645*	-2.16415*

We can see that the Price Index have changed from two to one lag, Policy Rate have changed from one to zero lags, Building Costs from four to three lags, Unemployment Rate from four to three lags, Inflation from two to one lag, Squaremeters total mass from two to four lags and GDP from three to four lags.

8.5 Augmented Dickey-Fuller test with first difference variables

Table 8.5.1 - Augmented Dickey-Fuller test with first difference variables

Variable	Lags	With constant, without trend and drift	With trend	With drift	Without constant
First Difference Price Index	1	-0.495	-1.861	-0.495	-1.194
First Difference Policy Rate	0	-9.595***	-10.153***	-9.595***	-9.644***
First Difference Building Costs	3	-4.658***	-4.621***	-4.658***	-1.578
First Difference Unemployment Rate	3	-2.370	-2.636	-2.370***	-2.328**
First Difference Inflation	1	-8.104***	-8.084***	-8.104***	-5.776***
First Difference m2 total mass	4	-4.224***	-4.817***	-4.224***	-0.599
First Difference GDP	4	-6.372***	-6.337***	-6.372***	-6.109***

***= Significance on 1% level   **= Significance on 5% level   *= Significance on 10% level

We can now see that we have statistical significance at 1% level for Policy Rate, Building Costs, Inflation, Squaremeters total mass and GDP. However, we are still struggling with the Price Index and the Unemployment Rate. Therefore, we will try a second difference on these variables to see if we can get rid of the non-stationarity.

8.6 Augmented Dickey-Fuller test with Second Difference variables

First, we choose the number of lags.

Table 8.6.1 AIC / SBIC - Second Difference Price Index

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	627.652				5.2e-08*	-13.9256*	-13.9144*	-13.8978*
1	627.769	.23462	1	0.628	5.3e-08	-13.906	-13.8836	-13.8504
2	627.806	.07357	1	0.786	5.5e-08	-13.8846	-13.851	-13.8013
3	627.819	.02618	1	0.871	5.6e-08	-13.8627	-13.8178	-13.7515
4	627.827	.0154	1	0.901	5.7e-08	-13.8406	-13.7846	-13.7017

Table 8.6.2 AIC / SBIC - Second Difference Unemployment Rate

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	242.543				.000273	-5.36762	-5.35642	-5.33985
1	256.014	26.942	1	0.000	.000207	-5.64475	-5.62235	-5.5892
2	264.532	17.037*	1	0.000	.000175*	-5.81183*	-5.77823*	-5.7285*
3	265.207	1.3505	1	0.245	.000176	-5.80461	-5.75981	-5.69351
4	265.421	.42676	1	0.514	.00018	-5.78713	-5.73113	-5.64825

We can see that the Price Index changed the optimal lag length from one to zero, and that Unemployment Rate changed from four to two lags.

Table 8.6.3 - Augmented Dickey-Fuller test with second differenced variables

Variable	Lags	With constant, without trend and drift	With trend	With drift	Without constant
Second Differenced Log Price Index	0	-10.066***	-10.123***	-10.066***	-9.998***
Second Differenced Log Unemployment Rate	2	-8.499***	-8.452***	-8.499***	-8.545***

We can now see that with second difference on these two variables, we have stationarity on all the variables in our dataset.

8.7 Durbin Watson test for autocorrelation

We use the Durbin Watson test for autocorrelation and got this result:

```
Durbin-Watson d-statistic(  7,    94) =  2.019942
```

When the number is close to 2 in this test, it means that there is no or very low autocorrelation in the dataset. This test has critical values between 1.535 and 1.802, and the result express that there is no evidence that the data are positively correlated. And since 4-2,019942 is 1,98, and this value is higher than 1.535, there is no statistical evidence that the data are negatively correlated, either. The Durbin Watson results shows us that we have no autocorrelation in our dataset.

8.8 VIF-test for multicollinearity

We want to test for another assumption, which is no perfect multicollinearity.

Variance Inflation Factor test results:

Table 8.8.1 – VIF Test for multicollinearity

Variable	VIF	1/VIF
Dgdp	1.29	0.777569
Dinflation	1.25	0.802245
Dsquaremet~s	1.10	0.909771
Dbuildingc~s	1.06	0.943431
DDunemploy~e	1.03	0.970488
Dpolicyrate	1.01	0.992315
Mean VIF	1.12	

We can see that we have results from 1,01 to 1,29. If the results are 5 or higher, we may have problems with multicollinearity, although we can maybe accept up to about 10.

With the highest value of 1,29, we can conclude that we have no issue with multicollinearity between the independent variables in our dataset.

9. Empirical Results

In this part, we will go through the results we got from the study. Table 9.1 display the four different models we ended up with. From the method and analysis, we know that we have to use stationary data to be able to present valid and reliable results. We also saw that some variables needed second differencing to get stationarity, and therefore we must use minimum second difference on these variables to hold this assumption. After trying out different models, we saw the need to use the same differencing for all variables to get statistically significance, while we also know that we are using stationary data.

Table 9.1 – Regression results

	Model 1	**Model 2**	**Model 3**	**Model 4**
Dependent Variable	**DD Price Index**	**DD L1 Price Index**	**DD L1 Price Index**	**DD L1 Price Index**
DD Unemployment Rate	0,001047 (0.001409)	-0,0020221 (0,001309)		
DD Policy Rate	-0,0000401 (0.000198)	-0,000648*** (0,000176)	- 0,0006466*** (0,000173)	-0,0006466* (0,000386)
DD Building Costs	-0,0094656 (0,007437)	0,012193* (0,007050)	0,0147573** (0,006805)	0,0147573 (0,009330)
DD Inflation	-0,0123715** (0,004904)			
DD Squaremeters total mass	0,0094962 (0,0267481)		-0,0431298** (0,021046)	-0,0431298** (0,017589)
DD GDP	-0,0000249 (0,000152)	-0,000148 (0,000127)		
DD L1 Inflation		-0,012429*** (0,003892)	- 0,0141822*** (0,003733)	-0,0141822** (0,0071357

DD L1 Squaremeters total mass		-0,0108324 (0,0266478)		
Constant	-0,0000249 (0,000023)	-0,000028 (0,000021)	-0,000231 (0,000022)	-0,0000231 (0,000022)
Adjusted R-Squared	0,0358	0,2002	0,2190	
R-Squared	0,0980	0,2524	0,2530	0,2530
Durbin Watson	2,032982	1,814998	1.831141	1.831141

***= Significance on 1% level **= Significance on 5% level *= Significance on 10% level

D = First Difference

DD = Second Difference

L1 = One lag

The value in the parenthesis behind the coefficients is the standard deviation.

The regressions in Table 9.1 can also be seen in Model Outputs.

Table 9.1 shows us the results we got from the regressions. The four models gave different results, and we found the most preferred model, model 4.

As we can see from model 1, the second differenced unemployment rate variable is not statistically significant when we are using the second differenced price index as dependent variable. After all, we can also see that the same independent variable for unemployment rate is not statistically significant when using second difference and one lag on the independent variable price index. Further, we can conclude that unemployment rate is not one of the variables that is affecting the rental prices for commercial real estate in Norway. When we look at the policy rate, we can see that the second differenced policy rate is not statistically significant in model 1, but it is statistically significant at 1% level in model 2 and 3, and statistically significant at 10% level in model 3. It is seen from model 1 to model 2, that we got much more statistical significance overall, when we are using one lag on the dependent variable price index and one lag on inflation and squaremeters total mass. Even though the independent and the dependent variable are the same, the coefficients and statistical significance can change because when you change other variables, all variables will consider the effect on the other variables, and we will see some of these effects in our four different models. The difference between model 3 and 4 is that we have used a heteroscedastic robust regression in model 4. Heteroscedasticity can make skewness in the regression results, yet when we use the heteroscedasticity robust regression, this function consider heteroscedasticity, so the results does not get skewness. This is also an important task to do, to get reliable and valid regression results. Therefore, we can conclude that policy rate is statistically significant and that it will affect the rental prices on commercial real estate. Another independent variable is the second differenced variable building costs. As we can see, this variable is not statistically significant in model 1 and model 4, but it is statistically significant at 10% level in model 2 and 5% in model 3. Since it is not statistically significant in our preferred model, model 4, it is hard to conclude that this variable, with certainty, will affect the rental prices on commercial property. We can see that it is statistically significant in model 3 with 5%, which is almost the same model as model 4. In model 4, we can see from Table 9.1 that this variable has p-value at 0,117, which means it is 0,017 outside the 10% significance. We can think that, in reality, this variable will affect the rental prices to a certain extent, since it is statistically significant in model 2 and 3, and just slightly outside the 10% significance in model 4. On the other hand, it is not statistically significant in our preferred model, model 4, therefore we cannot conclude that it will affect our dependent variable, the price index. Another variable that was statistically significant in all models was inflation. This variable was with only second difference in the first model, but after we lagged the dependent variable, the rental price, we also lagged the independent variable. We can see that it was statistically significant on 5% level in model 1, and after the lag, it was statistically significant on 1% level in model 2 and 3. After we used the robust regression, it fell to 5% statistically significance. When we used lag, we moved the time trend/observation one time, which is here, one month. When we tried to lag the dependent variable and not lagged the inflation, we saw that it was not statistically significant. Therefore, we had to use lag on this variable too. The conclusion is that inflation is one of the variables that will affect the rental prices on commercial real estate. Squaremeters total mass is another independent variable with different results from the different models. We can see that it is not statistically significant in model 1, and even when we try both with and without lag in model 2, it was not statistically significant. Yet when we go to model 3, we can see that it is statistically significant at 5% level. The difference here is that we deleted the unemployment rate and GDP from the

regression. Since the variables are influenced by each other, we can think that unemployment rate and GDP was problem variables, as we increase both statistically significance and the total degree of explanation, although we omitted these two variables. Therefore, we can say that we omitted these problem variables to get a more precise model.
We can conclude that squaremeters total mass is affecting the rental price for commercial real estate.
GDP is an independent variable in model 1 and 2, and it is not statistically significant. We also tried to use this variable in model 3 and 4, but it was not statistically significant, and it also destroyed the statistically significance for the other variables.

All variables in all models we have used is stationary. We can also see the Durbin Watsons values ranging from 2,03 to 1,81. In all the models, the critical values are lower than this value, so we have no trouble with autocorrelation in the models. We can also see from the table below that we have no issues with the multicollinearity in our preferred model, and we had no issues with that in the other models, neither.

Table 9.2 – VIF Test model 4

Variable	VIF	1/VIF
DDlogbuild~s	**1.19**	**0.837753**
DDloginfla~n		
L1.	**1.16**	**0.858740**
DDlogsquar~s	**1.04**	**0.958333**
DDlogpolic~e	**1.02**	**0.981280**
Mean VIF	**1.11**	

Since we have used logistic regression, we must interpret the regressions results another way than normal regression. From our preferred model, model 4, we can see that the second differenced policy rate have a negative coefficient on 0,0006466. That means, one percent change in the difference of policy rate gives a 0,0006466% negative change in the difference of the price index. Although all variables here are second difference, i.e., differenced on the same level, the interpret will be the same for the variable as a whole, not just for the difference of it. Squaremeters total mass have a coefficient on -0,0431298, which means that a one percent change in squaremeters total mass will affect a -0,0431298% change in the difference of the rental price index. Inflation has a coefficient on -0,0141822 which means that one percent change in the difference of inflation will give a -0,0141822% change in the difference of the rental price index.

The R-squared values is also different between the four models, and it is at its highest on model 3 and model 4. The R-squared value tells us how much of the total variance in Y which can be explained by the X variables in the regression. The adjusted R-squared state the same but consider that there are multiple variables that explains the total variation of Y, and therefore they can overlap with estimation, and therefore normal R-squared can “overfit” the model (Corporate Finance Institute, 2022). We can see that our preferred model has an R-squared value of 0,2530 which mean this model explains 25,30% of the total variation in Y. Because we use the robust regression in this model, where we consider heteroscedasticity, we don’t get the adjusted R-squared value, only the normal R-squared value.

10. Discussions and conclusion

In this thesis, we wanted to study which factors affect the rental prices of commercial property in Norway. Through a literature review and a theory part, we have gotten variables that we wanted to investigate, while at the same time we had to use variables that we could only collect in a fairly short amount of time. We faced many challenges in the beginning of the assignment related to collecting data, and thus we ended up with the data set that we did, this was the macroeconomic data, that we had the opportunity to find.

There has been relatively limited research on the area, and the research that exists varies greatly in results, it is certainly not the case that the different articles get the same results. Our hypotheses are partly based on the literature review and partly based on the theory part. Unemployment was one of the variables we thought would affect rental prices for commercial property to a greater extent, as it is reasonable to believe that many people in work, combined with the associated high economic activity, means that the prices for renting commercial property are pushed upwards. This combined with the fact that other previous research has found this to be statistically significant made us believe that we would also get this result. Yet the fact is that we do not, in our defined period from 2012 - 2019, manage to find this variable statistically significant. There can be many explanations for this, including the period we have used in the study and the fact that the prices of commercial real estate in Norway are also largely based on inflation-adjusted contracts, so that shorter periods with changes in unemployment do not reflect enough in the rental prices. As we believed in our hypotheses, we find that the key interest rate, the total mass of square meters and inflation are statistically significant variables that we can confidently say from our studies affect the rental prices of commercial property. We are unable to find statistical significance for GDP and construction costs, which is in accordance with our hypotheses.

Through this assignment, we have spent a great amount of time collecting relevant material and research that we can use for our further research in the area. Our perception is that there is an interest out there in researching within the market, an interest that has certainly not diminished in the last 20 years, at least considering the enormous price increase commercial property has had since the financial crisis. We believe that the biggest disadvantages of research in this area is that it is difficult to collect good data, in the form of monthly data, quarterly data and other interesting data such as vacancy rate.

The results we obtained in our preferred model agree well with some results from previous research, while at the same time, it does not agree well with other previous research. We believe that we have obtained a good data set with valid and reliable data. Nevertheless, we also believe that our interpolation on the dependent variable, price index, may have influenced the results to a certain extent, and as something that can have created bias in the results. Due to the data and the thesis in total, we have gotten a lot more challenges than we thought in the beginning, but we have a feeling we have solved it in an excellent way.

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Model outputs

Model 1

Source	SS	df	MS
Model	4.5536e-07	6	7.5894e-08
Residual	4.1925e-06	87	4.8190e-08
Total	4.6479e-06	93	4.9977e-08

Number of obs	=	94
F(6, 87)	=	1.57
Prob > F	=	0.1641
R-squared	=	0.0980
Adj R-squared	=	0.0358
Root MSE	=	.00022

DDlogpriceindex	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
DDlogunemploymentrate	.001047	.0014092	0.74	0.459	-.0017539	.003848
DDlogpolicyrate	-.0000401	.000189	-0.21	0.832	-.0004159	.0003356
DDlogbuildingcosts	-.0094656	.0074366	-1.27	0.206	-.0242467	.0053154
DDloginflation	-.0123715	.0049039	-2.52	0.013	-.0221185	-.0026245
DDlogsquaremeterstotalmass	.0094962	.0267481	0.36	0.723	-.0436685	.0626608
DDloggdp	-.0000567	.0001517	-0.37	0.709	-.0003582	.0002447
_cons	-.0000249	.0000227	-1.10	0.275	-.0000699	.0000201

Durbin-Watson d-statistic(7, 94) = 2.032982

Model 2

Source	SS	df	MS
Model	1.1729e-06	6	1.9548e-07
Residual	3.4744e-06	86	4.0400e-08
Total	4.6473e-06	92	5.0514e-08

Number of obs	=	93
F(6, 86)	=	4.84
Prob > F	=	0.0003
R-squared	=	0.2524
Adj R-squared	=	0.2002
Root MSE	=	.0002

L.DDlogpriceindex	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
DDlogunemploymentrate	-.0020221	.0013083	-1.55	0.126	-.004623	.0005788
DDlogpolicyrate	-.0006479	.0001759	-3.68	0.000	-.0009977	-.0002981
DDlogbuildingcosts	.0121927	.0070492	1.73	0.087	-.0018206	.026206
DDloginflation						
L1.	-.0124287	.0038912	-3.19	0.002	-.0201642	-.0046932
DDlogsquaremeterstotalmass						
L1.	-.0108324	.0266478	-0.41	0.685	-.0638065	.0421417
DDloggdp	-.000148	.000127	-1.17	0.247	-.0004004	.0001044
_cons	-.0000227	.0000209	-1.09	0.279	-.0000642	.0000188

Durbin-Watson d-statistic(7, 93) = 1.814998

Model 3

Source	SS	df	MS
Model	1.1756e-06	4	2.9389e-07
Residual	3.4718e-06	88	3.9452e-08
Total	4.6473e-06	92	5.0514e-08

Number of obs	=	93
F(4, 88)	=	7.45
Prob > F	=	0.0000
R-squared	=	0.2530
Adj R-squared	=	0.2190
Root MSE	=	.0002

L.DDlogpriceindex	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
DDlogpolicyrate	-.0006466	.0001729	-3.74	0.000	-.0009903	-.000303
DDlogbuildingcosts	.0147573	.0068051	2.17	0.033	.0012335	.0282811
DDloginflation						
L1.	-.0141822	.0037331	-3.80	0.000	-.021601	-.0067635
DDlogsquaremeterstotalmass	-.0431298	.0210459	-2.05	0.043	-.0849542	-.0013054
_cons	-.0000231	.0000206	-1.12	0.266	-.000064	.0000179

Durbin-Watson d-statistic(5, 93) = 1.831141

Model 4

Linear regression

Number of obs	=	93
F(4, 88)	=	2.22
Prob > F	=	0.0729
R-squared	=	0.2530
Root MSE	=	.0002

L.DDlogpriceindex	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
DDlogpolicyrate	-.0006466	.0003858	-1.68	0.097	-.0014133	.00012
DDlogbuildingcosts	.0147573	.0093297	1.58	0.117	-.0037834	.033298
DDloginflation						
L1.	-.0141822	.0071357	-1.99	0.050	-.0283629	-1.58e-06
DDlogsquaremeterstotalmass	-.0431298	.0175889	-2.45	0.016	-.078084	-.0081756
_cons	-.0000231	.0000207	-1.11	0.269	-.0000642	.0000181

Durbin-Watson d-statistic(5, 93) = 1.831141