



LUND UNIVERSITY

School of Economics and Management

Oil Price Changes and the Oslo Stock Exchange

A study of how oil price changes affected the Oslo Stock Exchange between 1990-2009

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Abstract

This paper addresses how oil price changes affect the Oslo Stock Exchange. Multiple linear regressions with eight explanatory variables have been used to investigate the relationship between oil and the Oslo Stock Exchange between 1990-2009. The time period has also been divided into two sub periods to investigate if the effects of oil price changes have become more prominent over the years. After deliberating between univariate and multivariate models we decided to use a multiple linear regression. The six sources of error of the OLS model have been thoroughly discussed and examined. The variables used in the regressions have been selected by revising previous research and economic theory.

The results for the entire period show that oil had a significant positive effect on the stock market with a coefficient of 0.24. This was not unexpected and is in accordance with our hypothesis. The same result was obtained for the first sub-period, 1990-1999. However, looking at the second sub period, 2000-2009, oil proved not to be significant. This result was surprising as it is contradictory to most previous research. Despite not being significant, investigations of the relationship between oil prices and the stock market showed that they remained rather correlated. This profound result is very interesting and might be explained by an underlying variable our model has not been able to capture.

Keywords: Oil price, Oslo Stock Exchange, Multiple Linear Regression, Mean Average Process

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1.

Introduction

Norway's oil and gas journey started in the late 1950s when the Dutch found gas in the Norwegian Sea. On the 13th of April 1965, 22 exploration and production licenses were rewarded to different contractors and already during the summer of 1966 the first well was drilled, however, it came out dry. It was not until 1969 the journey really started when the first oil- and gas field *Ekofisk* was found. Only a few years later the Norwegian-owned oil company Statoil was established, which today is by far the largest company on the Oslo Stock Exchange.¹ The relationship between oil price and stock returns has been discussed and thoroughly researched through the years. Since the oil and energy sector is such a vast part of the Oslo Stock Exchange it is interesting to see the effect of oil price changes on the stock market.

1.1 Purpose and research question

The purpose of this paper is to investigate the relationship between changes in oil price and stock prices on the Oslo Stock Exchange. The hypothesis of this paper is that changes in oil price have a significant effect on the stock market. The research question of this paper is: *How did changes in oil price affect the Oslo Stock Exchange during 1990-2009, and were these effects significant?* Multiple linear regressions with eight different explanatory variables have been constructed in order to assess if such a relationship can be significantly proven.

1.2 Limitations and data

This paper has been limited to investigating the Oslo Stock Exchange covering 20 years starting with the first quarter of 1990 to the last quarter of 2009. The correlation between various stock indices has been investigated and merely two, S&P 500 (USA) and FTSE 100 (Great Britain), have been included as explanatory variables in the regression. All the data have been collected from Thomson Reuters DataStream database except for GDP and inflation figures which have been collected from the

¹ Norwegian Ministry of Petroleum and Energy

Norwegian Central Bureau of Statistics. The GDP figures are real values measured in 2009 price level. The interest rate has been collected from the Central Bank of Norway. All data are quarterly measured as percentage differences.

1.3 Methodology

The method used to investigate the relationship between oil price changes and the Oslo Stock Exchange is a multiple linear regression. When choosing explanatory variables for the regression we have studied similar research and economic theory. All the variables are measured as percentage changes from one quarter to another to remove any stationarity problems that might occur when using time series data. The econometric software EViews 7 has been used when calculating the regression and correcting for sources of error. We have also divided the period 1990-2009 into two sub-periods to more thoroughly investigate if the effects of oil price changes have become more prominent.

When choosing which model to use, different alternatives have been examined in order to find the most appropriate. The model has been tested by adding, removing and lagging the variables to see if the model could be improved. All residual plots have been scrutinized to decide if any variable should be logged, squared or altered in any other way. We have also discussed the possible use of VAR- and other multivariate models, however, in our level of education up until now we have mostly focused on linear regressions, and therefore we have decided to use such a model.

1.4 Disposition

Chapter 2 reviews previous research concerning stock markets and macroeconomic variables. In chapter 3 background information on the oil sector and stock market is provided. Theory of how the pricing mechanism of oil and stocks function is also explained. The actual regression model and the explanatory variables used is introduced in chapter 4. Discussions on the variables effect on the Oslo Stock Exchange are also presented. Chapter 5 describes the theory of the multiple linear regression model used in this paper and the conditions that must be satisfied. Chapter 6 presents our results with an in-depth analysis. In chapter 7 a conclusion is presented and issues for further research are suggested.

2.

Revised Literature

In chapter 2 previous research is revised and discussed. Eleven papers are presented and argued for. The results of the different papers are contradictory as some claim oil price changes have a significant effect on stock market returns and some claim they do not. Despite the contradictory results, consensus seems to be that there is in fact a strong relationship between changes in oil prices and movements on the stock exchange.

Chen, Roll, and Ross (1986) investigated the effect of macroeconomic variables on the stock market. They found, using multivariate time-series regressions, that variables such as interest rate, inflation rate, and industrial production have risks incorporated into the market return. However they did not find any significant relationship between changes in oil price and stock market return. Hamao (1989) replicated the study of Chen et al. in the multi-factor APT framework to investigate the Japanese market and reached the very same conclusion. Kaneko and Lee (1995) later continued the investigation with more recent Japanese equity data and found that their results were contradictory to Hamao and Chen et al. It was evident that the oil price now did in fact have an impact on the stock market.

Jonas and Kaul (1996) studied the stock market's reaction to oil price shocks in the United States, Canada, the United Kingdom and Japan. Based on quarterly data during the postwar period 1974-1991 they tested the hypothesis that oil shocks would be absorbed by changes in both current and future cash flows and in expected return. They reached the conclusion that the American and Canadian markets reacted as expected by directly absorbing the oil price shocks into their current and expected future real cash flows, later confirmed by Papapetrou (2001). However, the results following Britain's and Japan's stock markets were not as apparent and left them rather puzzled. It was not possible to explain the effects of oil price shocks using changes in future cash flows and expected return, consequently, concluding that post war oil shocks had instead generated excess volatility in the market.

Huang, Masukis and Stoll (1996) showed that oil futures strongly affected individual oil companies stocks, but had no significant effect on larger indices like the S&P 500. Thus, stating that oil price shocks had no influence on the aggregate economy. Ciner (2001) strongly refuted this result and claimed that Huang Masukis and Stoll had disregarded strong non-linear linkages. Ciner, using HMS data, found “*a significant nonlinear causal correlation between crude oil futures returns to S&P 500 index returns and evidence that stock index returns also affect crude oil futures*”.²

Sadorsky (1999) used a vector autoregressive model (VAR) when analyzing monthly data during the period 1947-1996. In the research paper “*Oil price shocks and stock market activity*” he investigated the relationship between oil prices, interest rate, consumer price index, and industrial production in the United States. When studying the total period, Sadorsky found that the stock market explained most of its own variance. He also found that interest rate shocks had a greater impact on the stock market than oil price shocks. However, when dividing the examined period into two sub-periods, 1950-1985 and 1986-1996, he discovered that in the second sub period oil price shocks played a greater role in explaining the stock market variance compared to sub period one. Further, Sadorsky tested for symmetry and discovered that fluctuations in oil prices had an asymmetric effect on the stock market, in this case negative oil price shocks had a greater effect than positive.

Basher and Sadorsky (2004) used an international multi-factor model that allowed for both conditional and unconditional risk factors to study the effects of oil price changes on emerging stock market returns. The data presented in their study covered daily closing prices for 21 emerging stock markets. The data retrieved from DataStream included the period December 31st 1992 to October 31st 2005 totaling 3348 observations. The study was carried out in two steps. Firstly, an *unconditional* model to test the relationship between world stocks return, exchange rate, country market returns, and oil price, and secondly, a *conditional* model including two binary variables. D_1 equaled one (zero) if the market was negative (positive) and D_2 equaled one (zero) if the oil return was positive (negative) to later test for symmetry. They

² Ciner 2001, p. 204

concluded that oil price risk is positive and significant at the 10 % level in most models and that an asymmetric effect was evident.

Hammoudeh and Li (2005) examined the effect of oil price changes on the stock market specifically in economies that are net exporters of oil. Using data from Norway and Mexico during the period 1986-2003 to compute a VAR model they proved that both stock market indices were highly positively affected by rising oil prices. This meant that the gained revenues, due to the increase in the oil price, would be reflected by an upsurge in the stock market.

Park and Ratti (2008) examined in their paper “*Oil price shocks and stock markets in the U.S. and 13 European countries*” the effect of oil price shocks on the stock market through a VAR analysis. The 13 European countries were Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, The Netherlands, Norway, Spain, Sweden and the United Kingdom. The result showed that oil price shocks significantly decreased stock return in all countries but USA and Norway. This strengthened Hammoudeh and Li’s previous research further. Higher oil prices decreased net oil importing countries’ stock return and vice versa.

3.

The Oil Sector and Stock Exchange

In this chapter pricing of oil and the elements of the oil sector are revised. Brief explanations of how the oil price has developed through the years is also presented. Similarly, a section about the pricing of stocks and the Oslo Stock Exchange is described and the chapter ends with a visual explanation of the Oslo Stock Exchange's sector composition.

The oil business is renowned to be very unpredictable. Factors such as business cycles, production capacities and oil price highly affect oil companies' profitability. Rising oil prices result in a more lucrative market and a direct increase in company profits. The oil value chain is divided in three separate segments: upstream, midstream and downstream. Norway merely has two refineries and has instead focused on becoming world leading within exploration and production.³ The different segments are as follows⁴

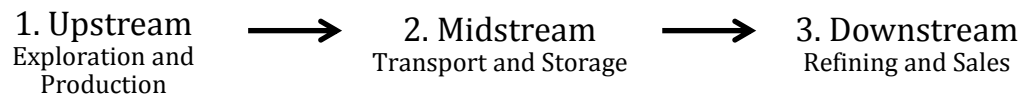


Figure 1 – Oil value chain

3.1 Pricing of oil

Pricing of oil is a mechanism very much decided by supply and demand and is highly correlated to the dynamics of macroeconomics. Oil is an input used in virtually every part of the industrial economy and thus in abundant demand. As an economy grows so does the demand for oil. USA is the absolute largest importer of oil, but the demand among growing economies is steadily rising and frequently pressuring the oil price to new heights.⁵ Oilfields are very geographically dependent, and the majority of the world's oilfields are found in the Middle East. The Organization of Petroleum

³ Store Norske Leksikon

⁴ MLP Investor

⁵ U.S Energy Information Administration

Exporting Countries (OPEC) consists of twelve countries and controls the production of oil in the Middle East. The purpose of OPEC is to stabilize the oil market and guarantee high returns to all member countries. The oil production among OPEC members is sufficient enough to influence the oil pricing through their supply policies.⁶

Oil is one of the most important sources of energy in the world. The high dependency on oil results in an extremely inelastic short-run demand curve. The short-run supply of oil is limited and the refining process long, also resulting in an inelastic supply curve.

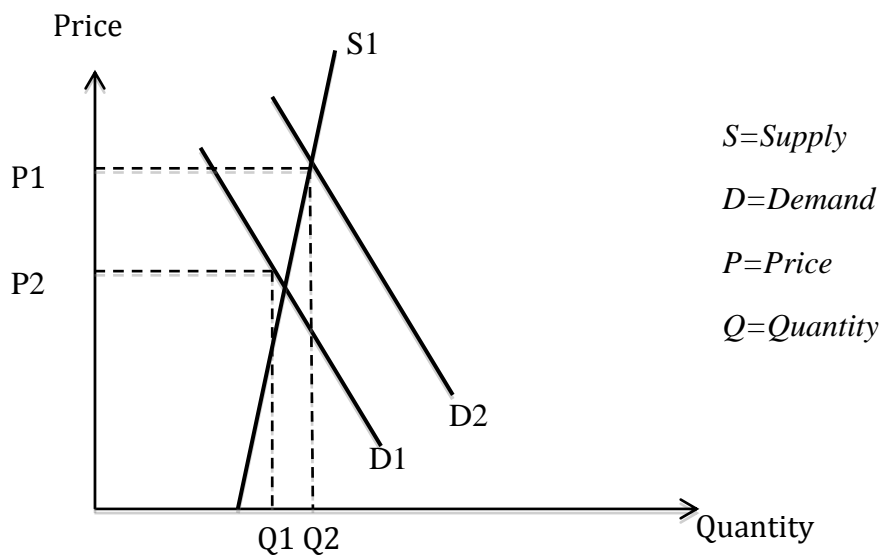


Figure 2 – Oil supply and demand

Figure 2 shows the effect of a positive demand shock for oil when both demand and supply are inelastic.⁷ The demand curve shifts from D_1 to D_2 , and evidently changes in demand result in large price and small quantity changes.

This is the case in the short-run, however, in a longer perspective advances in technology will alter this slightly since there will be new and more effective ways of refining oil. Substitutes for oil will slowly transfer energy demand away from oil and consequently force the demand curve to become more elastic.

⁶ Rousseau 1998, p. 1

⁷ Economist help

3.2 Oil price development

Figure 3 shows the development of the price of Brent blend (\$/barrel) from 1990 to 2010. Brent blend is the denotation for the different types of oil in the North Sea.⁸

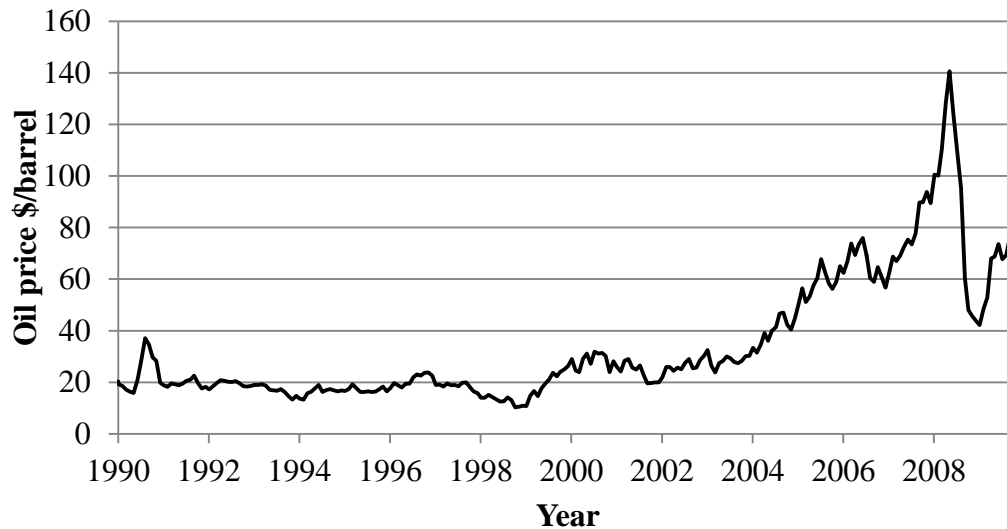


Figure 3 – Oil price development

The figure shows a steady upward trend in the oil price with the exception of a few extraordinary peaks.⁹ The jump in oil price from about 20 to 40 \$/barrel in 1990 can be explained by the Gulf War. When Iraq invaded Kuwait two major OPEC members stopped exporting oil, which led to a supply shock and an abrupt increase in price.¹⁰

The exponential rise in prices from 1999 to 2008 can be linked back to a conjunction of events such as the war against terror in the Middle East, natural disasters and increased demand due to the world's economic growth. The oil price peaked at 140 \$/barrel in 2008 and then plummeted during the financial crisis. As the world's economies slowly recovered during 2009-2010 so did the demand for oil, and its price has shown a gradual increase ever since.

3.3 Pricing of a stock

There exists several types of stocks, but the most traded stocks are preferred and common stocks. Preferred stocks are only entitled to a share of the dividend payments

⁸ Schofield 2007

⁹ Thomson Reuters DataStream

¹⁰ Rousseau 1998, p. 4

while common stocks typically also have voting rights. The fluctuations in stock prices can be explained by simple supply and demand. For example, if a large stakeholder decides to sell his entire share, the market will experience a supply shock and the stock price will decline due to excess supply.

One of the widely accepted stock pricing models is called the discounted cash flow model.¹¹ Typical cash flows received from a stock are dividend payments and the capital acquired when selling the stock. According to Elton and Gruber (2009) “discounted cash flow models are based on the concept that the value of a share of stock is equal to the present value of the cash flow that the stockholder expects to receive from it”.¹² Equation 1 shows how the value of a stock is dependent on the cash flow at period t (CF_t), the discounted rate (r) and the amount of periods the stock exists (N).

$$Value = \sum_{t=1}^N \frac{CF_t}{(1+r)^t}$$

Equation 1 – Pricing of stocks

Companies that are dependent on oil as an input factor (for example the shipping, aviation, and transport industry) are highly sensitive to changes in oil price. Higher prices result in higher costs and consequently lower profits. A dividend payment is defined as the portion of the corporate profits paid back to the company stakeholders, thus lower profits would shrink dividend payments and investors cash flow accordingly.¹³ Companies that, on the other hand, produce and sell oil (output factor) will experience the complete opposite effect.

3.4 Oslo Stock Exchange

King Carl Johan of Norway officially opened Christiania Exchange, now known as Oslo Stock Exchange, in April 1819. Its main purpose was to enable the trade of exchange rates. It was not until the beginning of the 20th century it became an exchange for commodities with listed prices for various goods. On 1 March 1881 the

¹¹ Graham et al. 2010, p. 140

¹² Elton et al. 2009, p 396-427

¹³ Business dictionary

first ever list of prices for 16 bonds and 23 shares was published, and is regarded as the date of origin of the modern Norwegian equity market.¹⁴ The index used in this study is the Oslo Exchange Benchmark – Total Return Index (OSEBX). The index functions as an indicator of the performance of the Oslo Stock Exchange and has a base value of 100 on the 31st of Dec 1995.¹⁵



Figure 4 – Oslo Stock Exchange development

Figure 4 shows the development on the Oslo Stock Exchange between 1990-2011. The stock exchange showed a steady upward trend through the 90s with the exception of the dip in 1998. During 2000-2003 the stock market lost half its value, which can largely be explained by the dotcom-bubble. However, the market quickly recovered and experienced an astonishing exponential growth all the way through 2007 and peaked at all-time-high 510 points. When the financial crisis hit in late 2007, oil prices as well as the stock market plummeted by more than 50%.

Norway has become one of the world leading countries in production and exportation of oil and gas, which has resulted in a substantial growth of the energy sector. Further, Statoil is the largest company within the energy sector and has one fourth of the total stock exchange market value.¹⁶ With the energy sector expanding and increasing its share of the total market value, the stock exchange should have become more exposed to fluctuations in oil and gas prices and exports.

¹⁴ Oslo Stock Exchange

¹⁵ Bloomberg

¹⁶ Statoil

3.4.1 Sector Composition

Stock exchanges are usually built up by several smaller sectors. Depending on the characteristics of the companies they get divided into similar groups, so called sectors. In this paper the companies have been divided by the international standard GICS (Global Industry Classification Standard) developed by Standard & Poor.¹⁷ The energy sector approximately aggregates to half of Oslo Stock Exchange's market value, and thus plays a huge role in the Norwegian economy. Within the energy sector we find companies that expertise in the construction of oilrigs, drilling equipment, and other related services. Research and exploration activities, production, refining and transport of oil and gas products are also included.

Knowledge regarding the development of the sector composition is essential when understanding the stock exchange's economic function. When evaluating the effect of a change in oil price on the Oslo Stock Exchange, it is important to know how large the proportion of companies related to the oil industry is.

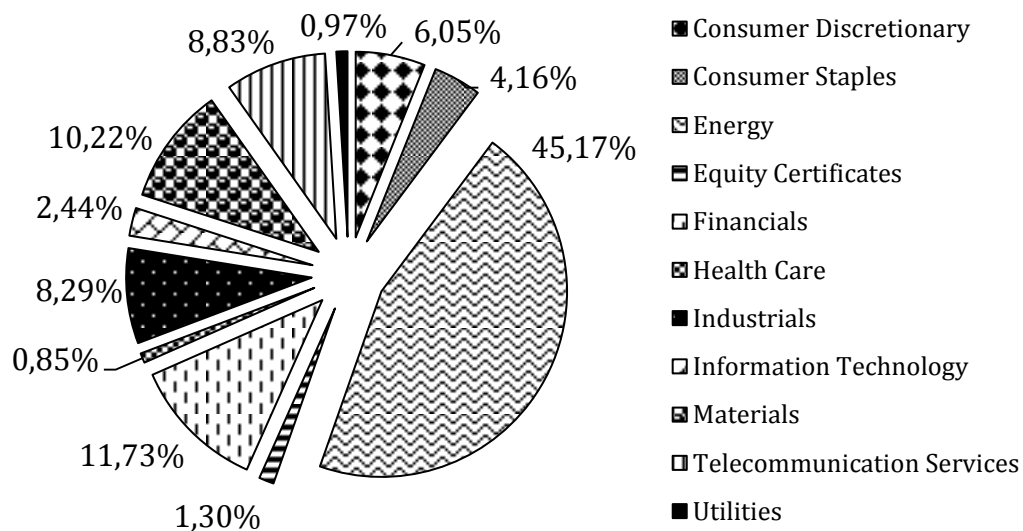


Figure 5 – Sector composition

The Oslo Stock Exchange consists of 45.17 percent energy related companies.¹⁸ Oil, as a major contributive factor to these companies' profits, should therefore have a significant impact on the companies' stock performance.

¹⁷ Oslo Stock Exchange 2010

¹⁸ Ibid.

4.

Regression parameters

In this chapter all the regression parameters are specified. The choice of regression parameters is reasoned for and explained. A thorough description of all the variables is given and discussions of how they ought to affect the Oslo Stock Exchange are held.

Modeling the Oslo Stock Exchange against merely oil price would generate serious estimation complications due to Omitted Variable Bias (OVB). According to Barreto and Howland (2006), OVB arises when the relationship between two variables is explained, but important variables that correlate and, or have a significant relationship with the dependent variable are excluded.¹⁹ It is therefore crucial to include other explanatory variables to avoid such a bias. We have used a number of explanatory variables when trying to explain as much variation as possible on the Oslo Stock Exchange. We have chosen the variables with regard to previous research and economic theory. Our regression model consists therefore of eight explanatory variables and is shown below

$$\Delta OSEBX = \beta_1 + \beta_2 \Delta CPI + \beta_3 \Delta GDP + \beta_4 \Delta \text{Interest Rate} + \beta_5 \Delta NOK / USD + \beta_6 \Delta NOK / GBP + \beta_7 \Delta FTSE 100 + \beta_8 \Delta S \& P 500 + \beta_9 \Delta \text{Oil Price}$$

Δ = Percentage Change

$OSEBX$ = Oslo Stock Exchange – Benchmark Index

CPI = Consumer Price Index

GDP = Gross Domestic Product

NOK/USD = Exchange rate US Dollars and Norwegian Krone

NOK/GBP = Exchange rate British Pound and Norwegian Krone

$FTSE 100$ = 100 largest stocks on the London Stock Exchange

$S\&P 500$ = 500 largest stocks on the New York Stock Exchange and NASDAQ

Equation 2 – Regression model

4.1 Dependent variable

Data for the stock market have been collected quarterly from Thomson Reuters Datastream and estimated as quarterly price differences in percent. Data from the first quarter of 1990 to the last quarter of 2009 have been used.

¹⁹ Barreto et al. 2006, p. 493

4.2 Explanatory variables

4.2.1 Gross Domestic Product

Gross domestic product (GDP) measures the value of all goods and services produced within a country during a specific time period, and is calculated using the following formula²⁰

$$GDP = Private\ consumption + Industry\ investments + Government\ spending + Export - Imports$$

Equation 3 – Gross Domestic Product

We have used quarterly GDP values starting 1 January 1990 from the Norwegian Central Bureau of Statistics in the regression. All values are measured in 2009 price levels.

4.2.2 Interest rate

The Norwegian interest rate is set by the Central Bank of Norway. An increase in the interest rate makes it more expensive for banks to borrow money, which again leads to higher borrowing costs for the individual consumer. Essentially, it becomes more attractive to save than to spend money. Companies are also affected since it becomes more expensive to take loans and invest, which will lead to lower profits.²¹ This could lower the stock prices for the companies since their estimated cash flow will go down.

Low interest rates result in more money being pushed into the economy. More money will be spent which will further lead to more investments and larger company profits. Low interest rates thus have a positive effect on the stock market as companies increase their future estimated cash flows. A consequence of low interest rate can be high inflation as more money circulates in the economy.²² In calculating the interest rates between 1990-2009 we have used quarterly data from the Central Bank of Norway.

²⁰ Swedbank

²¹ Ibid.

²² Ibid.

4.2.3 Inflation

In an economy, inflation measures the rise in general price level and is measured using consumer price index (CPI). To calculate CPI, the price of a basket of goods and services is each month compared to the very same basket as the month before.²³ Inflation arises when there is too much money chasing too few goods in the economy.²⁴ Inflation results in future income being worth less and thus has a negative effect on companies' stock performance. For this reason inflation ought to have a negative effect on our dependent variable. We have used quarterly CPI data from the Norwegian Central Bureau of Statistics.

4.2.4 Oil

Oil is an important input factor to the industrial sector and on the contrary an output factor to most of the energy sector. Changes in the price of oil ought to have a direct effect on companies' current and future cash flows and therefore affect the stock performance. An increase in the oil price would significantly increase the industrial sector's production costs and thus lower profit margins. On the other hand it would generate higher revenues to oil companies within the energy sector. The energy sector accounts for 45.17 percent of the total Oslo Stock Exchange market value, and thus fluctuations in the oil price should be apparent in the stock market's performance. Further, the oil price is defined as Brent Blend 1 Month Future and has been collected quarterly from Thomson Reuters DataStream.

4.2.5 FTSE 100 and S&P 500

Norway is considered a small economy highly dependent on export of raw materials and semi-processed goods such as oil, fish, minerals and forestry.²⁵ The international demand for Norwegian exports majorly affects the domestic economy. In order to capture this variation the two major stock indices S&P 500 (New York Stock Exchange and NASDAQ) and FTSE 100 (London Stock Exchange) are included as variables to represent the world's demand. Well performing stock indices indicate booming economies with high demand for local as well as foreign goods. In later

²³ Riksbanken

²⁴ Swedbank

²⁵ CIA World Factbook

years globalization has become a vital part of economics and the stock exchanges are now interlinked more than ever. International trade, technology transfers and capital flow between economies have created strong relationships.

	OSEBX	FTSE 100	S&P 500	TOPIX	CHSCOMP
OSEBX	1				
FTSE 100	0,73	1			
S&P 500	0,50	0,52	1		
TOPIX	0,47	0,46	0,42	1	
CHSCOMP	0,15	0,09	0,19	0,07	1

Table 1. Correlation matrix between Oslo, London, USA, Tokyo and Shanghai stock indices (1990.01 – 2010.01).

The correlation matrix above shows that FTSE 100 and S&P 500 are highly correlated with the Oslo Stock Exchange.²⁶ We have also calculated the correlation between the Oslo Stock Exchange and Tokyo Stock Exchange (TOPIX) as well as Shanghai Stock Exchange (CHSCOMP). Since both showed lower correlation with the Oslo Stock Exchange we decided to exclude them from the regression analysis and only include FTSE 100 and S&P 500.

4.2.6 Exchange rate NOK/USD and NOK/GBP

All large oil transactions take place in dollars.²⁷ This means that Norwegian companies that have cash flows in NOK will be sensitive to changes in the exchange rate. Kaneko and Lee (2005) found, in their study on the Japanese stock market, the relationship between the stock exchange and the exchange rate to be significant. For these reasons we have decided to include NOK/USD as a variable to capture the impact on companies' profits.

London is known to be the financial center of Europe. London Stock Exchange has a high liquidity and is therefore an arena for large transactions which many other stock markets are unable to perform. Great Britain accounts for 26.7 % of Norwegian exports and is thus Norway's largest export partner.²⁸ Trades are often made in Pound/Kroner or Kroner/Pound which makes the exchange rate between the two an essential part of the Norwegian economy.

²⁶ Reuters Datastream

²⁷ The Guardian

²⁸ CIA World Factbook

5.

Modeling

Chapter 5 explains the theory behind the regression model used. All of the conditions for the model are stated and the possible sources of error are elaborated. Detailed procedures of how to correct for all possible sources of errors in our regression are thoroughly explained.

When choosing a model to use we have revised several different types of models in order to find an appropriate one. VAR-models, factor analysis and linear regressions are some of the approaches discussed. We have based our decision upon the econometric courses we have studied up until now. During these courses the focus has been on linear regressions estimated with ordinary least square, and therefore we have decided to follow a similar approach. With this method we have the appropriate knowledge and expertise to conduct the regressions needed to investigate our research question.

5.1 Multiple linear regression

When estimating relationships between different variables, linear regressions can be an appropriate method to use. In the case of several explanatory variables, a multiple linear regression must be used.

$$y_i = \beta_1 + \beta_2 x_{1i} + \beta_3 x_{2i} + \dots + \beta_k x_{(k-1)i} + e_i$$

Equation 4 – Multiple Linear Model

β_i denotes the gradient and x_{ki} the explanatory variables. The interpretation of the β_i -coefficients are made under a strict ceteris paribus condition.²⁹ The purpose of using a multiple linear regression is to capture as much variation as possible in the dependent variable through the explanatory variables. It is important to base the

²⁹ Westerlund 2005, p. 138

choice of such variables upon previous research and economic theory in order to attain an appropriate model.

5.2 Ordinary Least Square

In order to estimate the β_i -coefficients we have used an OLS (Ordinary Least Squares) estimator. OLS models choose β_i in a way that minimizes the sum of squared distances from the predicted line and the observed values x_i and y_i .³⁰

For this method to be valid a number of conditions must be satisfied³¹

- 1) The dependent variable is a linear function of the explanatory variables.

$$y_i = \beta_1 + \beta_2 x_{1i} + \beta_3 x_{2i} + \dots + \beta_k x_{(k-1)i} + e_i$$

Equation 5 – OLS condition 1

- 2) The expected value of the residuals equals zero.

$$E(e_i) = 0$$

Equation 6 - OLS condition 2

- 3) The residuals are homoscedastic, meaning that they have the same variance for every i .

$$\text{Var}(e_i) = \sigma^2$$

Equation 7 - OLS condition 3

- 4) The covariance between e_i and e_j is zero for every (i,j) and thus the residuals are uncorrelated.

$$\text{Cov}(e_i, e_j) = 0 \text{ if } i \neq j$$

Equation 8 - OLS condition 4

- 5) x_{ki} is not random and there is no exact linear relationship between the x -variables.

³⁰ Ibid. p. 75

³¹ Ibid. p. 140

- 6) The residuals follow a normal distribution with the expected value 0 and variance σ^2 .

$$e_i \in N(0, \sigma^2)$$

Equation 9 - OLS condition 6

5.3 Sources of error

If conditions one to five are satisfied, OLS is the most efficient estimator. In order to use OLS and make correct interpretations of the regression the sixth condition must also be satisfied. We have tested for all six sources of error and corrected them where appropriate.

5.3.1 Homoscedasticity

If condition 3 is not satisfied the residuals are heteroscedastic. In other words the variance for the residuals is not constant. In such cases OLS is no longer the best and most efficient estimator for the regression, and correct inference and confidence intervals will no longer be possible.³² To examine if the residuals are heteroscedastic, plot the residuals against each x -variable and look for systematic variation amongst the spread of the observations. If a systematic variation is evident the residuals are heteroscedastic. A more accurate way of examining the residuals is to perform a Goldfeld-Quandt- or a Whites test. The difference between the two test methods is that the Goldfeld-Quandt test only can discover proportional heteroscedasticity whilst Whites test can discover all kinds of heteroscedasticity. We have therefore used Whites test when testing for condition three.³³ The test states following hypothesizes

H₀: Homoscedastic residuals

H₁: Heteroscedastic residuals

Starting with the multiple linear regression model

$$y_i = \beta_1 + \beta_2 x_{1i} + \beta_3 x_{2i} + \dots + \beta_k x_{(k-1)i} + e_i$$

Equation 10 – Multiple Linear Model

³² Ibid. p. 173ff

³³ Ibid. p. 180f

we can estimate the coefficients and calculate the residuals. The following equation is attained

$$\hat{e}_i^2 = \alpha_1 + \alpha_2 x_{1i} + \dots + \alpha_{ki} + \alpha_2 x_{1i}^2 + \dots + \alpha_{ki}^2 x_{(k-1)i}^2 + u_i$$

Equation 11 – Whites test: residuals

where u_i is an error term and α_i are slope coefficients. If, when estimating the new equation, all slope coefficients equal zero we are merely left with the intercept and error term $e_i^2 = \alpha_1 + u_i$. In a calculation of the variance we then have

$$\hat{\sigma}^2 = \frac{\sum_{i=1}^N \hat{e}_i^2}{N-k} = \frac{\sum_{i=1}^N (\alpha_1 - u_i)}{N-k} = \frac{\sum_{i=1}^N \alpha_1 - \sum_{i=1}^N u_i}{N-k} = \frac{\sum_{i=1}^N \alpha_1}{N-k} = \frac{N\alpha_1}{N-k}$$

Equation 12 – Whites test: variance

since $\sum u_i = 0$ and α_1 is a constant. As can be seen in equation 12 the variance is constant and the residuals are homoscedastic. If at least one of the slope coefficients equal any other value than zero the residuals are heteroscedastic.³⁴

In our regression we tested the residuals with White's test and received a p-value of 0.67 which indicates that we have homoscedastic residuals.

Heteroscedasticity Test: White	
F-statistic	0.87
Prob. F(44,35)	0.67

Table 2. Heteroscedasticity test

5.3.2 Autocorrelation

If the observations are dependent the data suffer from autocorrelation thus violating condition four. In such cases OLS is no longer the best linear and unbiased estimator (BLUE), and more efficient estimators with lower variance could be used to estimate

³⁴ Gujarati et al. 2009, p. 387

the regression coefficients. To test for autocorrelation, graphically examine the residuals against time and look for systematic variation or use a Durbin Watson test. Durbin Watson tests are conducted under the hypothesizes

H₀: No autocorrelation, ρ=0

H₁: Autocorrelation ρ > 0

The alternative hypothesis tests for positive autocorrelation since it is the most common kind of autocorrelation. By using the residuals from our multiple linear regression we can calculate the Durbin Watson-statistic

$$\begin{aligned}
 DW &= \frac{\sum_{i=2}^N (\hat{e}_i - \hat{e}_{i-1})^2}{\sum_{i=1}^N \hat{e}_i^2} = \frac{\sum_{i=2}^N \hat{e}_i^2 + \sum_{i=2}^N \hat{e}_{i-1}^2 - 2\sum_{i=2}^N \hat{e}_i \hat{e}_{i-1}}{\sum_{i=1}^N \hat{e}_i^2} = \frac{\sum_{i=2}^N \hat{e}_i^2}{\sum_{i=1}^N \hat{e}_i^2} + \frac{\sum_{i=2}^N \hat{e}_{i-1}^2}{\sum_{i=1}^N \hat{e}_i^2} - 2 \frac{\sum_{i=2}^N \hat{e}_i \hat{e}_{i-1}}{\sum_{i=1}^N \hat{e}_i^2} \\
 &\approx 1 + 1 - 2\hat{\rho} \\
 &= 2(1 - \hat{\rho})
 \end{aligned}$$

Equation 13 – Durbin Watson test

If $\hat{\rho} = 0$ the DW-statistic is approximately 2 and indicates no autocorrelation. If the regression suffers from positive autocorrelation on the other hand, the DW-statistic would be close to 0. The DW-value is compared to two critical values (D_{upper} and D_{lower}) to decide whether or not to discard the null hypothesis.³⁵

If $DW > D_{upper}$ the null hypothesis cannot be rejected

If $DW < D_{lower}$ the null hypothesis is rejected

Autocorrelation test: Durbin Watson

DW-statistic	2.04
Upper value	1.799
Lower value	0.895

Table 3. Autocorrelation test

³⁵ Westerlund 2005, p. 185, 195ff

In our regression we obtain a Durbin Watson value of 2.04. This is compared to the upper and lower critical values for eight explanatory variables and 80 observations. The upper value is 1.799 and the lower value is 0.895. Since the Durbin Watson value of 2.04 is larger than the upper critical value 1.799, the null hypothesis cannot be rejected. This means that no autocorrelation can be found amongst the residuals. Looking at the residuals plotted against time in figure 6 confirms this.

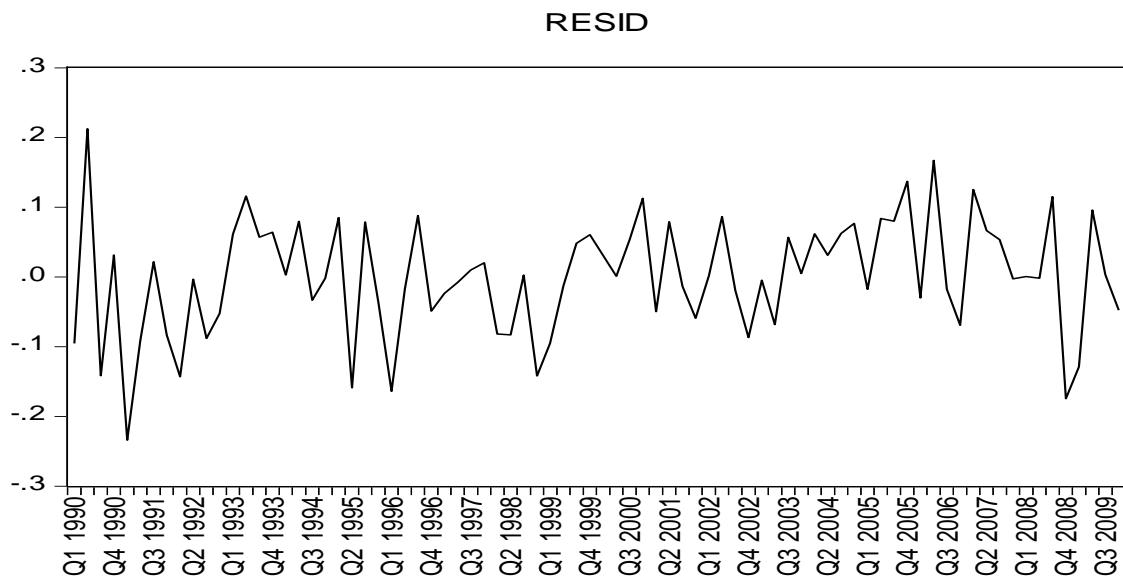


Figure 6 – Residual versus time

5.3.3 Normal distribution

If the sample is small the residuals must be normally distributed. This condition must be satisfied in order for correct and valid inference and confidence intervals to be possible. By using a Jarque-Bera test the residuals can be tested for the normality assumption by the following equations

$$JB = \frac{N}{6} \left(S^2 + \frac{(k-3)^2}{4} \right)$$

$$S = \frac{1}{N} \sum \frac{\hat{e}_i^3}{\hat{\sigma}^3}$$

$$k = \frac{1}{N} \sum \frac{\hat{e}_i^4}{\hat{\sigma}^4}$$

Equation 14 – Jarque Bera test

where S is a measurement for skewness of the residuals' probability distribution and k measures the kurtosis of the probability distribution. If the condition is satisfied, S will be close to zero and k will be close to three. The test statistic should therefore be close to zero in order for the normality condition to be fulfilled.³⁶

In our regression we obtained a JB-value of 0.95, which should be compared to appropriate critical values. However, the test also provides us with a p-value and needs only be compared to a chosen confidence level. In our regression we received a p-value of 0.62 which indicates that the residuals fulfill the assumption of normality.

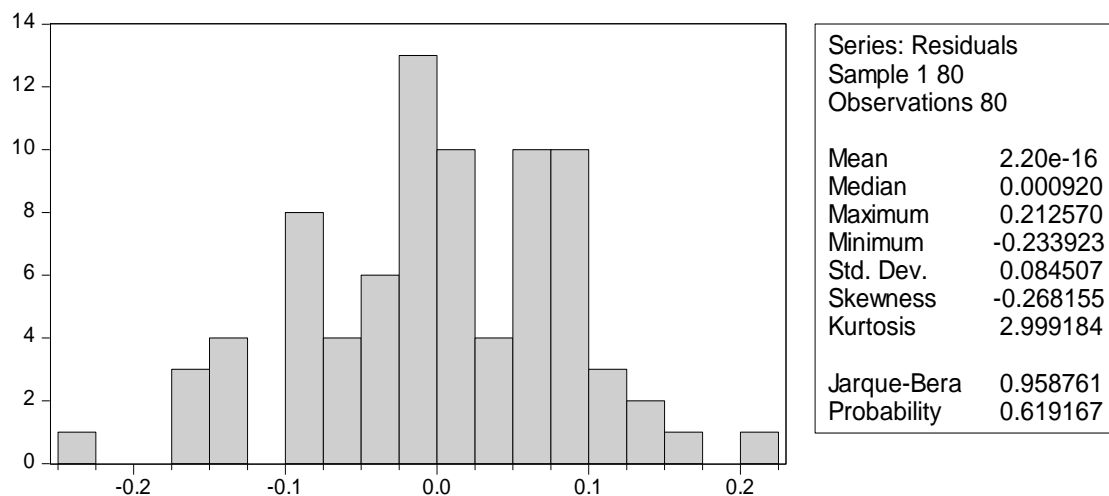


Figure 7 – Normality test

5.3.4 Multicollinearity

When estimating a model using more than one explanatory variable, the possibility of multicollinearity arises. When two variables are highly correlated, it can be difficult to separate their individual effects on the dependent variable since they virtually contain the same information. In models with multicollinearity, high variance and covariance is a common problem. As a result deciding which signs the regression coefficients should have become difficult. High R^2 -values together with few significant t-statistics is a typical indication of multicollinearity. When obtaining high R^2 -values, all F-tests constructed will likely reject the null-hypothesis indicating that the regressions slope coefficients equals zero, meaning that the t-statistics should be significant. This will not be the case if the degree of multicollinearity is high since most t-statistics will be non-significant. To correct for multicollinearity, one of the correlated variables can be discarded without causing the determination coefficient to

³⁶ Ibid. p. 134f

drop significantly. Although, one should be careful when excluding variables from the regression as the regression may become biased.³⁷

Multicollinearity is discussed in matters of degrees and not in matters of testing for its existence. To test the degree of multicollinearity in a regression, a variance inflation factor test (VIF) can be used. First, investigate the co-linearity between the x -variables by estimating regressions where each explanatory variable act as a dependent variable against the other explanatory variables. These equations are called subsidiary regressions.³⁸ In our paper we get seven different subsidiary regressions since we have eight explanatory variables.

$$\begin{aligned}
 x_1 &= \alpha_1 + \alpha_2 x_{2i} + \alpha_3 x_{3i} + \alpha_4 x_{4i} + \alpha_5 x_{5i} + \alpha_6 x_{6i} + \alpha_7 x_{7i} + \alpha_8 x_{8i} + u_i \\
 x_2 &= \alpha_1 + \alpha_1 x_{1i} + \alpha_3 x_{3i} + \alpha_4 x_{4i} + \alpha_5 x_{5i} + \alpha_6 x_{6i} + \alpha_7 x_{7i} + \alpha_8 x_{8i} + u_i \\
 x_3 &= \alpha_1 + \alpha_1 x_{1i} + \alpha_2 x_{2i} + \alpha_4 x_{4i} + \alpha_5 x_{5i} + \alpha_6 x_{6i} + \alpha_7 x_{7i} + \alpha_8 x_{8i} + u_i \\
 x_4 &= \alpha_1 + \alpha_1 x_{1i} + \alpha_2 x_{2i} + \alpha_3 x_{3i} + \alpha_5 x_{5i} + \alpha_6 x_{6i} + \alpha_7 x_{7i} + \alpha_8 x_{8i} + u_i \\
 x_5 &= \alpha_1 + \alpha_1 x_{1i} + \alpha_2 x_{2i} + \alpha_3 x_{3i} + \alpha_4 x_{4i} + \alpha_6 x_{6i} + \alpha_7 x_{7i} + \alpha_8 x_{8i} + u_i \\
 x_6 &= \alpha_1 + \alpha_1 x_{1i} + \alpha_2 x_{2i} + \alpha_3 x_{3i} + \alpha_4 x_{4i} + \alpha_5 x_{5i} + \alpha_7 x_{7i} + \alpha_8 x_{8i} + u_i \\
 x_7 &= \alpha_1 + \alpha_1 x_{1i} + \alpha_2 x_{2i} + \alpha_3 x_{3i} + \alpha_4 x_{4i} + \alpha_5 x_{5i} + \alpha_6 x_{6i} + \alpha_8 x_{8i} + u_i \\
 x_8 &= \alpha_1 + \alpha_1 x_{1i} + \alpha_2 x_{2i} + \alpha_3 x_{3i} + \alpha_4 x_{4i} + \alpha_5 x_{5i} + \alpha_6 x_{6i} + \alpha_7 x_{7i} + u_i
 \end{aligned}$$

Equation 15 – Subsidiary equations

To calculate VIF-values for each regression we used equation 16 where the coefficient of determination was received from each subsidiary regression.

$$VIF_i = \frac{1}{1 - R_i^2}$$

Equation 16 – VIF

³⁷ Gujarati 2006, p. 371ff

³⁸ Ibid.

x_i	R^2 -value	VIF-value
CPI	0.07	1.08
GDP	0.18	1.21
Interest rate	0.40	1.68
Oil	0.45	1.81
NOK/GBP	0.38	1.61
NOK/USD	0.37	1.60
FTSE 100	0.67	3.04
S&P 500	0.68	3.15

Table 4. VIF-values

The VIF value explains how much larger the variance for x_i becomes due to multicollinearity between x_i and the other variables. VIF values close to 1 suggest that there is no co-linearity between the x -variables.³⁹ Since none of our VIF-values are notably high, we do not have to correct for multicollinearity.

5.3.5 Stationarity

The random variable y is said to be stationary if its variance and mean is constant over time. The covariance between two variables should also be independent of time. If more than one non-stationary variable is included in the regression, the inference and confidence intervals can become misleading. The R^2 -value and t-statistics can be high, indicating a strong linear relationship when in fact there might be no relationship at all. The DW value also becomes very low, signifying autocorrelation. Such a regression is called a nonsense regression.⁴⁰ Nonstationarity is not uncommon when handling time series data. If the time series have an upward trend it is usually a sign of nonstationarity.⁴¹ In order to remove this problem we have used percentage differences, removing any possible upward trends.

³⁹ Westerlund 2005, p. 159ff

⁴⁰ Ibid. p. 202, 205

⁴¹ Gujarati 2006, p. 496

6.

Results and analysis

In chapter 6 our results are presented and analyzed. When testing for the period 1990-2009 it can be proven that oil has a significant effect on the Oslo Stock Exchange return. To investigate this in more detail, a moving average process and two separate regressions were executed for two sub-periods, 1990-1999 and 2000-2009. Possible reasons and explanations for the results are discussed and analyzed.

6.1 Original regression

In the first regression we tested the variable OSEBX against 8 different explanatory variables. All variables are measured as percentage differences between the observations.

Variabel	Coefficient	Standard error	P-value
Constant	-1.39	2.17	0.52
CPI	1.12	2.01	0.58
GDP	-0.13	0.27	0.63
Interest rate	-0.24	0.11	0.02**
Oil price	0.23	0.10	0.03**
NOK/GBP	0.46	0.33	0.16
NOK/USD	-0.21	0.21	0.32
FTSE 100	0.57	0.22	0.01**
S & P 500	0.59	0.24	0.01**
R ²	0.57		
Adjusted R ²	0.52		
Durbin-Watson	2.04		

Table 5 . *= significant on a 10 % -level, **=significant on a 5 % -level, ***=significant on a 1 % -level

As shown in table 5, four of the eight explanatory variables proved to be significant on a 5 percent significance level. Interest rate, oil, FTSE 100 and S&P 500 did all show significant effects on OSEBX.

The R^2 -value indicates how much of the total variation in the dependent variable that can be explained by the explanatory variables. This measurement does not consider the number of explanatory variables used in the regression and may thus lead to a misleading conclusion. The R^2 -adjusted value, however, is a much more accurate measurement as it takes the number of explanatory variables into account.

Variabel	Coefficient	Standard error	P-value
Interest rate	-0.24	0.11	0.02**
Oil price	0.23	0.10	0.03**
FTSE 100	0.57	0.22	0.01**
S&P 500	0.59	0.24	0.01**

Table 6. *= significant on a 10 % -level, **=significant on a 5 % -level, ***=significant on a 1 % -level

Since all observations are percentage differences, the interpretation of the regression coefficients will be in percentages. FTSE 100 has a coefficient equal to 0.57 which means that a one-percentage increase on the London Stock Exchange will lead to a 0.57 percent increase on the Oslo Stock Exchange. S&P 500 also has a positive effect on the Oslo Stock Exchange, as its regression coefficient is 0.59. The reason for the positive correlations between the stock markets leads to the argument of economic globalization. There is more and more profound proof of the fact that events in large country's economy also affect smaller economies. Free trade agreements, larger capital flows and technology and labor transfers have created strong relationships between countries, which leads to a more integrated world economy.

The interest rate displays a negative effect on the Oslo Stock Exchange. The regression coefficient of -0.24 indicates that a one-percentage increase of the interest rate leads to a 0.24 percentage decrease on the Oslo Stock Exchange. This is in agreement with our hypothesis from previous chapters. When the central bank increases the interest rate it becomes more expensive for banks to loan money. Consequently banks increase their own borrowing rate and individuals and companies

tend to postpone investments until funding becomes cheaper. This results in a lower aggregate demand. Referring back to the future cash flow model, such an event will affect the stock market as the stock price is set by the future cash flow of the company. When a company cuts back on investments and spending it will consequently decrease future cash flow and therefore lower the stock price.

The variable under scrutiny in this paper, oil, is significant on a five percent confidence level and has a coefficient equal to 0.23. Thus a one-percentage increase in oil price leads to a 0.23 percent increase on the Oslo Stock Exchange. This confirms earlier studies conducted by Kaneko and Lee (1995), Hammoudeh and Li (2005) and Park and Ratti (2008). The result was not unexpected and provides evidence for our hypothesis that changes in oil price does have a significant effect on the Oslo Stock Exchange. Higher oil prices directly increase company profits and consequently the total market value. The energy sector accounts for almost half of Oslo Stock Exchange's market value, and for this reason any other result would be alarming. Hammoudeh and Li and Park and Ratti also advocate that stock markets in net oil-exporting countries benefit from higher oil prices. Norway is a large net exporter of oil and our findings further strengthens their conclusions.

Oslo Stock Exchange's sector composition has undergone some noteworthy changes during the twenty-year time period studied. From the early 1990s to 2010 the energy sector has approximately doubled, and currently has 45.17 percent of the total market value. For this reason it is very interesting to see whether changes in oil price play a more prominent role now than before. To investigate this, the regression above has been divided into two sub periods, 1990-1999 and 2000-2009, to see if oil has had a different effect during the two periods. In both sub regressions all possible sources of error have been corrected for.

6.1.1 Sub-period 1: 1990-1999

Variabel	Coefficient	Standard error	P-value
Constant	4.17	4.41	0.35
CPI	-4.37	4.00	0.28
GDP	0.11	0.47	0.82
Interest rate	-0.51	0.14	0.0007***
Oil price	0.45	0.14	0.0031***
NOK/GBP	0.16	0.45	0.73
NOK/USD	0.64	0.31	0.04**
FTSE 100	0.45	0.25	0.08*
S & P 500	-0.06	0.37	0.87
R ²	0.60		
Adjusted R ²	0.49		
Durbin-Watson	2.05		

Table 7. *= significant on a 10 %-level, **=significant on a 5 %-level, ***=significant on a 1 %-level

In the regression for the period 1990-1999 the same four explanatory variables proved to be significant except for S&P 500 that has been replaced by NOK/USD. The adjusted R²-value decreased to 0.49 and the regression explains less of the variation in OSBEX than the first. Interest rate is significant on a 1 %-level which is a higher level than in the previous regression. On the other hand FTSE 100 is now significant on a 10%-level compared to its previous 5 %-level, indicating that it explains a smaller part of the variation in OSBEX during 1990-1999 than 1990-2009. The variable oil is now significant on a 1 %- level and yields the coefficient 0.45, which means that a one-percentage increase in oil prices leads to an increase of 0.45 percent on the Oslo Stock Exchange. When comparing this value to the regression covering the entire period, it is evident that changes in oil prices had a bigger effect on the Oslo Stock Exchange in 1990-1999. These results agree with our hypothesis and previous results and are in no way surprising.

A noteworthy change for this period is the variable NOK/USD. The exchange rate is now significant on a 5 %-level. Since USA is a major export partner for Norway, such

a result was to be expected. Between 1990 and 2000 Norwegian exports to the USA more than doubled from \$2152 million to \$4553 million. During this time they substantially increased their exposure to dollars, explaining its significance.⁴²

6.1.2 Sub-period 2: 2000-2009

Variabel	Coefficient	Standard error	P-value
Constant	-2.22	2.19	0.32
CPI	1.87	2.05	0.37
GDP	-0.39	0.27	0.17
Interest rate	-0.03	0.13	0.83
Oil	0.08	0.12	0.50
NOK/GBP	0.72	0.39	0.07*
NOK/USD	-0.45	0.23	0.06*
FTSE 100	1.02	0.32	0.0036**
S & P 500	0.42	0.30	0.17
R ²	0.81		
Adjusted R ²	0.76		
Durbin-Watson	2.49		

Table 8. *= significant on a 10 %-level, **=significant on a 5 %-level, ***=significant on a 1 %-level

In the regression for the sub-period 2000-2009 there were only three significant variables. The exchange rates NOK/USD and NOK/GBP and the stock exchange FTSE 100. The exchange rates are both significant on a 10 %-level while FTSE 100 is significant on a 1%-level. Interest rate is no longer significant and yields a very high p-value of 0.83. The most surprising result however, is that oil is not significant at all which is puzzling considering the results in previous regressions and research. This is the most important and interesting result we have found so far. This raises the question of why it is no longer significant when most research begs to differ. Looking at figure 8, which shows the relationship between oil price and the Oslo Stock Exchange, both seem rather correlated thus making our results surprising. This

⁴² OECD, 2003

indicates that there is an underlying factor affecting both oil prices and the stock market which our model has not been able to capture.

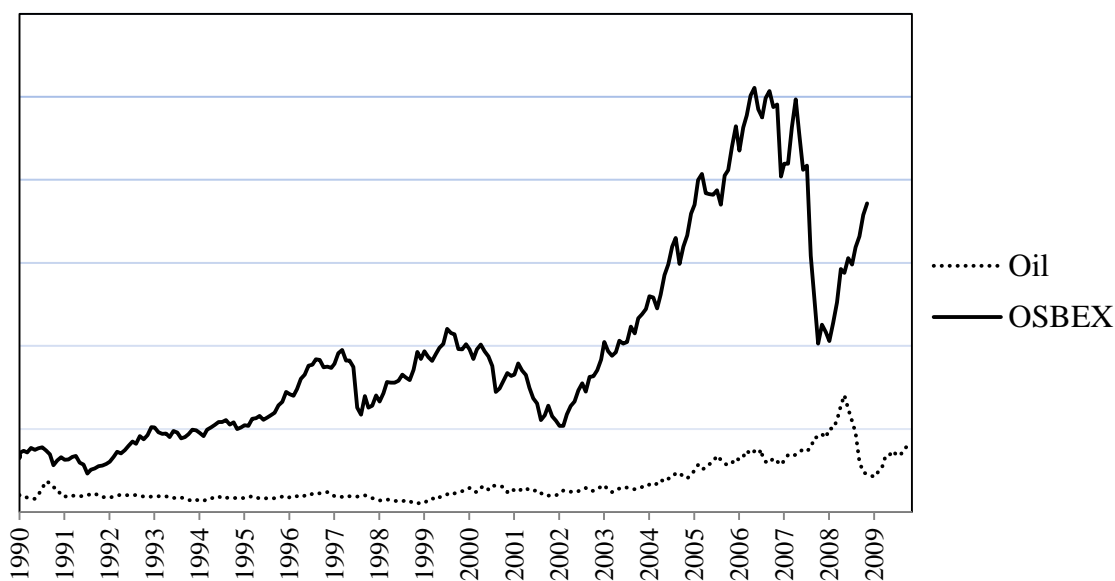


Figure 8 – Oil price and stock prices

The energy sector has seen a substantial growth during the second sub-period, at the same time the composition of the Oslo Stock Exchange has also changed. The stock exchange can in fact be explaining a lot of its own variation, making oil price changes play a smaller role than before.⁴³ Another very important notation is the changes made in the Norwegian oil industry. Norway has in the last decade focused more on intelligence and technology research within the oil industry, than on refining crude oil. There are only two refineries left in Norway today and most oil is sent abroad as crude oil and later imported as refined products. Therefore the Norwegian economy has diversified its exposure to oil price changes and spread the risks within the entire oil industry.

6.1.3 Moving Average Process

Due to the oil not being significant in the second sub period, we decided to construct a moving average process in hope of finding specific time points where oil is non-significant. The moving average process was created by simulating the same regression but with overlapping time periods, all being four years long. Figure 9 shows the process with the p-values for oil from each regression.

⁴³ See Sadorsky 1999

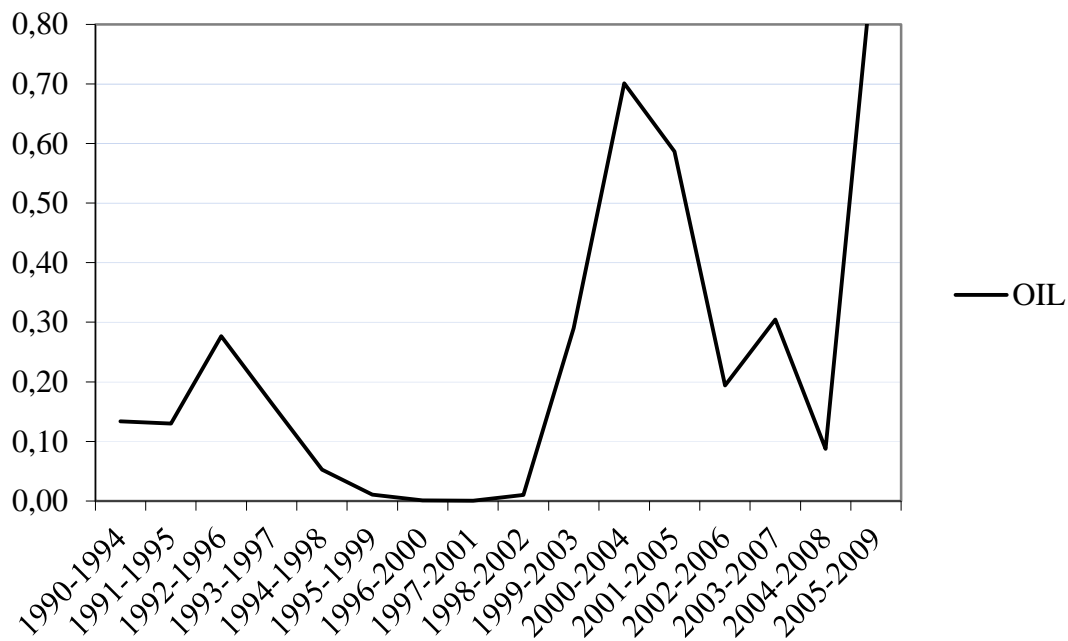


Figure 9 – Moving Average Process

As can be seen, oil is no longer significant from the interval 1999-2003 and forward. It is obvious that there is another factor affecting both Oslo Stock Exchange and oil prices. The world suffered from numerous catastrophes during the first decade of the 21st century which may possibly be the underlying factors we are looking for. In 2001 USA was the target of a terrorist attack that started a war against terrorism. It was mainly located in the middle-east which is the geographic location of most OPEC members. Figure 9 shows how the p-value for oil suddenly, in the period 1999-2003, becomes extremely non-significant. In the same time period, the world economy suffered deeply due to the dotcom-bubble causing the world's stock exchanges to drop drastically. Later in 2007, an enormous financial crisis hit the world economy leaving many countries in great crisis. All these events have caused serious disruptions to stock markets around the world. These crises might also be a possible explanation of why oil no longer has a significant effect on the Oslo Stock Exchange.

In neither regressions GDP or CPI are significant. We find this odd as this suggests that the Oslo Stock Exchange is more affected by external factors than local. This indicates that Norway is a small and open economy, highly influenced by the world economy.

7.

Conclusion

In this chapter a summary of our results are presented. The hypothesis in the beginning of the paper is compared to the final results and suggestions for further research are given.

The purpose of this paper was to investigate the relationship between changes in oil price and changes on the Oslo Stock Exchange. The hypothesis of this paper was that changes in the oil price have significant effects on the stock market due to the energy sector's large proportion of the market value.

A multiple linear regression using an OLS estimator was constructed with data covering a twenty year time period starting with the first quarter of 1990 to the last quarter of 2009. The model was even divided into two equally long sub periods to assess whether the effects of changes in the oil price are more prominent now than before. Several explanatory variables were selected to avoid any omitted variable bias, and the result was unambiguous. All conditions needed to be fulfilled in order for OLS to be the best estimator has been corrected for.

After analyzing the entire time period, changes in oil price proved to have a significant effect on a 5 percent confidence level. One percentage increase in oil prices would approximately increase the stock exchange by 0.22 percent. Interest rate, FTSE100 and S&P500 were the only explanatory variables that were significant. Sadorsky found in 1999 that interest rates had a greater impact than oil shocks, which also was true in our study. The interest rate had a coefficient of -0.24 compared to 0.22. Our result also strengthens Hammoudeh and Li and Park and Ratti conclusion that stock markets in net-exporting countries like Norway will be positively affected by rising oil prices.

When examining the first sub-period it was evident that oil price changes were significant on a 1 percent confidence level. The coefficient equaled 0.45 which is approximately double the coefficient compared to when studying the whole twenty-

year period. This is quite a notable increase and knowledge of the oil price development could indeed have been very lucrative. Even during the 90s, interest rate had a greater impact than changes in oil price, which again agrees with Sadorsky's conclusion from 1999.

The result from the second sub-period, however, was startling. Expecting changes in oil price to have an even greater impact than in the first sub period, it proved not to be significant at all. Oil had a very high p-value of 0.50 and a rather low coefficient of 0.08. After further analysis of the material we reached the final conclusion that the stock exchange and oil remain highly correlated, but both seem to be following another factor our model has not been able to capture. It would be very interesting to continue this research and find the factor affecting both the stock market and the oil price.

In our study we chose to include the two most correlated stock exchanges. However, using factor analysis numerous exchanges can be included without experiencing multicollinearity problems. Using this method it would be possible to describe a set of p stock exchanges X_1, X_2, \dots, X_p in terms of a smaller number of indices or factors, and in such a way elucidate the relationship between the stock exchanges. Further we chose to use a multiple linear regression due to our level of econometric education, although the vector autoregression (VAR) model is one of the most successful and flexible models to use for the analysis of multivariate time series. For further research we would find it interesting to use a VAR model that would allow for direct comparisons with previous research and more in-depth analysis.

8.

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Appendix

Moving Average Process (p-values)

Tidsperiod	R2-adjusted	CPI	FTSE100	£/NOK	GDP	INTEREST RATE	OIL	S&P500	\$/NOK
1990-1994	37,92%	0,1122	0,2961	0,6725	0,03826	0,032	0,1335	0,5162	0,1893
1991-1995	46,32%	0,2105	0,2545	0,6245	0,9859	0,018	0,1302	0,237	0,0821
1992-1996	29,31%	0,5218	0,486	0,8115	0,9269	0,0827	0,2766	0,7554	0,2892
1993-1997	6,11%	0,7177	0,7674	0,4129	0,5425	0,1095	0,1644	0,7862	0,7404
1994-1998	49,51%	0,7063	0,154	0,7542	0,2863	0,0653	0,0525	0,8071	0,6221
1995-1999	57,93%	0,5334	0,0677	0,5918	0,1325	0,0295	0,0105	0,8075	0,5141
1996-2000	72,19%	0,6071	0,0663	0,8011	0,0306	0,0081	0,0013	0,8557	0,1077
1997-2001	84,94%	0,4809	0,1449	0,2566	0,0928	0,0019	0,0008	0,0844	0,0115
1998-2002	79,04%	0,8118	0,1608	0,126	0,3845	0,0196	0,0102	0,1245	0,0842
1999-2003	78,97%	0,9733	0,3167	0,9009	0,3997	0,9472	0,2902	0,0207	0,8355
2000-2004	83,14%	0,8301	0,034	0,6301	0,6792	0,9557	0,7007	0,0609	0,9434
2001-2005	85,47%	0,8341	0,0095	0,4048	0,8826	0,9961	0,5867	0,4913	0,9441
2002-2006	79,29%	0,6118	0,0017	0,4832	0,6112	0,1706	0,1938	0,6206	0,8038
2003-2007	65,04%	0,3537	0,0007	0,4541	0,1878	0,388	0,3045	0,8601	0,8656
2004-2008	70,04%	0,5564	0,0054	0,8287	0,4803	0,5042	0,0875	0,818	0,5943
2005-2009	53,99%	0,6918	0,0733	0,1521	0,2968	0,9939	0,959	0,5639	0,0522

Residual plots of the explanatory variables

