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Dynamic relations between the Norwegian stock market and macroeconomic variables

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Content

Abstract

We investigate the dynamic relations between the Norwegian stock market and various macroeconomic variables by employing a cointegration test and the vector error correction model (VECM). The data reveals that Oslo Børs benchmark Index and the selected macroeconomic variables are cointegrated, confirming that there exists a long-run equilibrium relationship. Consistent with US, Japanese and Singaporean discoveries, positive dynamic relations are found between Norwegian stock market and the variables Deutscher Aktien index and exchange rate USD/NOK. Negative dynamic relations are found between the stock market and the variables exchange rate EUR/NOK and unemployment rate. Lastly, a causality running from the Deutscher Aktien index and unemployment rate to Oslo Børs benchmark index was found in the analysis. We conclude that the relationship found in larger market from previous research, are also to some degree valid in a smaller and open economy like Norway.

1.0 Introduction

The relationship between macroeconomic variables and the return on the stock market has been of attention in the financial and economic literature for several decades with different methods. Ross (1976) established the Arbitrage Pricing Theory (APT) and based the idea that assets return can be estimated using the linear relationship between expected asset return and a number of macroeconomic variables to capture the market risk. Engle & Granger (1987) established a valid method for testing cointegration in a single equation framework. Johansen (1988, 1991) established a cointegration test where it allows for more than one cointegration relationship, unlike Engle & Granger (1987). Most of the literatures that have used these methods have focused their research on big capital markets and how macroeconomic variables affect the stock market. While we want to see if similar result can be interpreted in a small and open country as Norway and also if the stock market affect macroeconomic variables.

Chen, Roll & Ross (1986) demonstrates that changes in macroeconomic variables, through their effect on future dividends and discount rates, systematically influence the return on stocks. They find that the returns are priced in relation with their exposures to systematic economic news measured as innovations in state variables. With these findings, they have laid the groundwork for the idea that a long-run equilibrium relationship exists between stock prices and the various macroeconomic variables. Granger (1986) suggests that a valid method for detection of such a relationship could be to apply a cointegration analysis. When applied in economics, a cointegrated relationship would indicate that a long-run equilibrium relation exists between the relevant factors.

The vast majority of previous studies, by Chen et al. (1986) in the US, Mukherjee & Naka (1995) in Japan and Maysami, Howe & Hamzah (2004) in Singapore are all conducted in larger markets. In these large and well-developed markets, like US and Japanese markets, findings suggest that a significant relationship between macroeconomic variables and stock returns exists. This paper searches to extend the knowledge about this issue and to investigate if similar findings hold in a small, open and less developed financial market like in Norway.

Gjerde & Sættem (1999) is the most acknowledged and cited study on this topic, focusing on the Norwegian economy. They found that the stock market was positively related to industrial production and negatively related to interest rate. Among practitioners a common statement is that the Norwegian economy is driven by the development of oil. Gjerde & Sættem (1999) investigates this relationship and finds that the market responds accurately to changes in oil price.

This study applies Johansen´s (1991,1995) cointegration test and VECM in examining the long-term equilibrium relationship between selected macroeconomic variables and the Oslo Børs benchmark index. The cointegration method is superior to the multivariate vector autoregressive (VAR) method for the research at hand because of its ability to explore dynamic comovements among the variables. The VAR approach is not appropriate in this research due to its failure to incorporate potential long-term relations. Furthermore, we investigate the short-run relations and establish the dynamic interactions among the variables by applying results from the VECM. We conduct a variance decomposition in order establish the amount of information each variable contributes to the other variables in the regression. Lastly, we conduct an impulse response analysis to see the reaction of Oslo Børs benchmark index after a shock in the selected macroeconomic variables, and vice versa.

This study focuses on the dynamic relationship, both short- and long run, between the Oslo Børs benchmark index and the selected macroeconomic variables; the Deutscher Aktien index, price of Brent oil, the exchange rate USD/NOK, the exchange rate EUR/NOK, long-term government bond, unemployment rate and the consumer price index as a proxy for inflation. This study also aims to answer the question of which variables are the causes and which variables are the effects. This is revealed by applying a Granger causality test were a bidirectional- or a unidirectional relationship can be detected.

After analyzing the results, we find that the stock market have a positive long-run relationship with the Deutscher Aktien index (DAX) and the exchange rate USD/NOK and a negative relationship with unemployment and the exchange rate EUR/NOK. Thus, with additional insight from the Granger causality test it would seem that the Norwegian stock market reacts to changes in the labor market and the Deutscher Aktien index. Furthermore, causalities running from the stock market to both the exchange rates were identified. Thus, only unidirectional causalities were found in the Granger causality analysis.

The structure of this paper will be as follows. In section 2 we discuss earlier research on the subject. Section 3 presents different relevant theories. In section 4, we explain the approach based on the VECM framework. In section 5, variables and description of the dataset are presented. In section 6, we discuss the results and lastly the conclusion is presented in section 7.

2.0 Literature review

It is commonly believed that asset prices react sensitively to economic news and that economic state variables have a systematic influence on stock market returns. This would seem coherent with modern financial theory, stating that these systematic influences serve as the likely source of investment risk. Thus, from the perspective of efficient-market hypothesis and the APT, asset prices should linearly depend on their exposures to the state variables that describe the economy. One of the earliest studies on the relationship of macroeconomic variables and the stock market was the research conducted by Chen et al. (1986). They investigated selected macroeconomic variables and the New York stock exchange, exploiting a sample of US data from 1953 to 1983. Chen et al. (1986) tests if innovations in macroeconomic variables are risks that are rewarded in the stock market in accordance with the APT framework. Candidates as sources of systematic asset risk and which would form a set of economic state variables were justified with the following arguments. The discount factor *k* is an average of rates over time and changes with level of rates and term-structures spreads, thus, unexpected changes in rates will influence stock prices and therefore the variables Treasury-bill rate 1 month and long-term government bonds were included. The discount rate also depends on the risk premium, which again is influenced by changes in marginal utility of real wealth measured by the variable real consumption changes. In the numerator, changes in expected inflation would influence expected cash flow and the nominal rate of interest. Innovations in the expected level of real production would affect current real value of cash flow and therefore the variable industrial production is included. Several of the chosen economic variables were found to be significant in explaining expected return on stocks, most particularly industrial production, changes in risk premium, twists in the yield curve, unanticipated inflation and changes in expected inflation.

Later studies in the US by Kim (2003) investigated the relationship between macroeconomic variables (Industrial production, real dollar exchange rate, interest rate and inflation) and the S&P 500 using the VECM method. The Johansen cointegration procedure was applied to detect if the stock price had a long-run relationship with the four determinant variables. The empirical analysis indicates that the stock price is positively related to the industrial production variable and negatively related to the interest rate, exchange rate, and inflation.

When looking at the larger emerging and growth-leading economies in other parts of the world, there are several studies that show a causal relationship between macroeconomic variables and the prices of stocks. Mukherjee & Naka (1995) wanted to find a dynamic relation among these variables following the cointegration framework, similar approach to Kim (2003) in the US. With a sample covering the period from 1971-1990 and the VECM they found that a cointegration exists between the Tokyo Stock Exchange and six Japanese macroeconomic variables. The signs of the long-term elasticity coefficient of the macroeconomic variables on the stock prices were found to be mostly consistent with the hypothesized equilibrium relations. Money supply, Industrial production and the depreciation of the Yen against USD had a positive effect on stock prices, however the relationship between stock returns and inflation was negative.

Following the APT framework as Chen et al. (1986) did in the US, Hamao (1988) studies the Japanese stock market and finds evidence that changes in expected inflation, unanticipated changes in risk premium and the term structure of interest rates significantly affect the Japanese stock returns. Forson & Janrattanagul (2014) identified a similar behavior in the capital market in Thailand using a sample from 1990 to 2009. They analyzed the long-run relationship between the Thai Stock Exchange Index (SET) and selected macroeconomic variables, namely money supply, the consumer price index, interest rate and the industrial production index (as a proxy for GDP). Their findings show that the SET and the selected macroeconomic variables are cointegrated at I (1)[1] and have a significant equilibrium relationship over the long run. In line with the findings of Mukherjee & Naka (1995), they detected that money supply had a strong positive relationship with the Thai stock exchange index over the long run and that CPI had a negative long-run relationship with the SET index. The variable industrial production was found to have a negative relationship in the long run with the SET, which contradicts Mukherjee & Naka´s (1995) findings in the Japanese capital market were industrial production had a positive relationship with the Tokyo stock

[1] I(1) means that the variable are integrated by order one. I.e the variable are stationary after taking the first difference. I(0) means that the variable are stationary in level form.

exchange in the long run. They also find that in non-equilibrium circumstances the error correction mechanism implies that the CPI index, the industrial production index and money supply, each provide an effect in restoring equilibrium. Similar studies were conducted in Korea where Kwon & Shin (1999) investigated whether current economic activities can explain the return on the Korean stock exchange by applying a cointegration test and a Granger causality test, from a vector error correction model. The VECM implies that returns on the stock market are cointegrated with a set of macroeconomic variables, which in this study are exchange rates, trade balance, production level and money supply. Their findings of cointegrated relationship shows direct long run and equilibrium relations with the tested macroeconomic variables.

In a small and developed economy in Singapore, equivalent to the Norwegian economy, similar investigation have been conducted by Maysami et al. (2004) using a sample from 1989 to 2001. Their motivation was to examine the long-term equilibrium relationship between macroeconomic variables and the Singapore stock market index (STI), as well as different Singapore exchange sector indices – the finance index, the property index, and the hotel index. The tool they used was the Johansen (1990) VECM, a full information likelihood estimation model. The chosen variables were short and long-term interest rates, industrial production, price levels, exchange rates and money supply. Their conclusion was that the Singapore stock market and the property index showed significant relationships with all the macroeconomic variables identified. The finance index only formed relationships with some selected macroeconomic variables, real economic activity and money supply was shown not to be significant. For the hotel index the results revealed that the variables money supply and short- and long-term interest rates were insignificant. Supporting their findings, Maysami & Koh (2000) found similar results in the Singapore capital market with 20 years of data and furthermore conclude that the Singapore stock market is significantly and positively cointegrated with the stock markets of Japan and the United States.

Studies in Europe have mostly been conducted by following the approach of Chen et al. (1986). In Spain, Martinez & Rubio (1989) using similar variables as Chen et al. (1986) found no significant relationship between the stock market and macroeconomic variables. Poon and Taylor (1991) also failed to explain stock returns using the same factors in the UK. However, more recently, by utilizing the VECM approach and the macroeconomic variables; Consumer price index, industrial production, exchange rate, money supply and interest rate, Masuduzzaman (2012) found significant relations in UK and Germany. Plíhal (2016) investigated Granger causality in Germany and used mainly the same variables as Masuduzzaman (2012). He discovered a unidirectional causality running from the DAX to industrial production and interest rate. He therefore concludes that the stock market is a leading indicator in real activity and development of the interest rate.

Furthermore, and very much relevant for this study, Gjerde & Sættem (1999) investigated to what extent the relationship between stock market returns and macroeconomic variables from bigger and more evolved markets are valid in a small, open economy like Norway. They utilized the VAR approach, using data from 1974 to 1994. In line with results from the US and Japan, they find that the real interest rate is also an important component in the Norwegian economy and changes in this variable have a negative relation with the stock returns. Further findings are that the real interest rate explains a substantial fraction of the inflation. The Norwegian economy is often characterized as being sensitive to changes in commodity prices. Gjerde & Sættem (1999) finds that the Norwegian stock market responds spontaneously positively to oil price changes. This relationship is not often spotted in other European markets, where researchers have trouble detecting a relation between the stock market and the macroeconomic variables. However, those studies did not use the VAR approach. Utilizing the VAR or VECM framework, dependent on the characteristics of the data, could potentially have been a more appropriate technique to reveal the macroeconomic forces in the economy.

3.0 Theory

The stock market is usually considered to respond to external forces and is viewed to reflect future expectations in current prices. It is often said that all relevant information is incorporated in its price and therefore serve as a leading indicator and can be used for predicting the economy.

3.1 Efficient markets

Asset prices are generally perceived to react instantly to the arrival of new information. Daily observations in various stock markets appear to confirm this view that individual asset prices are sensitive to a wide range of events. The efficient market hypothesizes (EMH) pioneered by Fama (1970) has long been recognized in explaining the prices in the stock market. A market in which prices "fully reflect" available information is by the hypothesis referred to as "efficient". Fama divides the efficiency of the market into three subsets, namely *weak form, semi-strong form and strong form. Weak-form efficiency* states that stock prices reflect all information contained in market trading data (historical price series, trading volume etc.) *Semi-strong form efficiency* states that stock prices reflect all public information about a firm´s prospects. Finally, *strong form efficiency* states that stock prices reflect all information relevant to the firm, even inside corporate information.

3.2 Defining efficiency

The causal relationship between macroeconomic variables and the prices of stocks indicates if the market exhibits informational efficiency. Perception of the cointegrated relationship depends on how "efficiency" is defined. Granger (1986) argued that in an efficient market asset prices cannot be cointegrated. Dwyer & Wallace (1992), however, shows that cointegration does not automatically violate the notion of information efficiency as defined by Fama (1991). They define market efficiency as the absence of arbitrage opportunities. Fama (1991) also states that in the presence of time-varying expected returns, the ability to predict stock price changes may be compatible with stock market efficiency. As known the economy runs in business cycles, which produce predictable time-varying risk premiums, which are reflected with noise, in realized returns. Nonetheless this predictability does not necessarily provide arbitrage profit opportunities.

3.3 Arbitrage pricing theory

Other studies that give supports to the statement that one can in some degree predict stock price changes with the help of macroeconomic variables have been around for several decades now. Early studies that attack the conclusion of the EMH is the works of Fama & Schwert (1977) and Jaffe & Mandelker (1976), which both concludes that macroeconomic variables affect stock returns. These studies were concentrated on the US stock exchanges and they tried to determine the economic effects in a theoretical frame based on the famous APT framwork, pioneered by Ross (1976). In general, the APT attempts to measure the risk premiums on the various factors that influence the returns of a given asset. The returns on a risky asset are considered to follow a factor intensity structure if they can be expressed as follow:

$$r_j = a_j + b_{j1}F_1 + b_{j2}F_2 + \ldots. + b_{jn}F_n + \varepsilon_j \qquad (1)$$

Where a_j is a constant for asset j, F_k is the systematic factor, b_{jk} is the sensitivity of the *j*th asset to factor *k* (the factor loading) and ε is the idiosyncratic random shock with mean zero, which is assumed to be uncorrelated with the factors. The APT then states that if the assets return follow a factor structure then the following relationship exists between return and the factor sensitivity:

$$E(r_j) = r_f + b_{j1}RP_1 + b_jRP_2 + \ldots. + b_{jn}RP_n \qquad (2)$$

Where RP is the risk premium of that factor and r_f is the risk-free rate. This shows that the expected return on asset *j* is a linear function of the assets sensitivity to the various *n* factors.

3.4 Other explaining approaches

Another approach in shedding light on the effect of macroeconomic variables on stock prices is the “Expected discounted dividends model”, which is practiced by many and developed on the original ideas of the economist John Burr Williams (1938). Here one tries to model equity returns as functions of macroeconomic variables and non-equity asset returns. Stock prices can be expressed as expected discounted dividends:

$$p = \frac{\mathrm{E}(c)}{k}\,, \tag{3}$$

Where c is the expected stream of dividends and k is the discount rate. This explains that actual returns in any period is given by

$$\frac{dp}{p} + \frac{c}{p} = \frac{d[E(c)]}{E(c)} - \frac{dk}{k} + \frac{c}{p} \tag{4}$$

From this equation, it follows that the systematic forces that effect returns are those that change discount factors, *k,* and expected cash flow, E(c). The discount rate is an average, and changes with interest rate level and term-structure spreads with different maturities. Furthermore, unanticipated changes in the risk-free rate will affect pricing and influence the time value of future cash flow, which again affect the returns. Expected cash flow with both real and nominal forces. Changes in expected inflation will affect expected cash flow as well as the nominal interest rate, which again affect the returns. Among other impacting factor changes, changes in a factor like expected real production would influence current real value of cash flows.

4.0 Methodology

By the work of Chen et al. (1986), the foundation was laid for the idea that a long-run equilibrium relation exists between stock prices and a set of macroeconomic variables. Granger (1986) suggests a cointegration analysis to test the validity of this idea. In this study we utilize the Johansen`s (1991, 1995) VECM in order to test whether the selected macroeconomic variables and the Oslo Børs benchmark index are cointegrated. The following section describes the methodology that is used and how we go about investigating the relationships.

4.1 Unit Root

The first step to utilize the methodology in our analysis is to test the economic variables for stationarity. A stationary series can be defined as one with a constant mean, constant variance and constant autocovariances for each given lag (Brooks, 2014, pp. 353). If a time-series contain a unit root, the independence assumption of the ordinary least square (OLS) methodology would be violated and e.g. spurious regression[2] could occur. It is different ways to test for stationarity, but in this research the augmented Dickey Fuller (1981) test is used and takes the following form with constant and trend[3].

$$\Delta y_t = \alpha_0 + \beta T + \theta y_{t-1} + \sum_{i=1}^{N} \alpha_i \Delta y_{t-i} + \varepsilon_t \qquad (5)$$

Where α_0 is the intercept, T is the linear trend, $\theta = (\rho - 1)$, y_t is the variable being tested, Δ is the first difference operator and ε_t is assumed to be identical and independently distributed with zero mean and constant variance. If the underlying data generating process does not have a constant or/and a trend[4], the equations would be changed to the right equation. This is done, by taking out the linear trend and/or intercept coefficient (α, T). The ADF test assumes the asymptotic

[2] Stochastic trends can lead to that two time series appear related when they are not, a problem called **spurious regression** (Stock & Watson, 2015, pp. 601).

[3] In equation (5) and (6) we test the null hypothesis H_0: $\theta = 0$ against alternative hypothesis H_1: $\theta < 0$. You can reject the H_0 if t-statistic is lower that critical calue ($\hat{t} < C$). To determine the critical values to the different statistically significance level, Mackinnon (1994) finite sample critical value were applied to both the unit root tests.

[4] ADF test with different characteristics; No constant, no trend: $\Delta y_t = \theta y_{t-1} + \sum_{i=1}^{N} \alpha_i \Delta y_{t-i} + \varepsilon_t$
Constant, no trend: $\Delta y_t = \alpha_0 + \theta y_{t-1} + \sum_{i=1}^{N} \alpha_i \Delta y_{t-i} + \varepsilon_t$

normality of the idiosyncratic error term ε. Unit root tests are tested on level and first difference.

Phillips and Perron (1988) test will also be utilized to get a stronger result. The Phillips and Perron (PP) unit root test takes the following form with constant and trend.

$$\Delta y_t = \alpha_0 + \beta T + \theta y_{t-1} + \varepsilon_t \tag{6}$$

Where the parameters are the same as in equation (5). The reason to include the PP test is that this test is more robust to general forms of heteroskedasticity in the error term (ε_t), than the ADF test. When a variable is I(1) in the ADF test, the error term (ε_t) is I(0) and may be heteroskedastic. Also, when employing the PP test you don't have to specify a lag length in the test regression[5] to account for serial correlation. Whereas the ADF test include lags of the first difference of the dependent variable to handle serial correlation.

Further, we need to find the appropriate and optimal lag length. It is important to find the optimal lag length, since if to few lags are included it can decrease forecast accuracy because valuable information is lost, however, adding to many lags can increase estimation uncertainty (Stock & Watson, 2015, pp. 596). The F-test, information criteria or Schwert rule of thumb, is here a reasonable alternative. Previous research, as by Maysami et al. (2004) and Maysami & Koh (1998), uses Akaike's information criterion (AIC) to find the optimal lag length. Another information criterion that can be used is Schwarz's Bayesian information criterion (BIC). Schwert (1989) come up with a rule of thumb that also could be used to find the optimal lag length. It takes the following form:

$$\rho_{max} = 12\left(\frac{n}{100}\right)^{1/4} \tag{7}$$

Where n equals the sample size and ρ refers to number of lags. But in our case with over 169 observations would the lag length be almost 14 lags. This would result in to many coefficients in one regression in our case, therefore we rule out

[5] Phillips & Perron test uses Newey & West (1987) standard error to account for serial correlation.

this opportunity. There is no clear rule of witch alternative that is the best to use, however, most of the literature suggest AIC and BIC. We decide to use AIC in this thesis and it would take the following form:

$$AIC(p) = ln\left(\frac{SSR(p)}{T}\right) + (p+1)\frac{2}{T} \qquad (8)$$

Where *SSR(p)* is the sum of squared residuals of the estimated AR(p) and *T* equals sample size.

4.2 Johansen cointegration test and vector error correction model

In an analysis with two variables, the series are cointegrated if each variables are I(1), but the linear combination of the series are I(0). If the two variables are cointegrated, then they have the same, or common, stochastic trend (Stock & Watson, 2015, pp. 703). If it exists a long run equilibrium relationship between two variables, it would indicate that they move together in the long run. After we have determined the order of integration of each variable and the optimal lag length, we would perform Johansen's cointegration test to examine if there exist a cointegration between our macroeconomic variables and the Norwegian stock market.

The two most famous cointegration tests that are used in empirical research are Engle & Granger (1987) test and the Johansen's test (1988, 1991 and 1995). Engle & Granger cointegration test are more appropriate in a bivariate analysis and Johansen's cointegration test works better in a multivariate analysis. This thesis will use Johansen's multivariate cointegration method to determine how many numbers of cointegrated relations that exists. Johansen's cointegration method start with the VAR of order p and looks like this:

$$y_t = \mu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t \qquad (9)$$

Where y_t is an $k \times 1$ vector of variables that are I(1), μ is $k \times 1$ vector of constants and ε_t is an $k \times 1$ vector of normally and independently distributed error terms and $A_1 - A_p$ are $k \times k$ matrices of parameters. This equation can be re-written to VECM form and looks like this:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{10}$$

Where $\Pi = \sum_{i=1}^{p} A_i - \mathrm{I}$ (I is the identity matrix that takes the form $k \times k$) and $\Gamma_i = -\sum_{j=i+1}^{p} A_j$. Both μ and ϵ_t are the same as in equation (9). If variables are nonstationary, I(1), we can have two possible states of numbers of linear combinations. It can either be, Π has rank $1 \leq r \leq k-1$ or Π has rank $r = 0$. Where *r* is the number of linear cointegration vectors. If $r = 0$ there is no cointegration between the variables and no long-run equilibrium relationship. If the variables are cointegrated and have a rank $1 \leq r \leq k-1$ we could decompose Π as:

$$\Pi = \alpha\beta' \tag{11}$$

Where α and β are both of dimension $k \times r$. Matrix β is a matrix of cointegration parameters, so that the linear combination $\beta' y_t$ is stationary and each of the *r* rows of $\beta' y$ is a cointegration long-run relation. Matrix α is the speed of adjustment back to the equilibrium (Bjørnland & Thorsrud, 2015, pp. 264). Equation (10) can be written as:

$$\Delta y_t = \mu + \alpha\beta' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{12}$$

Now the VECM equation contains information on both the long-run equilibrium and the short-term dynamics between the variables in y_t. The long run-run relationship between the variables is governed by $\beta' y_t$. In the short-run, economic variables may deviate from equilibrium, due to short-term dynamics (Bjørnland & Thorsrud, 2015, pp. 265).

To show how the matrix notations look like, we assume that number of dependent variables equals $3(k = 3)$ for simplicity. We assume that variables are I(1), then we can maximum have two equilibrium relationships $(r = 2)$ and the matrix notation for VECM look like this:

$$\begin{pmatrix}\Delta y_{1,t}\\ \Delta y_{2,t}\\ \Delta y_{3,t}\end{pmatrix} = \begin{pmatrix}\mu_1\\ \mu_2\\ \mu_3\end{pmatrix} + \begin{pmatrix}\alpha_{11} & \alpha_{21}\\ \alpha_{21} & \alpha_{22}\\ \alpha_{31} & \alpha_{32}\end{pmatrix}\begin{pmatrix}\beta_{11} & \beta_{21} & \beta_{31}\\ \beta_{12} & \beta_{22} & \beta_{32}\end{pmatrix}\begin{pmatrix}y_{1,t-1}\\ y_{2,t-1}\\ y_{3,t-1}\end{pmatrix} + \Gamma_1\begin{pmatrix}\Delta y_{1,t-1}\\ \Delta y_{2,t-1}\\ \Delta y_{3,t-1}\end{pmatrix} + \begin{pmatrix}\varepsilon_{1,t}\\ \varepsilon_{2,t}\\ \varepsilon_{3,t}\end{pmatrix} \quad (13)$$

To determine how many cointegrated vectors that are present in the regressions, we apply the Johansen (1991, 1995) method. That is the number of cointegrated vectors that are found by characteristic roots (eigenvalue) of Π. Rank of Π would determine the number of eigenvalues that are different from zero. Johansen (1988, 1995) proposed two different maximum likelihood ratio tests for determining the number of non-zero eigenvalues (Bjørnland & Thorsrud, 2015, pp. 265). To calculate the number of appropriate rank we will use trace test and maximum eigenvalue test as it shown below:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \qquad r = 0, 1, 2, . . . n - 1 \quad (14)$$

$$\lambda_{max} = -T \ln(1 - \hat{\lambda}_{r+1}) \qquad r = 0, 1, 2, . . . n - 1 \quad (15)$$

Where λ_i are the estimated eigenvalues picked up by the matrix of Π, T is the number of observations. Both test the same null hypothesis, i.e. the number of cointegrated vectors are less than or equal to r. For the trace test the alternative hypothesis is that there are more than r cointegration relations and for maximum eigenvalue test the alternative hypothesis is that there are $r + 1$ cointegration relations (Bjørnland & Thorsrud, 2015, pp. 265-266)[6].

Cointegration test does not show the direction of causality, but estimation of the error correction model (ECM) in the VECM would help us with this. VECM also allowed us to distinguish between short-run and long-run dynamics of the time-series, if it exist a cointegration between the variables. If we assume a situation where we have y_t as stock market index and x_t as chosen macroeconomic variable as different time-series. The error correction model could be expressed in

[6] Procedure of deciding the number of cointegration vectors is done sequential. Start by testing the hypothesis that $r = 0$ versus the alternative $r = 1$ for the max eigenvalue statistic. If the hypothesis is rejected, we proceed to the hypothesis that $r = 1$ versus the alternative $r = 2$ for the max eigenvalue statistic. We continue until we get the first non-rejection (Bjørnland & Thorsrud, 2015, pp. 266).

the following way, with equation (16) as the stock market as dependent variable and equation (17) macroeconomic variable as dependent variable:

$$\Delta Y_t = \mu_1 + \sum_{i=1}^{n} \beta_{1i}\, \Delta Y_{t-i} + \sum_{i=1}^{n} \gamma_{1i} \Delta\, X_{t-i} + \alpha_1 ECT_{t-1} + \varepsilon_{1t} \qquad (16)$$

$$\Delta X_t = \mu_2 + \sum_{i=1}^{n} \beta_{2i}\, \Delta X_{t-i} + \sum_{i=1}^{n} \gamma_{2i} \Delta\, y_{t-i} + \alpha_2 ECT_{t-1} + \varepsilon_{2t} \qquad (17)$$

Where Δ is the first difference, μ_1 and μ_2 are constant, β_{1i} and β_{2i} are the coefficients to the lagged dependent variable, γ_{1i} and γ_{2i} are the coefficients to the lagged independent variable, *n* are the optimal lag lengths selection of the variables, α_1 and α_2 are the speed of adjustment back to long run equilibrium and are the coefficients to error correction term[7] (ECT), ε_{1t} and ε_{2t} are white noise error terms.

Equation (16) can be utilized to test the causality that is running from x_t to y_t, while equation (17) can be utilized to test the causality from y_t to x_t. To examine the short-run causality, we employ a F-test[8] to check the joint significance of the variables. The ECT relates to the last periods deviation from the long run equilibrium that influence the short-run dynamics of dependent variable. While the coefficient of ECT_{t-1} (α_1 and α_2) is the speed of adjustment and measures the speed of the dependent variable in returning to equilibrium after a change in the independent variable. This coefficient has to be negative and statistically significant to have an economically interpretation.

4.3 Variance decomposition and Impulse response function

By applying the F-test and an examination of causality in the VECM, will suggest which of the variables in the model that are related and which variable that statistically significantly impacts other variables in the system. However, this result will not be able to tell us the sign of the relationship or how long these effects require to take place. These answers will be provided through an

[7] $ECT_{t-1} = y_{t-1} - \pi_0 - \pi_1 x_{1,t-1} - \pi_2 x_{2,t-1} - \cdots - \pi_i x_{i,t-1}$, Where y_{t-1} is the dependent variable lagged one period, π_0 is a constant and π_i is the coefficient to a independent variable lagged one period $x_{i,t-1}$.

[8] F-test is done by Wald test. Where the null hypothesis is that all the regressor coefficients are zero simultaneously as a usual F-test. (Gujarati, 2011, pp. 339)

examination of the impulse responses and forecast error variance decompositions. The impulse response function, measure the response of the dependent variable in the VECM model to shocks in each of the independent variables (Brooks, 2014, pp. 336). To visualize these responses, the orthogonalized impulse response function are plotted to examine the direction, magnitude and the time that a variable is affected by a shock in itself or another variable within the system. Further, we would plot the response of OSEBX after an orthogonalized shock in each of the variables and the response in all the other variables to a shock in OSEBX. We want to use the variance decomposition to measure the proportion of the movements in the dependent variables that are due to their own socks, versus shocks to the other variables (Brooks, 2014, pp. 337). If the forecast error variance of a given variable cannot be explained by any of the various shocks in the other variables, it can point to that this variable is an exogenous. However, on the opposite side of the scale, if the shocks explain all the forecast error variance in the variable, one can say the variable is completely endogenous.

5.0 Data

Previous VECM or VAR model`s approaches have limited themselves to fewer variables. In this analysis it is included a wider set of variables assumed to be important to the Norwegian economy. The included variables are the Deutscher Aktien index, the oil price, the USD/NOK exchange rate, the EUR/NOK exchange rate, the Norwegian 10-year government bonds, the unemployment rate and finally the consumer price index

Table 1: Definitions of the variables

Variables	Definitions
$OSEBX_t$	Natural logarithm of the market-value weighted month- end closing price for the Oslo Børs Benchmark index
DAX_t	Natural logarithm of the market-value weighted month- end closing price for the Deutscher Aktien index
OIL_t	Natural logarithm of the month-end price of Brent oil
$USDNOK_t$	Natural logarithm of the month-end USDNOK exchange rate
$EURNOK_t$	Natural logarithm of the month-end EURNOK exchange rate
$LGNOR10Y_t$	Natural logarithm of the month-end 10-year Norwegian government bond
UR_t	Natural logarithm of the month-end Unemployment rate
CPI_t	Natural logarithm of the month-end Consume Price index

The natural logarithm is applied in each variable to prevent large outliers and fit the data to the purpose of this research.

The analysis contains monthly observations over 14 years from 2004 to 2018, containing 169 observations, which should be sufficient for our analysis. OSEBX, DAX, OIL, USDNOK, EURNOK, and LGNOR10Y are collected from Bloomberg and as end of month closing prices and treated as is. The variable CPI, collected from Bloomberg, is published the 10^{th} the following month and is applied in the dataset when the variable occurred and not in the month it is published. The variable unemployment rate (UR), collected from Statistics Norway, is seasonally adjusted and not known until two months after the time of observation and is also applied in the dataset in the same way as CPI. The analysis includes eight variables, this is twice as many as in the studies by Kwon & Shin (1999) and Forson & Janrattanagul (2014), but similar to Gjerde & Sættem (1999).

5.1 Definition of variables

The Norwegian 10-year government bond (LGNOK10Y) variable was included because we expect changes in the yields to affect the discount rates through their effect on the nominal risk-free rate. Another effect of increased rates in long term bonds can result in investors shifting their demand away from stocks and over to the bond market. We therefore expect a negative relationship between this variable and the stock market. The variable consumer price index (CPI) is included to reflect the changes in prices. An increase in inflation increases the nominal risk-free rate, raising the discount rate in the valuation model. The effect of a higher discount rate would be neutralized if cash flow increases with inflation (Mukherjee & Naka, 1995). As DeFina (1991) shows, the cash flow does not rise at the same rate as inflation, and therefore the rise in discount rate leads to lower stock prices. Therefore, we assume that CPI and the stock market take a negative relationship, which are also supported Fama & Schwert (1977), Chen et al. (1986) and Gjerde & Sættem (1999). One variable that is less included in the literature is the unemployment rate. We hypothesize that increased unemployment rate will signalize bad times and lower earnings; therefore a negative relationship with stock market is expected.

Mathur & Subrahmanyam (1990) concluded that the US stock market did not have a significant impact on the Norwegian stock market. We then want to see if another important stock market could have an influence on the Norwegian stock market, namely the DAX. The index contains the 30 largest companies in Germany and is a proxy for the economic state in Germany. The index is included because Germany is one of Norway's most important trading partners. We assume if the German economy does well, it will affect the Norwegian economy positively. Consequently, we believe a positive relationship is to be found between the indices.

Furthermore, a large fraction of the company's sales and costs comes from exporting and importing to other countries. We therefore chose to include the relevant exchange rates to express this fact. The impact exchange rates have on the Norwegian economy will depend on international trade and the trade balance. The direction of the impact an exchange rate will have on a single company, depends on the composition of exports and imports for that company. It can be crucial for a company's cash flow, if a depreciation or appreciation of an exchange rate occur, if the company isn't correctly hedged. If we sum up all of the companies on the OSEBX we want to see if there is a relation between two exchange rates and the OSEBX. We chose to include exchange rate USD/NOK, being one of the most traded currencies for Norwegian companies. Several important trading partners for Norway is countries in Europe and therefore we also want to include the exchange rate EUR/NOK in the model. This means that with a depreciation of the Norwegian Kroner against Euro, products become cheaper to buy from Norway. Furthermore, if the demand for these products is elastic one should see a rise in demand, which in turn would gives higher NOK cash flows (Mukherjee & Naka, 1995). The opposite should hold if the NOK appreciates against the EUR. As a result, we expect a positive relationship between the exchange rate EUR/NOK and the stock market. However, Norway being an import dominant economy against USA, our expectation is that a negative relationship should occur between the exchange rate USD/NOK and the stock market.

In 2017, raw oil amounted to approximately 25 % of Norway's total export (SSB). As a result, it is reasonable to include the oil price in this analysis. We assume that the Oslo stock exchange, containing a large fraction of oil related companies, to have a positive relation to the oil price variable, this assumption is also supported by Gjerde & Sættem (1999).

6.0 Oslo Børs Benchmark Index analysis

In this section we will present our empirical result. First step in the analysis are to examine if the variables contain unit root in level and after first difference. Second step are to test for cointegration relations. Third step, the results of the vector error correction model will be examined. Last step is to include the result of impulse response and variance decomposition analysis. Before testing for stationarity, all variables in the analysis were log-transformed. From now on, the abbreviation OSEBX referrers to the natural logarithm of Oslo Børs Benchmark Index. The same interpretation includes all variables and in VECM and all variables are differentiated (Δ)[9].

6.1 Stationarity test

Time series are often non-stationary and therefore it is important to test each variable for stationarity. In Johansen's cointegration test it is important that all variables are integrated by the same order, namely I(1). By doing this, we can get rid of the problem with spurious regression. Table 2 present the descriptive statistics of the variables presented:

Table 2: Descriptive statistics of all variables: January 31 2004 to Mars 31 2018

Panel A. Data in level form								
	OSEBX	DAX	OIL	USDNOK	EURNOK	LGNOR10Y	UR	CPI
Mean	6,069	8,883	4,274	1,871	2,118	1,040	1,297	4,526
Std.Dev.	0,356	0,336	0,358	0,148	0,073	0,435	0,188	0,082
Minimum	5,238	8,239	3,450	2,180	1,987	-0,030	0,876	4,392
Maximum	6,709	9,490	4,940	1,626	2,293	1,644	1,629	4,676

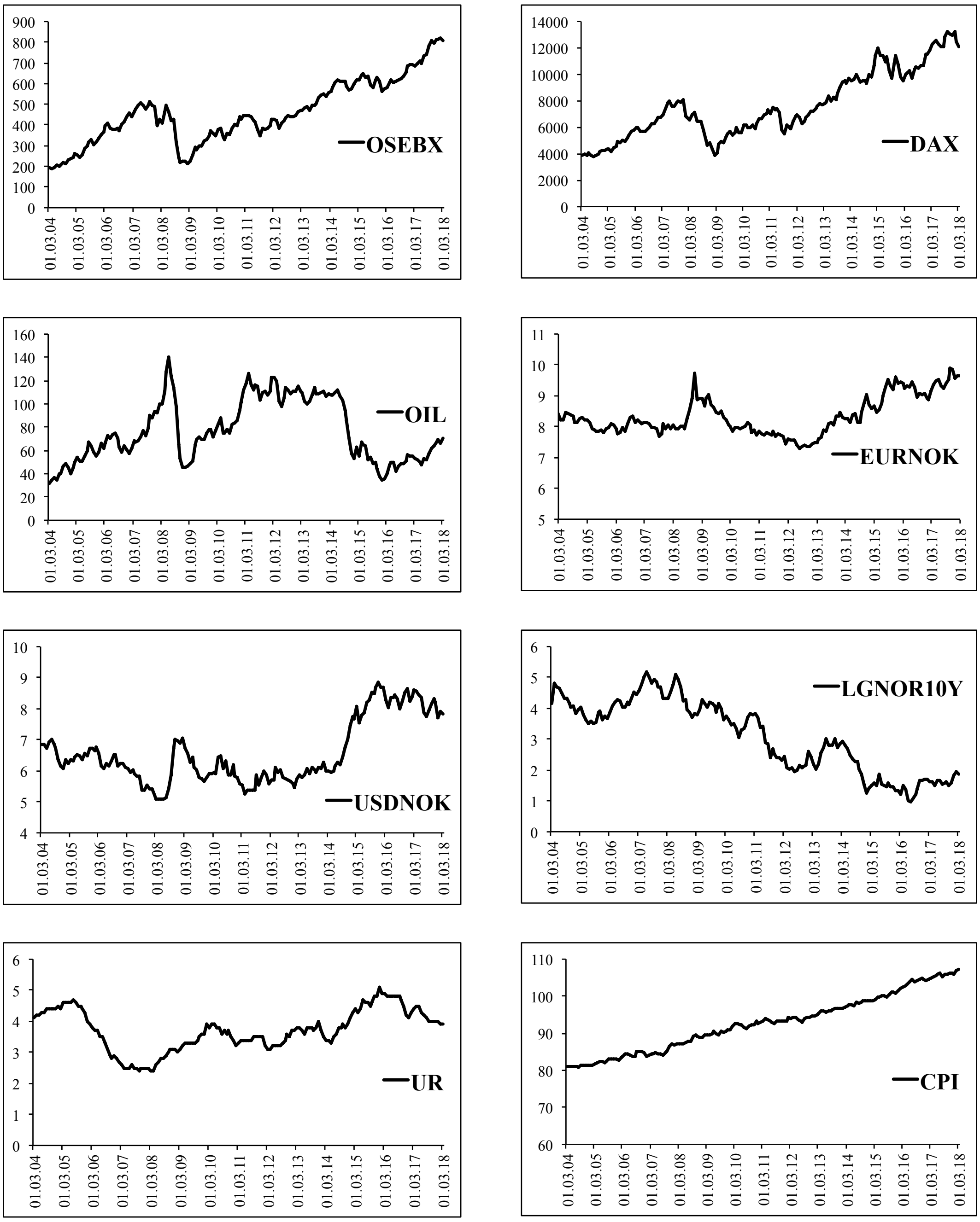
Panel B. Data in first difference form								
Mean	0,008	0,007	0,005	0,001	0,008	-0,005	0,000	0,002
Std.Dev.	0,058	0,051	0,089	0,034	0,021	0,076	0,032	0,004
Minimum	-0,290	-0,213	-0,407	-0,078	-0,093	-0,311	-0,090	-0,012
Maximum	0,147	0,155	0,254	0,138	0,088	0,217	0,080	0,016

Panel A displays the natural logarithm of the variables at level form. Panel B displays the natural logarithm of the variables at first difference.

To test for unit root we employ the ADF test and PP test. Before utilizing these tests, we need to get an understanding if the variables in the analysis have a constant or/and trend. In figure 1 are different graphs of the variables presented in price levels form before taking the natural logarithm and in a timeframe from March 2004 until March 2018.

[9] Δ is the symbol for the first difference operator. All transformed time-series is presented in a table 12 in appendix.

Figure 1: Time-series of the different economic variables



All the graphs are presented at level form to show the characteristics of the time series.

From the graphs we include just a constant in the variables OIL, USDNOK, EURNOK, LGNOR10Y and UR. While variables OSEBX, DAX and CPI exhibit trend characteristic and therefore a constant and trend are included in the unit root test. Table 3 present the tests for stationarity.

Table 3: Unit root test

Variable	Lags	ADF t-Statistic	PP t-Statistic
OSEBX	1	-2,722	-2,597
ΔOSEBX	0	-10,398***	-10,419***
DAX	4	-2,799	-2,468
ΔDAX	3	-5,375***	-11,193***
OIL	2	-2,737	-2,701
ΔOIL	0	-9,846***	-9,874***
USDNOK	0	-1,280	1,412
ΔUSDNOK	0	-12,322***	-12,341***
EURNOK	0	-1,241	-1,182
ΔEURNOK	3	-7,930***	-12,894***
LGNOR10Y	0	-1,097	-1,123
ΔLGNOR10Y	0	-12,474***	-12,474***
UR	5	-2,087	-1,525
ΔUR	4	-4,039***	-10,842***
CPI	13	-2,160	-3,368*
ΔCPI	12	-3,634**	-25,341***
Critical values			
1 %		-3,469	-3,469
5 %		-2,879	-2,879
10 %		-2,576	-2,576
Critical values with trend			
1 %		-4,014	-4,014
5 %		-3,437	-3,437
10 %		-3,143	-3,143

Δ represents first difference. * Implies significance level at 1%, ** significance implies level at 5% and * implies significance level at 10%. Optimal lags are computed from using Akaike's Information criteria in Augmented Dickey Fuller test.**

From the result of the unit root test we can conclude that all variables are stationary after taking the first difference at 1% significance level except CPI, which is only significant at the 5% level. However, we choose to keep the variable in the model and conclude that all variables are I(1).

6.2 Optimal lag length

Next step is to figure out the optimal lag length to include in the model. Using too few lags can decrease forecast accuracy because valuable information is lost; adding to many lags increases estimation uncertainty (Stock & Watson, 2015, pp. 596). Also, an important point with choosing optimal lag length is to make the error term white noise[10]. Lag length selection is utilized by likelihood ratio (LR) test and different information criteria tests as, the Final Prediction Error (FPE), Akaike's information criterion (AIC), Schwarz criterion (SC) and Hann Quinn information criterion (HQ). Results from lag length selection, are presented in Table 4.

[10] White noise means that each observation is uncorrelated with all other values in the sequence. Where $\varepsilon_t \sim i.i.d.N(0, \sigma^{2)}$, meaning ε_t has mean zero and constant variance σ^2 and are independent and indentically distributed.

Table 4: Lag length selection by different information criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1247,661	NA	3,42E-17	-15,211	-15,059	-15,149
1	2791,667	2917,509	4,45E-25*	-33,370*	-32,004*	-32,815*
2	2839,656	85,969	5,44E-25	-33,174	-30,592	-32,126
3	2885,011	79,798	6,93E-25	-32,945	-29,149	-31,404
4	2922,557	59,889	9,84E-25	-32,620	-27,610	-30,586
5	3001,538	118,229*	8,55E-25	-32,804	-26,579	-30,277
6	3048,546	65,753	1,12E-24	-32,596	-25,155	-29,575

*** Indicates the lag order selected by LR test and the different information criterion test. The procedure for LR test is by looking at the test of model with most lags before proceeding up the table. The first test that rejects the null hypothesis is the lag order selected. For FPE, AIC, SC and HQ the lag with the smallest value is the lag order selected by the different information criterion test.**

From the result we can see that FPE, AIC, SC and HQ all recommend one lag, while LR recommends five lags. By including one lag in the model, we find evidence of heteroskedasticity and serial correlation. Also the speed of adjustment coefficients was positive and insignificant. Therefore, we chose not to pursue with one lag in the model. By including five lags as LR recommend in the model, we took a diagnostic test, namely Lagrange multiplier residual test (LM Test) to figure out if the model had serial correlation in the residuals. Results from the LM test are presented in table 5.

Table 5: Diagnostic check with five lags

Lags	LM-Stat	Prob
1	62,052	0,546
2	55,517	0,766
3	59,633	0,632
4	78,437	0,106
5	72,617	0,215

Table 5 illustrates the serial correlation LM-statistics for the VECM with lag lengths of five. Where null hypothesis of no residual serial correlation cannot be rejected.

As we can se from the test all lags passes the 10% significance level of no residual serial correlation in the residuals. We then move forward with the recommendation from the LR test and include five lags in the model.

6.3 Cointegration test

Since five of eight variables do not include a linear deterministic trend when testing for unit root, we select a model with just an intercept and not including a linear deterministic trend when employing the Johansen's cointegration test.

Table 6: Johansen cointegration test

Hypothesized No. Of CE(s)	Trace Statistic	0,05 CV(Trace)	Max-Eigen Statistic	0,05 CV(Max-Eigen)
None	196,99 ***	159,53	58,21 **	52,36
At most 1	138,78 ***	125,62	52,13 **	46,23
At most 2	86,65	95,75	37,41	40,08
At most 3	49,24	69,82	19,43	33,88
At most 4	29,81	47,86	15,79	27,58
At most 5	14,01	29,80	8,24	21,13
At most 6	5,78	15,49	5,55	14,26
At most 7	0,23	3,84	0,23	3,84

Table 6: Present Trace- and Max Eigenvalue statistics test and critical value at 5%. * Implies significance level at 1% and ** implies significance level at 5%**

In Table 6, the Johansen's cointegration test indicates that both the trace and maximum eigenvalue tests suggest two cointegrated equations at 5% significance level. Both tests recommend two-cointegration equations, but when testing VECM with two cointegration equations, just one of the two coefficients to ECT is significantly and negative. For simplicity and better understanding of the interpretation of the results we pursue further with one cointegrated equation in the VECM. Results of the two cointegrating equations are presented in Table B) and C) in the appendix,

6.3.1 Long run dynamics

The ECT is retrieved from the normalized cointegration vector in Johansen cointegration test and it represents the long-run relationship in the model. ECT consists of several factors and is represented in general form in equation (18).

$$\alpha ECT_{t-1} = \alpha(\beta_1 OSEBX_{t-1} + \beta_2 DAX_{t-1} + \beta_3 OIL_{t-1} + \beta_4 USDNOK_{t-1} + \beta_5 EURNOK_{t-1} + \beta_6 LGNOR10Y_{t-1} + \beta_7 UR_{t-1} + \beta_8 CPI_{t-1}) \quad (18)$$

The estimated coefficients of the variables (β_i) in the ECT-part of the VECM are displayed in table 7 and the coefficient of ECT (α), or speed of adjustment is presented in table 8.

Table 7: Coefficients in vector error correction model (VECM)

Normalized cointegration coefficients	OSEBX (-1)	DAX(-1)	OIL(-1)	USDNOK(-1)	EURNOK(-1)	LGNOR10Y(-1)	UR(-1)	CPI(-1)	C
Coefficients	1	-1,056	-0,002	-0,590	0,945	-0,102	0,252	-0,299	3,555
Standard error		(0,051)	(0,098)	(0,302)	(0,351)	(0,064)	(0,070)	(0,395)	
T-statistics		[−20,916]	[−0,022]	[−1,953]	[2,690]	[−1,596]	[3,607]	[−0,757]	

Table 7: First row show the coefficients, second row with (. . .) shows the standard errors and third row with [. . .] show the T-statistics. The critical value of the significance level of 1%, 5% and 10% are 2.575, 1.960 and 1.645, respectively. When extracting out the normalized cointegration coefficients number from the table, we have to change signs of the coefficients.

Table 8: Coefficients to error correction term

	ΔOSE	ΔDAX	ΔOIL	ΔUSDNOK	ΔEURNOK	ΔLGNOR10Y	ΔUR	ΔCPI
Coefficients	-0,199	0,023	-0,368	0,248	-0,015	-0,031	-0,102	0,010
T-statistics	[-2,184]	[0,274]	[-2,737]	[4,685]	[-0473]	[-0,244]	[-1,883]	[1,439]
Prob	0,030	0,764	0,007	0,000	0,637	0,807	0,062	0,152

Table 8: Shows the speed of adjustment coefficients (α). In the first row the coefficients are presented, second row the T-statistics and the last row are the p-value presented.

The long-run relationship between OSEBX and all the independent variables in VECM are explained in equation (19):

$$OSEBX_t = 1{,}056\ DAX_t + 0{,}002\ OIL_t + 0{,}590\ USDNOK_t - 0{,}945\ EURNOK_t + 0{,}102\ LGNOR10Y_t - 0{,}252\ UR_t + 0{,}299\ CPI_t - 3{,}555 \qquad (19)$$

From equation (19) we can see that DAX and USDNOK are positive and significant, at 1% and almost 5% significance level, respectively. EURNOK and UR are negative and significant at 1% level. OIL, LGNOR10Y and CPI are insignificant to have an explanation to a long-run relationship with OSEBX.

Results of the long-run cointegration relationship, reveals that DAX are positive and heavily significant to OSEBX. This is consistent with similar research from other countries. Maysami and Koh (2000) found that it exists positive long-run relations between US and Japanese stock market to the Singapore stock market. The Singapore stock market responds quickly to changes in the US and Japanese stock market, but not the other way around. Similar results can be observed in our model. From Table 8 we can see that α are small and insignificant for DAX. This may suggest that DAX are exogenous to changes in OSEBX. While a negative and significant α in the case of OSEBX, means that OSEBX respond quickly to changes in DAX. We can conclude that OSEBX follow the direction of DAX, but DAX does not follow the direction of OSEBX.

The relation between OSEBX and the USDNOK exchange rate is positive and very close too be significant at 5% level. This means that OSEBX increases when NOK depreciate against USD. Similar results are consistent with studies in Japan by Mukherjee and Naka (1995) and in US by Kim (2003). Norwegian products get cheaper in United States. As a result, if the demand for these goods are elastic, the volume of Norwegian export should increase, causing higher NOK-denominated cash flow to Norwegian companies.

While the USDNOK have a positive relation with OSEBX, the opposite is true for the relation between EURNOK and OSEBX. We find evidence that when EURNOK appreciate, it is good news for OSEBX. This is consistent with studies in Singapore by Maysami and Koh (2000) and Maysami et al. (2004). Maysami and Koh (2000) explain this with a strong domestic currency lowers the cost of import inputs[11] and this will help the local producers to be more competitive internationally. As we hypothesized, the relation between UR and OSEBX is negative and significant. Our evidence indicates that OSEBX will increase when UR goes down.

The speed of adjustment coefficient in determination of OSEBX is negatively and statistically significant, which must be fulfilled for it to have a meaningful interpretation. With a speed of adjustment to equilibrium at 19,9% can be interpreted as 19,9% of any previous disequilibrium in the long run will be corrected in the short run. Speed of adjustment is often measured by half-life[12], meaning the time needed in order to eliminate 50% of the deviation. In our case half-life estimation is 3,5, meaning it will almost take four months to eliminate 50% of the deviation. We can therefore categorize OSEBX' speed of adjustment to equilibrium as medium speed.

6.3.2 Short run dynamics

This section focuses on the short-run dynamics between the chosen macroeconomic variables from the model and Granger causality. The VECM model contains eight variables and we recognize that there is a chance of a random effect arising with explanatory power. Table 9 displays the lagged coefficients on the left side and the significant variables retrieved from the Granger causality test represented under F-value on the right side.

[11] Appreciation of domestic currency make it cheaper for the country to import.

[12] Half-life is calculated as followed: $t_{halftime} = \frac{LN\ 2}{\alpha} \approx \frac{0{,}69}{-0{,}199} = 3{,}5$

Table 9: Short-run dynamics

	Model estimates						F-value
a)	$\Delta \boldsymbol{OSEBX_t}$:	$+0{,}397\Delta OSEBX_{t-2}$	$+0{,}361\Delta OSEBX_{t-3}$	$-0{,}516\Delta DAX_{t-2}$	$-0{,}322\Delta DAX_{t-3}$	$-0{,}363\Delta UR_{t-2}$	ΔDAX: 21,571 (0,000) ΔUR: 12,846 (0,012)
		(0,012)	(0,021)	(0,000)	(0,031)	(0,014)	
b)	$\Delta \boldsymbol{DAX_t}$:	$-0{,}314\Delta DAX_{t-2}$	$-1{,}990\Delta CPI_{t-4}$				
		(0,024)	(0,047)				
c)	$\Delta \boldsymbol{OIL_t}$:	$+0{,}775\Delta OSEBX_{t-1}$	$+0{,}568\Delta OSEBX_{t-2}$	$-0{,}829\Delta DAX_{t-2}$	$-0{,}532\Delta UR_{t-1}$		ΔOSEBX: 15,064 (0,005 ΔDAX: 14,181 (0,005) ΔUR: 8,203 (0,084)
		(0,001)	(0,015)	(0,000)	(0,014)		
d)	$\Delta \boldsymbol{USDNOK_t}$:	$-0{,}244\Delta OSEBX_{t-1}$	$-0{,}193\Delta OSEBX_{t-2}$	$+0{,}312\Delta DAX_{t-2}$	$+0{,}239\Delta UR_{t-1}$	$+0{,}202\Delta UR_{t-4}$	ΔOSEBX: 11,285 (0,024 ΔDAX: 14,975 (0,005) ΔUR: 12,584 (0,014)
		(0,009)	(0,035)	(0,000)	(0,005)	(0,019)	
e)	$\Delta \boldsymbol{EURNOK_t}$:	$-0{,}133\Delta OSEBX_{t-2}$	$+0{,}119\Delta DAX_{t-2}$	$-0{,}135\Delta DAX_{t-4}$	$-0{,}195\Delta EURNOK_{t-4}$	$+0{,}053\Delta LGNOR10Y_{t-3}$	ΔOSEBX: 10,324 (0,035 ΔDAX: 15,806 (0,003)
		(0,019)	(0,027)	(0,011)	(0,041)	(0,025)	
f)	$\Delta \boldsymbol{LGNOR10Y_t}$:						ΔDAX: 11,169 (0,025)
g)	$\Delta \boldsymbol{UR_t}$:	$-0{,}180\Delta DAX_{t-1}$	$+0{,}187\Delta UR_{t-1}$				
		(0,049)	(0,031)				
h)	$\Delta \boldsymbol{CPI_t}$:	$-0{,}189\Delta CPI_{t-3}$	$-0{,}267\Delta CPI_{t-4}$				
		(0,023)	(0,002)				

VECM coefficients, under model estimates, with 5 lags and only coefficients with significance level of 5% or better are presented. P-value in parenthesis (. . .). Under F-value on the right hand side, the significant variables at 5% level are displayed, retrieved from the Granger causality test.

From the different equations in Table 9 we can interpret the short-run relation between the variables. From equation a) we see that the second and third lag of ΔOSEBX are positively related to current changes in the same variable. Further, we see that the second and third lag of ΔDAX have a negative relation, as well as the third lag of ΔUR. By the F-value on the right side of equation a) it would seem there is causality running from ΔUR to ΔOSEBX. This partly coincide with the work of Boyd, Hu & Jagannathan (2005), who found that bad news about unemployment rates results in a rise in stock prices in economic expansions and a fall during contractions. In our study we find evidence of a causality running from ΔUR to ΔOSEBX, supplemented with the negative lagged coefficient of ΔUR, would imply a negative relation, and thus, similar findings to what Boyd et al. (2005) found in an economy during contractions. Further, looking at the F-statistic we see that both ΔUR and ΔDAX jointly cause changes in the stock market. This supports the findings in the long-run analysis, i.e. OSEBX follows the direction of DAX. Furthermore, from equation g) the opposite causality from ΔOSEBX to ΔUR does not occur, i.e. there are no bidirectional relationship between these two variables. This result is in contrast with the work of Geske & Roll (1983) who found that the stock market return is a statistically significant predicator of future change in the unemployment rate. They showed that the relationship is negative, meaning high stock returns would indicate a reduction in the unemployment rate the next period.

Equation c) reveals that ΔOIL is significantly related to the two first lags of ΔOSEBX, as well as the second lag of ΔDAX and first lag of ΔUR. Additionally, we also see that ΔDAX and ΔOSEBX jointly affect ΔOIL. The coefficients reveal a positive relationship between ΔOSEBX and ΔOIL and unidirectional causality running from ΔOSEBX to ΔOIL, as we find that the opposite causality does not occur in equation a). We realize that ΔOSEBX affecting ΔOIL in a significant extent is somewhat unlikely, and we suspect that this causality from ΔOSEBX to ΔOIL is driven by other international factors incorporated in ΔOSEBX. However, other studies have documented a causality running from changes in oil prices to stock returns. Jones & Kaul (1996) showed that US and Canadian stock markets react rationally to oil price shocks, while Japanese and UK markets do not.

In equation d) by Table 9, we observe that ΔOSEBX, ΔDAX and ΔUR jointly cause changes in USDNOK. Equation d) indicates that there exists a causality running from ΔOSEBX to ΔUSDNOK, and the first and second lagged coefficients of OSEBX indicate that there is a negative relation between them. One explanation for this occurrence can be that a rise in stock prices causes higher demand from foreign investors, which in turn causes a short-run appreciation of NOK against USD. In contrast, the opposite was found in Japan, by Mukherjee & Naka (1995), who found a positive relation between the Tokyo stock exchange and exchange rate USD/JPY in their study.

Equation e) indicates that the EURNOK exchange rate are influenced by the second lag of ΔOSEBX and ΔDAX, as well as fourth lag of ΔDAX and third lag of ΔLGNOR10Y. We see that ΔOSEBX is negatively related to ΔEURNOK, which is intuitive given that an increase in price of stocks on the Norwegian stock exchange would imply a short-run appreciation of NOK against EUR. Further in equation e), ΔLGNOR10Y have a positive relation to ΔEURNOK, which is consistent with the study by Chow, Lee & Solt (1997) in the US. They found similar results of a positive relationship between XRTE (dollar per unit of foreign currency) and US denominated long-term bonds, i.e. weaker (stronger) dollar increases (decreases) domestic bonds. In contrast to Chow et al. (1997) our results did not show the opposite causality running from ΔEURNOK to ΔLGNOR10Y, thus a unidirectional relationship between these two variables is indicated by this research.

6.3.4 Impulse response function

Before employing the impulse response function and variance decomposition, different diagnostic test were conducted. This was done to make sure that the model is reliable and stable[13]. We have already investigated that the model does not include serial correlation in the residuals. It also passed the Breusch - Godfrey serial correlation LM test that there are no serial correlations in the model. Also we did not find any evidence for heteroscedasticity by including a VEC residual heteroscedasticity test. For stability diagnostics a COSUM[14] test were employed and the test found no evidence of parameter instability. It seems that the model is stable and well specified and can now conduct impulse response function and variance decomposition with consistent estimates.

By conducting an impulse response function we can estimate how a shock in one of the variables, will impact other variables. First, we will focus on how shocks in the chosen variable will impact the OSEBX and then how shocks in OSEBX will impact the chosen variable in this analysis. The orthogonalized impulse response function was based on the VECM outputs and graphs of the different orthogonalized impulse response function is presented in figure 2 and 3.

[13] See appendix for the results of the different diagnostic tests

[14] The CUSUM test (Brown, Durbin & Evans, 1975) is based on the cumulative sum of the recursive residuals.

Figure 2: The response of OSEBX after one positive standard deviation shock in each of the variables separately

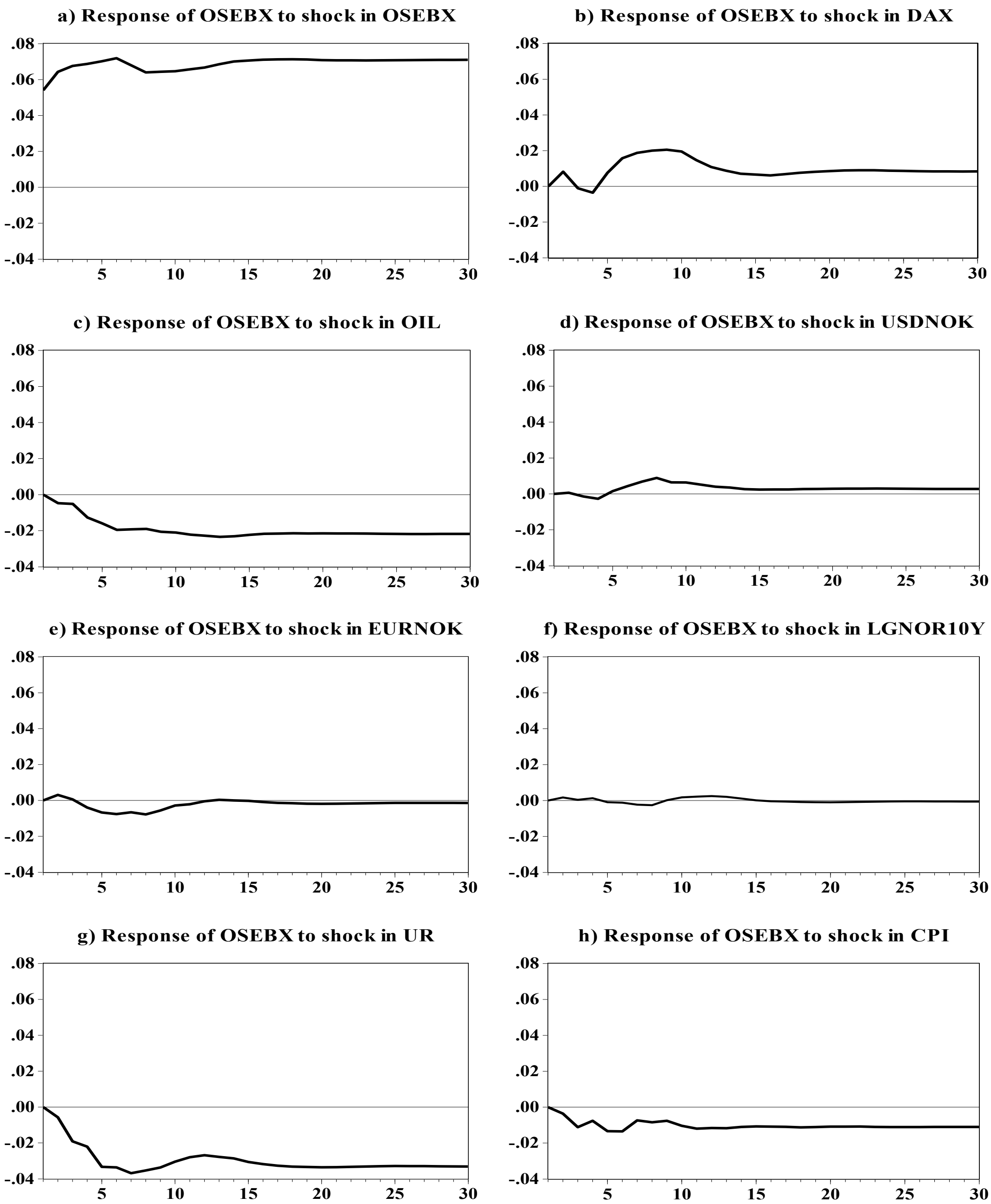


Figure 2: Response to Cholesky one standard deviation innovations.

Depicted graphs illustrate how OSEBX responds to one standard deviation shocks in OSEBX and each of the seven economic variables. A shock in OSEBX increases OSEBX exactly with one standard deviation and increases the next six periods before reversing back to almost its initial shock. One reasoning for this behavior can be that it occurs a price momentum in stock prices in the short run and its reverse back to mean in the long run. OSEBX have a positive and delayed effect to a shock in DAX. This confirms the positive causality result we found earlier, that OSEBX often follow the direction of DAX.

A shock in unemployment rate occurs to have negative and delayed effect on OSEBX. While a shock in oil price and inflation does not have much effect on OSEBX. As we can see from figure 1, the big drop in oil price in 2014 didn't affect OSEBX too much. This can imply that the Norwegian economy is not as sensitive to oil prices as in earlier years. An increase in inflation will increase the nominal interest rate and this will increase the cost of capital of investor that further would want higher return on their investment and would lead to a lower stock prices. Positive shock in unemployment rate may give a negative response to OSEBX and this will lower the stock prices on OSEBX. Intuitively, this is reasonable, since with higher unemployment rate more people are out of work and less money are used in the economy. A shock in USDNOK, EURNOK and LGNOR10Y did not give too much of a response to OSEBX.

Figure 3: The response of each variable after a one positive standard deviation shock in OSEBX

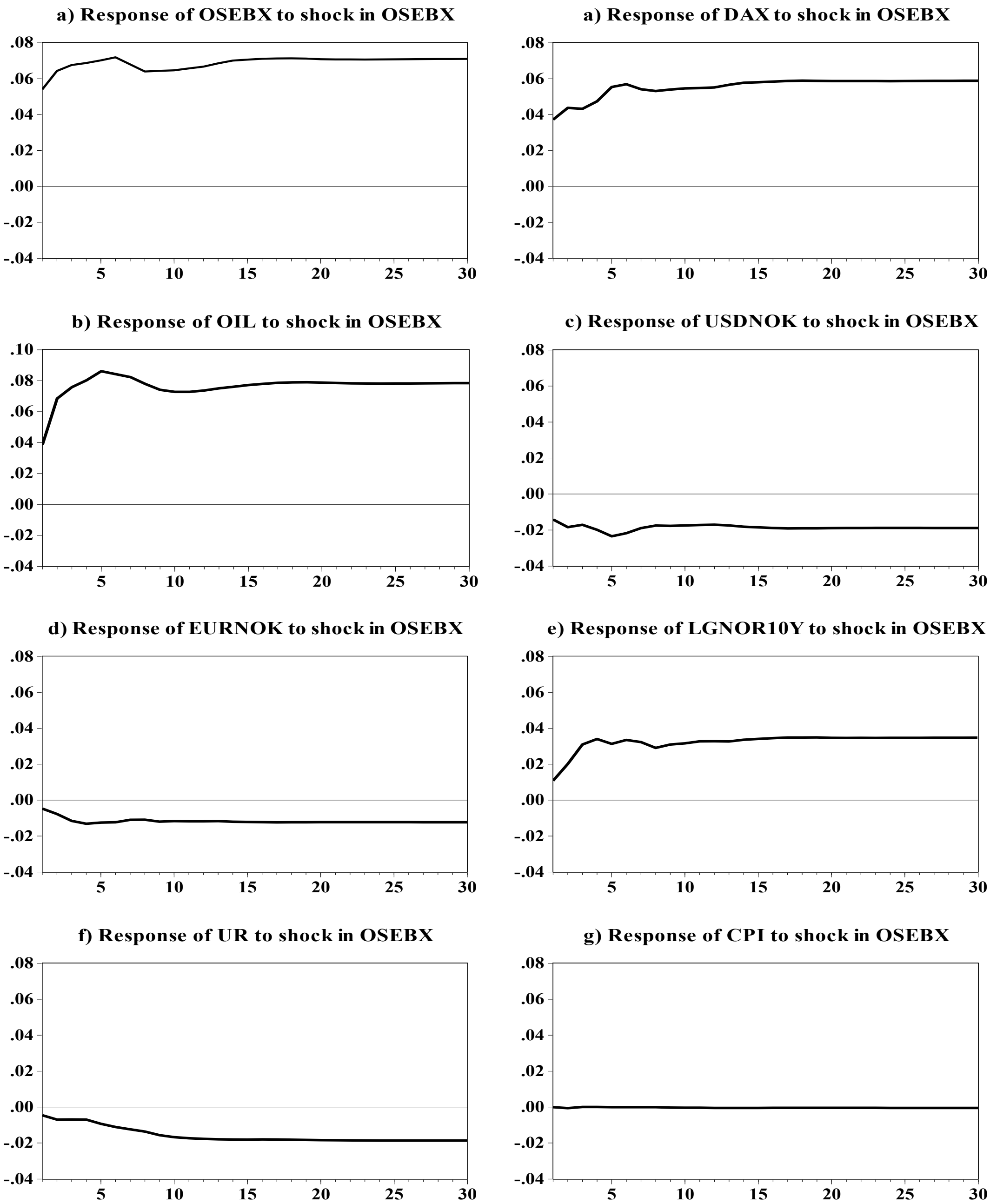


Figure 3: Response to Cholesky one standard deviation innovations

DAX, oil prices and long term government bonds response positive and permanent to a shock in OSEBX. DAX seems to have the same properties as OSEBX, it responds immediately and exhibits price momentum in the short run but in the long run it fade away and go back to the mean. OIL does also seem to have the same properties, it responds immediately and permanent to the shock. Confirming the short-run unidirectional causality between OSEBX and OIL.

Both of exchange rates, USDNOK and EURNOK, seems to appreciate immediately to a shock in OSEBX and diminishes after five periods and stabilizes at the initial level of the shock. A positive shock in OSEBX seems to lower the unemployment rate in ten periods before stabilizing. Confirming the unidirectional causality between unemployment rate and OSEBX. CPI is unaffected by a positive shock in OSEBX, confirming the low explanatory power we see in Table 12.

6.3.5 Variance decomposition

In order to further investigate the findings of VECM and to elaborate on the impact of the impulse response functions, this part will discuss the results from the variance decomposition analysis. Table 11 and 12 display the dynamic interaction between Oslo Børs benchmark index and the chosen variables. Table 11 presents the decomposed variance of OSEBX that can be attributed to its own innovation or innovations in other variables. In order to understand the development of the effect by the various shocks we have chosen to present results from time periods 1-, 6-, 12-, 18-, 24- and 30 months.

Table 11. Variance Decomposition of OSEBX

Period	S.E.	OSEBX	DAX	OIL	USDNOK	EURNOK	LGNOR10Y	UR	CPI
1	0,05	100,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
6	0,18	83,91 %	1,22 %	2,67 %	0,10 %	0,41 %	0,02 %	9,90 %	1,77 %
12	0,26	75,76 %	3,29 %	4,99 %	0,41 %	0,40 %	0,05 %	13,47 %	1,63 %
18	0,33	75,58 %	2,38 %	5,91 %	0,30 %	0,26 %	0,04 %	13,81 %	1,71 %
24	0,39	75,09 %	2,04 %	6,16 %	0,25 %	0,20 %	0,03 %	14,50 %	1,73 %
30	0,44	74,86 %	1,83 %	6,34 %	0,22 %	0,16 %	0,02 %	14,82 %	1,74 %

The decomposed variance in OSEBX, attributed to its own innovation (column 3), and innovations in other variables (column 4-10) at horizons spanning from 1-30 months (column 1).

As can be seen from Table 11, all movements in OSEBX is explained by its own innovations the first month, and after decreasing down to 74,86% in the longest forecast horizon, namely 30 months. This implies that for longer time horizons, other variables have explanatory power of the variation of OSEBX. The variables with the strongest explanatory power on the variation of OSEBX, is OIL and UR, which also increases with time. These results coincide with the two variables that give the highest effect on OSEBX in the impulse response function. Furthermore, Table 11 and Table 12 reveals that UR has a stronger effect on the variation of OSEBX than the other way around. This is consistent with the findings in the short-run analysis Table 9, where a unidirectional causality running from UR to OSEBX was found. Although OIL has a small explanation of the variation in OSEBX, Table 12 reveals that a movement in OSEBX has a greater explanation of the variations in OIL. This is consistent with the results in Table 9, i.e. a unidirectional causality running from OSEBX to OIL.

Table 12: Percentage of forecast error variance explained by the innovation of OSEBX

Period	OSEBX	DAX	OIL	USDNOK	EURNOK	LGNOR10Y	UR	CPI
1	100,00 %	55,54 %	23,45 %	20,27 %	5,88 %	2,09 %	2,03 %	0,01 %
6	83,91 %	69,00 %	46,26 %	31,88 %	33,10 %	11,52 %	3,47 %	0,53 %
12	75,76 %	67,84 %	46,42 %	27,15 %	34,14 %	12,53 %	6,63 %	0,74 %
18	75,58 %	69,58 %	46,42 %	28,02 %	35,76 %	13,58 %	7,97 %	1,14 %
24	75,09 %	70,15 %	47,16 %	28,42 %	36,53 %	14,23 %	8,62 %	1,35 %
30	74,86 %	70,50 %	47,63 %	28,67 %	37,03 %	14,62 %	8,99 %	1,49 %

Explanatory power of innovations in OSEBX on itself (column 2) and the other variables (column 3-9) at different time horizons (column 1).

Table 12 shows the effect of innovations in OSEBX on other variables. As can be seen, a shock in OSEBX contributes to large parts of the variation in the variables DAX, OIL, USDNOK and EURNOK. The variables LGNOR10Y and UR are affected to a lesser degree by OSEBX, and CPI is almost not affected at all.

The findings on EURNOK and USDNOK gives additional contributions to the results in Table 9 in the short-run analysis, i.e. a causality running from OSEBX to the above mentioned exchange rates, but not the other way around.

Examinations of the remaining variables in the variance decomposition, are presented in Table H in the appendix. OSEBX and UR gives the highest explanatory power to the variance of OIL in the model with 47,63% and 19,75%, respectively, in the end of time horizon. While USDNOK have variables as OSEBX, DAX, OIL and UR that gives significantly explanatory power to changes in its variation. The model also states that a significant portion of the variance of EURNOK are mostly connected with changes in OSEBX with 37,03% at end of time horizon. The remaining variables LGNOR10Y, UR and CPI seems to be the most exogenous variables with explanatory power with 69,85%, 75,20% and 78,43% at last time horizon, respectively. While DAX, OIL and USDNOK seems to be the most endogenous variables with explanatory power with 11,26%, 28,00% and 16,52% at last time horizon, respectively.

The results indicate that the Norwegian stock market for the most part act as an indicator of changes in macroeconomic variables. This can give support to the efficiency of the Norwegian stock market, i.e. OSEBX having the ability to signal the condition of the economy. Further, one should acknowledge the increasing standard errors displayed in Table 11, which implies a lack of estimating efficiency as the forecasting horizon increases.

7.0 Conclusions

This study on Norwegian data tries to expand the knowledge about relations between the stock market and macroeconomic variables. In this analysis we find evidence of a cointegrated relationship, implying a long-run relationship between Oslo Børs benchmark index and our chosen macroeconomic variables, and with additional investigation, evidence of unidirectional causalities between the variables are found. Our model points out that Oslo Børs benchmark index have positive long-run relations to the Deutscher Aktien index and the exchange rate USD/NOK, but have negative long-run relations to unemployment rate and the exchange rate EUR/NOK.

In the short-run analysis, we find unidirectional causalities running from Deutscher Aktien index and unemployment rate to Oslo Børs benchmark index. It seems that the Norwegian stock market react to changes in the labor market and movements in Deutscher Aktien index. We also investigate if it exists causalities from Oslo Børs benchmark index to the chosen macroeconomic variables. Evidence of unidirectional causalities running from the Norwegian stock market to price of Brent oil and both of the exchange rates are revealed. While the opposite sign of long-run relationship between Oslo Børs benchmark index and the exchange rates are spotted, evidence are found that both of the exchange rates respond negatively to one positive standard deviation shock in the Oslo Børs benchmark index, meaning that both exchange rates appreciates due to a positive shock in Oslo Børs benchmark index. Further, the analysis identifies unidirectional causalities running from Deutscher Aktien index to the variables long term government bonds, price of Brent oil and both of the exchange rates. Furthermore, a unidirectional causality running from unemployment rate to the exchange rate USD/NOK was also established.

These results shows that the dynamic relationships found in previous research in larger and more developed stock markets also holds in a smaller and open capital market as in Norway. This study shows evidence that Oslo Børs benchmark index follows the direction of Deutscher Aktien index. This can be useful information to portfolio managers, i.e. the two equity markets are seemingly integrated, resulting in limited diversification benefits. Both the long-run and short-run analysis shows no significant evidence that the Norwegian stock market are affected by changes in the oil price. The statement that the Norwegian stock market is driven by changes in oil price, where not supported by our data.

The variance decomposition shows a surprisingly result, namely that movements in Oslo Børs benchmark index is closely connected with the variance of most of the variables, except the consumer price index. Lastly, most of the innovations in the Oslo Børs benchmark index in the variance decomposition is explained by itself, indicating efficiency in the stock market. Thus, using macroeconomic variables to predict the direction of the Norwegian stock market needs to be handled with caution as the variance decomposition implies that the stock market has a stronger ability to signal movements in the macroeconomic variables, than the other way around.

7.1 Further research

It would be interesting to see a VECM framework with a larger proportion of important foreign macroeconomic variables and how those relate to the Norwegian stock market. Other Norwegian variables that would be interesting to look into is the term spread between long- and short interest rate, industrial production, trade balance and money supply. It can also be interesting to use the VECM methodology with the same variables on similar countries, to see if the similar results is revealed there. Countries as Sweden, Denmark and Finland could be good candidates.

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9.0 Appendices

Appendix I: Definition of time-series transformation

Table A: Definition of time – series transformation

Time-series transforamtion	
$\Delta OSEBX_t = OSEBX_t - OSEBX_{t-1}$	Monthly return on OSEBX
$\Delta DAX_t = DAX_t - DAX_{t-1}$	Monthly return on DAX
$\Delta OIL_t = OIL_t - OIL_{t-1}$	Monthly change in price of Brent oil
$\Delta USDNOK_t = USDNOK_t - USDNOK_{t-1}$	Monthly change in USDNOK exchange rate
$\Delta EURNOK_t = EURNOK_t - EURNOK_{t-1}$	Monthly change in EURNOK exchange rate
$\Delta LGNOR10Y_t = LGNOR10Y_t - LGNOR10Y_{t-1}$	Monthly change on 10-year Norwegian Government
$\Delta UR_t = UR_t - UR_{t-1}$	Monthly change in unemployment rate
$\Delta CPI_t = CPI - CPI_{t-1}$	Monthly realized Inflation rate

Table A: The Δ is the first difference operator symbol. All variables are first differenced on the natural logarithm of the variables.

Appendix II: VECM outputs with two cointegrating equations

Table B: Speed of adjustment coefficients with cointegrating equations

	ΔOSEBX	ΔDAX	ΔOIL	ΔUSDNOK	ΔEURNOK	ΔLGNOR10Y	ΔUR	ΔCPI
CointEq1	-0,275	0,017	-0,500	0,246	0,017	-0,065	-0,145	0,010
Prob	0,004	0,845	0,000	0,000	0,608	0,628	0,011	0,199
CointEq2	0,303	-0,017	0,551	-0,259	-0,024	0,074	0,160	-0,010
Prob	0,003	0,857	0,000	0,000	0,509	0,606	0,009	0,210

Table B: Represents 2 cointegrating equations from the recommended Johansen's cointegration test. The first row report the first speed of adjustment coefficients to the first ECT_{t-1} and row three report the second speed of adjustment coefficients to the second ECT_{t-1} in VECM. Row two and four reports the p-value of the respective speed of adjustments coefficients.

Table C: Coefficients to the error correction term in VECM

Normalized cointegrating coefficients with 2 cointegrating equations									
	OSEBX (-1)	DAX(-1)	OIL(-1)	USDNOK(-1)	EURNOK(-1)	LGNOR10Y(-1)	UR(-1)	CPI(-1)	C
First Eq.	1	0	-7,152	-41,904	28,451	-5,849	3,255	-4,031	62,638
t-statistics			(-3,715)	(-7,139)	(3,869)	(-4,394)	(-2,509)	(-0,491)	
Second Eq	0	1	-6,769	-39,115	26,042	-5,441	2,938	-3,534	55,938
t-statistics			(-3,772)	(-7,149)	(3,799)	(-4,385)	(2,357)	(-0,461)	

Table C: The first row displays the coefficients in the ECT_{t-1}, from the first normalized cointegration equation with its associated t-statistics in the second row. The third row displays the coefficients in the ECT_{t-1}, from the second normalized cointegration equation with its associated t-statistics in the fourth row. The critical value of significance level 1%, 5% and 10% are 2.575, 1.960 and 1.645, respectively

Appendix III: Complete list of VECM outputs

Equation A: Represent the VECM model

$$\Delta OSEBX_t = \beta_{10} + \sum_{i=1}^{5} \beta_{11}\, \Delta OSEBX_{t-i} + \sum_{i=1}^{5} \beta_{12}\, \Delta DAX_{t-i} + \sum_{i=1}^{5} \beta_{13}\, \Delta OIL_{t-i} + \sum_{i=1}^{5} \beta_{14}\, \Delta USDNOK_{t-i} + \sum_{i=1}^{5} \beta_{15}\, \Delta EURNOK_{t-i} + \sum_{i=1}^{5} \beta_{16}\, \Delta LGNOR10Y_{t-i} + \sum_{i=1}^{5} \beta_{17}\, \Delta UR_{t-i} + \sum_{i=1}^{5} \beta_{18}\, \Delta CPI_{t-i} + \alpha ECT_{t-1} + \varepsilon_{1t} \qquad (A)$$

Table D: Complete list of VECM outputs, excluding cointegration equations

Explanatory Variable	$\Delta OSEBX_t$	ΔDAX_t	ΔOIL_t	$\Delta USDNOK_t$	$\Delta EURNOK_t$	$\Delta LGNOR10Y_t$	ΔUR_t	ΔCPI_t
α_i	-0,199**	0,023	-0,368***	0,248***	-0,015	-0,031	-0,102*	0,010
ΔOSEBX(-1)	0,280*	0,157	0,775***	-0,244***	-0,048	-0,193	0,171*	-0,023*
ΔOSEBX(-2)	0,397***	0,184	0,568**	-0,193**	-0,133**	0,246	0,094	-0,007
ΔOSEBX(-3)	0,361**	0,182	0,163	-0,162*	-0,063	0,165	0,039	-0,008
ΔOSEBX(-4)	0,005	0,118	0,289	-0,101	0,090*	-0,071	0,075	0,016
ΔDAX(-1)	-0,003	0,018	-0,265	0,149	-0,017	0,407*	-0,180**	0,006
ΔDAX(-2)	-0,516***	-0,314**	-0,823***	0,312***	0,120**	-0,326	-0,036	0,015
ΔDAX(-3)	-0,322**	-0,153	0,003	0,038	0,009	-0,042	-0,066	0,004
ΔDAX(-4)	0,196	0,120	-0,193	-0,027	-0,135**	0,249	-0,118	-0,017
ΔOIL(-1)	-0,056	0,000	0,065	-0,076*	0,001	0,080	-0,017	0,010*
ΔOIL(-2)	0,003	0,015	-0,037	-0,033	-0,030	0,083	0,025	0,002
ΔOIL(-3)	-0,114	-0,048	-0,187*	-0,012	-0,013	-0,196*	-0,014	0,006
ΔOIL(-4)	0,033	-0,052	0,120	-0,066	-0,025	0,071	0,034	-0,006
ΔUSDNOK(-1)	-0,092	0,136	0,260	-0,152	0,002	0,108	0,064	-0,004
ΔUSDNOK(-2)	-0,071	0,161	-0,444	0,072	0,017	-0,274	0,039	-0,014
ΔUSDNOK(-3)	-0,035	-0,017	-0,311	-0,005	-0,088	0,105	-0,095	-0,006
ΔUSDNOK(-4)	0,288	0,202	0,003	-0,125	-0,037	0,289	0,053	0,013
ΔEURNOK(-1)	0,303	0,232	-0,374	-0,163	-0,181*	-0,521	0,083	0,015
ΔEURNOK(-2)	-0,118	-0,393	0,235	-0,151	-0,146	0,287	-0,116	-0,002
ΔEURNOK(-3)	-0,042	-0,078	-0,280	-0,154	-0,020	0,198	-0,015	0,035*
ΔEURNOK(-4)	-0,373	-0,010	-0,249	-0,143	-0,195**	0,321	0,003	0,012
ΔLGNORY(-1)	0,007	-0,021	0,077	0,040	0,001	0,040	-0,039	-0,004
ΔLGNORY(-2)	-0,035	-0,063	-0,046	0,039	0,025	-0,040	-0,069*	-0,002
ΔLGNORY(-3)	-0,039	0,043	-0,137	0,057	0,053**	-0,017	-0,019	0,008
ΔLGNORY(-4)	-0,093	0,012	-0,117	0,046	0,028	0,010	-0,01	0,002
ΔUR(-1)	-0,133	-0,063	-0,532**	0,239***	0,086*	-0,145	0,187**	0,009
ΔUR(-2)	-0,363**	-0,196	-0,013	-0,008	-0,008	-0,159	0,157*	0,006
ΔUR(-3)	0,176	-0,019	0,230	-0,082	-0,087	0,123	-0,163*	0,006
ΔUR(-4)	-0,276*	-0,061	-0,326	0,202**	0,064	-0,108	0,122	0,022*
ΔCPI(-1)	-0,916	-0,100	-1,113	0,534	0,371	1,291	0,259	-0,093
ΔCPI(-2)	-1,963*	-0,476	-0,621	0,116	0,071	-1,218	0,327	-0,105
ΔCPI(-3)	1,204	0,074	0,316	0,099	-0,113	1,872	0,535	-0,189**
ΔCPI(-4)	-1,246	-1,990**	0,568	-0,258	-0,251	0,825	-0,706	-0,267***
Constant	0,008	0,008	-0,002	0,005	0,004*	-0,014	-0,002	0,003***
R-Squared	0,32	0,251	0,356	0,319	0,294	0,227	0,218	0,290
Adj. R-squared	0,147	0,061	0,193	0,146	0,115	0,031	0,019	0,109

Table D: Complete list of VECM estimates with one cointegrated equation, where * implies 1% significance level, ** implies 5% significance level and * implies 10% significance level.**

Appendix IV: Granger causality test

Table E: Granger Causality Results based on VECM

Dependent Variable	Statistics of lagged first differenced term (p-value) Independent Variables							
	ΔOSEBX	ΔDAX	ΔOIL	ΔUSDNOK	ΔEURNOK	ΔLGNOR10Y	ΔUR	ΔCPI
ΔOSEBX	--	21,571*** (0,000)	3,168 (0,0530)	2,768 (0,597)	3,305 (0,508)	2,459 (0,652)	12,846** (0,012)	6,818 (0,146)
ΔDAX	3,388 (0,495)	--	1,215 (0,876)	2,867 (0,580)	4,225 (0,377)	1,903 (0,754)	3,274 (0,513)	4,212 (0,378)
ΔOIL	15,064*** (0,005)	14,841*** 0,005	--	4,810 (0,307)	2,537 (0,638)	4,177 (0,383)	8,203* (0,084)	1,014 (0,908)
ΔUSDNOK	11,285** (0,024)	14,975*** (0,005)	5,769 (0,217)	--	2,968 (0,563)	5,273 (0,260)	12,584** (0,014)	1,133 (0,889)
ΔEURNOK	10,324** (0,035)	15,806*** (0,003)	2,344 (0,673)	2,027 (0,731)	--	7,048 (0,133)	5,423 (0,247)	1,866 (0,760)
ΔLGNOR10Y	3,497 (0,478)	11,169** (0,025)	5,402 (0,249)	2,885 (0,577)	3,756 (0,440)	--	1,755 (0,781)	3,276 (0,513)
ΔUR	4,253 (0,372)	5,572 (0,233)	1,183 (0,881)	1,593 (0,810)	1,014 (0,908)	4,470 (0,346)	--	2,640 (0,620)
ΔCPI	6,357 (0,174)	5,182 (0,269)	5,820 (0,213)	1,932 (0,748)	3,626 (0,549)	3,550 (0,470)	6,305 (0,178)	--

Table E: Complete list of the different estimates of the Wald test. Where * implies 1% significance level, ** implies 5% significance level and * implies 10% significance level.**

Figure A: Casual channels are summarized below

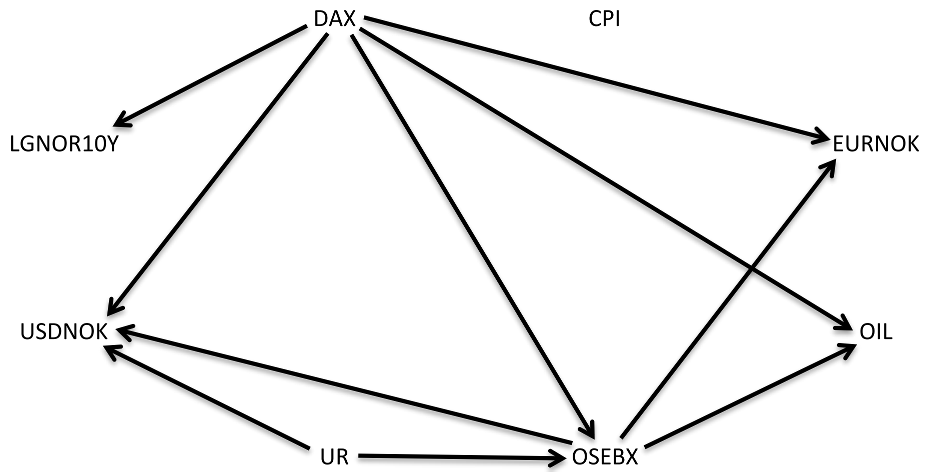

Figure A: Explain the unidirectional causalities from table E. Where we can see the causalities running from one variable to another.

Appendix V: Diagnostics tests

Table F: Breusch - Godfrey Serial Correlation LM test

F-statistic	1,102	Prob. F(5,126)	0,363
Obs*R-squared	6,924	Prob. Chi-Square (5)	0,226

Table F: The null hypothesis is that there is no serial correlation in the residuals up to five lags. As the test shows we cannot reject the null hypothesis.

Table G: VEC Residual Heteroscedasticity Tests: No Cross Terms (Joint test)

Chi-sq	df	Prob
2392,846	2376	0,400

Table G: The null hypothesis is that there are no heteroscedasticity in the residuals. The test shows that we cannot reject the null hypothesis.

Figure B: Cusum test

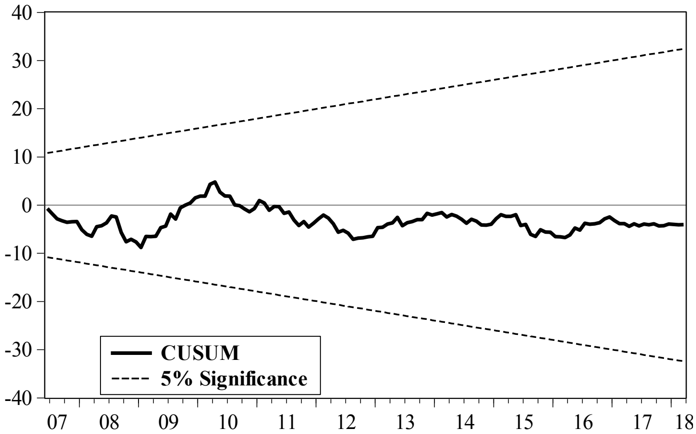

Figure B: CUSUM test assess the stability of the coefficients. This plots the cumulative sum together with 5% critical lines. The test finds parameters instability if the cumulative sum goes outside the area between the two lines.

Appendix VI: Complete list of variance decomposition

Table H: Variance Decomposition of OSEBX

	Period	S.E.	OSEBX	DAX	OIL	USDNOK	EURNOK	LGNOR10Y	UR	CPI
OSEBX	1	0,054	100,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
	6	0,177	83,91 %	1,22 %	2,67 %	0,10 %	0,41 %	0,02 %	9,90 %	1,77 %
	18	0,330	75,58 %	2,38 %	5,91 %	0,30 %	0,26 %	0,04 %	13,81 %	1,71 %
	30	0,436	74,86 %	1,83 %	6,34 %	0,22 %	0,16 %	0,02 %	14,82 %	1,74 %
DAX	1	0,050	55,54 %	44,46 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
	6	0,141	69,00 %	22,13 %	2,99 %	0,31 %	0,14 %	0,23 %	3,15 %	2,06 %
	18	0,272	69,59 %	13,86 %	6,55 %	0,24 %	0,13 %	0,13 %	7,41 %	2,09 %
	30	0,363	70,50 %	11,26 %	6,92 %	0,16 %	0,12 %	0,15 %	8,76 %	2,13 %
OIL	1	0,080	23,45 %	3,26 %	73,29 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
	6	0,267	46,26 %	1,71 %	38,11 %	0,50 %	1,46 %	0,29 %	11,15 %	0,51 %
	18	0,471	46,42 %	2,10 %	29,88 %	0,22 %	2,12 %	0,18 %	18,48 %	0,49 %
	30	0,609	47,63 %	1,81 %	28,00 %	0,13 %	2,04 %	0,12 %	19,75 %	0,51 %
USDNOK	1	0,031	20,27 %	0,95 %	15,07 %	63,71 %	0,00 %	0,00 %	0,00 %	0,00 %
	6	0,084	31,88 %	4,89 %	16,40 %	28,69 %	0,24 %	0,27 %	17,31 %	0,32 %
	18	0,148	28,02 %	17,57 %	12,01 %	17,99 %	0,36 %	0,47 %	23,24 %	0,33 %
	30	0,191	28,67 %	18,45 %	10,97 %	16,52 %	0,24 %	0,47 %	24,33 %	0,35 %
EURNOK	1	0,019	5,88 %	1,08 %	11,38 %	10,65 %	71,01 %	0,00 %	0,00 %	0,00 %
	6	0,046	33,10 %	3,52 %	6,25 %	5,67 %	44,28 %	3,60 %	2,87 %	0,72 %
	18	0,081	35,76 %	1,92 %	3,32 %	3,69 %	41,75 %	6,04 %	6,52 %	0,99 %
	30	0,106	37,03 %	1,76 %	2,70 %	3,39 %	40,15 %	6,53 %	7,42 %	1,02 %
LGNOR10Y	1	0,075	2,09 %	0,25 %	6,80 %	0,76 %	4,35 %	85,75 %	0,00 %	0,00 %
	6	0,203	11,52 %	1,87 %	8,09 %	0,71 %	4,62 %	70,94 %	1,98 %	0,25 %
	18	0,361	13,58 %	1,82 %	4,08 %	0,30 %	6,37 %	70,61 %	3,04 %	0,21 %
	30	0,469	14,62 %	1,49 %	3,28 %	6,84 %	6,83 %	69,85 %	3,49 %	0,18 %
UR	1	0,032	2,03 %	0,04 %	0,00 %	0,81 %	2,01 %	0,12 %	94,99 %	0,00 %
	6	0,104	3,47 %	0,44 %	0,44 %	2,95 %	6,64 %	1,62 %	84,52 %	0,31 %
	18	0,218	7,97 %	0,71 %	0,19 %	3,98 %	9,07 %	1,49 %	76,39 %	0,21 %
	30	0,297	8,99 %	0,86 %	0,13 %	4,11 %	9,18 %	1,34 %	75,20 %	0,20 %
CPI	1	0,004	0,01 %	0,21 %	1,24 %	0,00 %	0,01 %	0,00 %	0,01 %	98,51 %
	6	0,008	0,53 %	3,45 %	7,63 %	0,28 %	1,64 %	0,58 %	5,47 %	80,41 %
	18	0,013	1,14 %	2,39 %	7,73 %	0,19 %	0,75 %	0,34 %	7,96 %	79,50 %
	30	0,016	1,49 %	1,91 %	7,77 %	0,14 %	0,50 %	0,23 %	9,52 %	78,43 %

Table H: Column 2 report the different time horizons spanning from 1-30 months. The first section with OSEBX as the dependent variable (Period 1, 6, 18, 30), report the effect on the variance of OSEBX by a shock in itself (Column 4) and a shock in the remaining variables (column 5-11). And the same interpretation can be done in the remaining rows and columns when looking further down in the table.

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BI Norwegian Business School

Relations between macroeconomic variables and stock market return in Norway

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1.0 Introduction

The relationship between macroeconomic variables and the return on the stock market has been of attention in the financial and economic literature for several decades. One of the most common way to explain stock prices has long been models like the "Future discounted dividends model". The model states that the price of a stock can be written as the expected future cash flow, *E(ct)* earned by the owner of the stock, discounted by a factor (*k*). The notion is that changes in the systematic risk factors affect the price of the stock through the expected cash flow, E(*ct*), the discount factor *k*, or through both.

Chen, Roll & Ross (1986) demonstrates that economic state variables, through their effect on future dividends and discount rates, systematically influence the return on stocks. They find that the returns are priced in relation with their exposures to systematic economic news measured as innovations in state variables. With these findings, they have laid the groundwork for the idea that a long-run equilibrium relationship exists between stock prices and the appropriate macroeconomic variables.

The proper way to test the possession of this relationship is according to Granger (1986) by applying a cointegration analysis, leading the way for a (by now) much used approach to examine the relationship between macroeconomic variables and stock prices. In statistics, if a cointegrated relationship among relevant factors were to be found this would indicate that a linear combination of nonstationary time series exhibits a stationary series. Applying this existence into economics, would tell us that such a linear relationship establishes a long-term equilibrium relation.

The vast majority of previous studies, by Chen, Roll and Ross (1986), Mukherjee & Naka (1995) and Kim (2003), among others, has primarily focused on the influence of macroeconomic variables on composite indices. The lack in literature up to now has been on the examination of cointegration between macroeconomic variables and *sector indices*. This paper will complement the literature, by focusing on the both the sector indices and the composite indices.

We will apply Johansen´s (1990) vector error correction model in examining the long-term equilibrium relationship between selected macroeconomic variables and the various sector indices on the Norwegian Oslo Stock Exchange, namely the OSE10 Energy, OSE15 Materials, OSE20 Industrials, OSE40 Financials and in addition the composite index OSEBX.

In the following section of this Preliminary Thesis there will be a literature review of previous research which establishes both the theoretical and empirical justifications for the modelling of the stock market indices using economic variables. We discuss the estimation procedure with applying Johansen`s (1990) vector error correction model (VECM) and in addition an explanation of which economic variables are to be implemented in the study. The last section will give an indication of our progress towards finalizing our Master Thesis.

2.0 Literature review

When looking at the larger emerging and growth-leading economies in Asia, there are several studies that shows that there is a causal relationship between macroeconomic variables and the prices of stocks. Chen, Roll and Ross (1986) revealed that macroeconomic variables affect stock prices through the effect on the expected cash flow and the appropriate discount rate with their study on the US stock market using the multivariate arbitrage model (APM). Based on this valuation method Mukherjee & Naka (1995) wanted to find an equilibrium relation among these variables. To do this they used a cointegration framework which by their opinion would be an appropriate tool to test for an equilibrium. With a sample covering the period from 1971-1990 and a vector error correction model (VECM) they found that a cointegration exists between the Tokyo Stock Exchange and six Japanese macroeconomic variables. The signs of the long-term elasticity coefficient of the macroeconomic variables on the stock prices were found to be mostly consistent with the hypothesized equilibrium relations. Money supply, Industrial production and the depreciation of the Yen against USD had a positive effect on stock prices, however the relationship between stock returns and inflation was negative.

Supporting the findings of Mukherjee & Naka, another study by Hamao (1988) on the Japanese stock market finds evidence that changes in expected inflation, unanticipated changes in risk premia and the term structure of interest rates significantly affect the Japanese stock returns. Forson & Janrattanagul (2014) identified a similar behavior in the capital market in Thailand using a sample from 1990 to 2009. They analyzed the long-run relationship between the Thai Stock Exchange Index (SET) and selected macroeconomic variables, namely money supply, the consumer price index, interest rate and the industrial production index (as a proxy for GDP). Their findings prove that the SET and the selected macroeconomic variables are cointegrated at I (1) and have a significant equilibrium relationship over the long run. In line with the findings of Mukherjee & Naka, they detected that money supply had a strong positive relationship with the Thai stock exchange index over the long run and that CPI had a negative long-run relationship with the SET index. The variable industrial production they found to have a negative relationship in the long run with the SET, which contradicts Mukherjee & Naka´s findings in the Japanese capital market were industrial production had a positive relationship with the Tokyo stock exchange in the long run. They also find that in non-equilibrium circumstances the error correction mechanism implies that the CPI index, the industrial production index and money supply, each provide an effect in restoring equilibrium.

Similar studies were conducted in Korea were Kwon & Shin (1999) investigated whether current economic activities can explain the return on the Korean stock exchange by applying a cointegration test and a Granger causality test,' from a vector error correction model. The VECM implies that returns on the stock market are cointegrated with the set of macroeconomic variables, which in this study are exchange rates, trade balance, production level and money supply. Their findings on a the cointegrated relationship shows direct long run and equilibrium relations with the tested macroeconomic variables.

The relationship between macroeconomic variables and the return on the stock exchange has been thoroughly investigated in other parts of the world as well, namely in America. One of the earliest studies on the subject was the investigation conducted by Chen, Roll and Ross (1986) on the impact of macroeconomic variables on stock prices in the US, namely the New York stock exchange, using a sample from 1953 to 1983. The paper investigates a set of economic state variables as a systematic influence on the stock market returns as well as their influence on the pricing of assets. Several of the chosen economic variables were found to be significant in explaining expected return on stocks, most particularly industrial production, changes in risk premia, twists in the yield curve, unanticipated inflation and changes in expected inflation. Similarly, using the VECM method, Kim (2003) investigated the relationship between macroeconomic variables (Industrial production, real dollar exchange rate, interest rate and inflation) and the S&P 500. The Johansen cointegration procedure was also applied to detect if the stock price had a long-run relationship with the four determinant variables. The empirical analysis indicates that the stock price is positively related to the industrial production variable and negatively related to the interest rate, exchange rate, and inflation.

In the small and developed economy in Singapore, equivalent to the Norwegian economy, similar investigation has been conducted by Maysami, Howe & Hamzah (2004) using a sample from 1989 to 2001. Their motivation was to examine the long-term equilibrium relationship between macroeconomic variables and the Singapore stock market index (STI), as well as different Singapore exchange sector indices – the finance index, the property index, and the hotel index. The tool they used was the Johansen (1990) VECM, a full information likelihood estimation model. The chosen variables were short and long-term interest rates, industrial production, price levels, exchange rates and money supply. Their conclusion was that the Singapore stock market and the property index showed significant relationships with all the macroeconomic variables identified. The finance index only formed relationships with some selected macroeconomic variables, real economic activity and money supply was shown not to be significant. For the hotel index the results revealed that the variables money supply and short- and long-term interest rates were insignificant. Supporting their findings, Maysami & Koh (2000) found similar results in the Singapore capital market with 20 years of data and furthermore conclude that the Singapore stock market is significantly and positively cointegrated with the stock markets of Japan and the United States.

Furthermore, Gjerde & Sættem (1999) study causal relations among stock returns and macroeconomic variables in the Norwegian stock market. By using a multivariate vector autoregressive approach with 10 years of data, they find that real interest change has negatively relations with the stock returns. Also, that real interest rate explains a substantial fraction of the inflation. Another finding was that oil price changes influence the stock market.

3.0 Theory

3.1 Efficient markets

Asset prices are generally perceived to react instantly to the arrival of new information. Daily observations in various stock markets appear to confirm this view that individual asset prices are sensitive to a wide range of events. The existence of the capital market is by the perception of many a way for allocation of ownership of the economy´s capital stock. The optimal market would be a place which prices offer precise signals for resource allocation. The efficient market hypothesizes (EMH) pioneered by Fama (1970) has long been recognized in explain the prices in the stock market. A market in which prices "fully reflect" available information is by the hypothesis referred to as "efficient". Fama divides the efficiency of the market into three subsets, namely *weak form, semi-strong form and strong form. Weak-form efficiency* states that stock prices reflect all information contained in market trading data (historical price series, trading volume etc.) *Semi-strong form efficiency* states that stock prices reflect all public information about a firm´s prospects. Finally, *strong form efficiency* states that stock prices reflect all information relevant to the firm, even inside corporate information.

3.2 Defining efficiency

The causal relationship between macroeconomic variables and the prices of stocks indicates if the market exhibits informational efficiency. Perception of the cointegrated relationship depends on how "efficiency" is defined. Granger (1986) defined “efficiency” as absence of predictability and argues that in an efficient market asset prices cannot be cointegrated. Dwyer & Wallace (1992), however, shows that cointegration does not automatically violate the notion of information efficiency as defined by Fama (1991). They define market efficiency as the absence of arbitrage opportunities and show that the presence of cointegration is consistent with the absence of abnormal returns. Fama (1991) also states that in the presence of time-varying expected returns, the ability to predict stock price changes may be compatible with stock market efficiency. As known the economy runs in business cycles, which produce predictable time-varying risk premiums, whom are reflected with noise, in realized returns. Nonetheless this predictability does not necessarily provide arbitrage profit opportunities.

3.3 Arbitrage pricing theory

Other studies offering weight on the statement that one can in some degree predict stock price changes with the help of macroeconomic variables has been around for several decades now. Early studies that attack the conclusion of the EMH is the works of Fama & Schwert (1977) and Jaffe & Mandelker (1976), which both concludes that macroeconomic variables affect stock returns. These studies were concentrated on the US stock exchanges and they tried to determine the economic effects in a theoretical frame based on the famous Arbitrage Pricing Theory (APT), pioneered by Ross (1976). In general, the APT attempts to measure the risk premiums on the various factors that influence the returns of a given asset. The returns on a risky asset are considered to follow a factor intensity structure if they can be expressed as follow:

$$r_j = a_j + b_{j1}F_1 + b_{j2}F_2 + \ldots + b_{jn} F_n + \in_j$$

Where a_j is constant for asset j, F_k is systematic factor, b_{jk} is the sensitivity of the jth asset to factor k (the factor loading) and $\in$ is the idiosyncratic random shock with mean zero, which is assumed to be uncorrelated with the factors. The APT then states that if the assets return follow a factor structure then the following relationship exists between return and the factor sensitivity:

$$E\,(r_j) = r_f + b_{j1}RP_1 + b_{j2}RP_2 + \ldots + b_{jn}RP_n$$

Where RP is the risk premium of that factor and r_f is the risk-free rate. This shows that the expected return on asset *j* is a linear function of the assets sensitivity to the various *n* factors.

3.4 Other explaining approaches

Another approach on shedding light on the effect of macroeconomic variables on stock prices is the "Expected discounted dividends model", which is practiced by many and builds on the ideas of the economist John Burr Williams (1938). Here one tries to model equity returns as functions of macroeconomic variables and non-equity asset returns. Stock prices can be expressed as expected discounted dividends:

$$p = \frac{\mathrm{E}(c)}{k},$$

where *c* is the expected stream of dividends and *k* is the discount rate. This explains that actual returns in any period is given by

$$\frac{dp}{p} + \frac{c}{p} = \frac{d[E(c)]}{E(c)} - \frac{dk}{k} + \frac{c}{p}$$

From this equation, it follows that the systematic forces that effect returns are those that change discount factors, *k,* and expected cash flow, E(*c*). The discount rate is an average, and changes with interest rate level and term-structure spreads with different maturities. Furthermore, unanticipated changes in the risk-free rate will affect pricing and influence the time value of future cash flow, which again effect the returns. Expected cash flow with both real and nominal forces. Changes in expected inflation will affect expected cash flow as well as the nominal interest rate, which again affect the returns. Among other impacting factor changes, changes in a factor like expected real production would influence current real value of cash flows.

4.0 Methodology

Our research will primarily follow Johansen & Juselius (1990) Vector error correction model (VECM) for analyzing the cointegration between stock market indices return and the economic variables. Engle & Granger (1987) also have a well know cointegration model, namely the two-step error correction model (ECM). Johansen's (1990) VECM are preferred by researchers when working with multivariate variables. This is because the VECM is a full information maximum likelihood estimation model, which allow for testing cointegration in a whole system of equations in one step (Maysami, Howe, Hamzah, 2004). This allows researchers to avoid carrying over the errors term from first- into the second step, unlike the case of Engle & Granger´s (1987) methodology. By using the VECM methodology we can determine if it is a long-term equilibrium relationship between our economic variables and our indices.

Maysami, Howe & Hamzah (2004) applied VECM in their methodology and we will base our work on their approach. VECM will then take the following form:

$$\Delta z_t = \Gamma_1 \sum \Delta z_{t-1} + \ldots + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-k} + \mu_t$$

Where Δ denotes the first differences, $\Gamma_i = -(I-A_1- \ldots -A_i)$, (I=1, … , k-1), $\Pi = -(I-A1- \ldots - A_k)$. The short and long-run adjustments to Z is specified by the estimated of Γ_i and Π. $\Pi=\alpha\beta'$ where α is the spread of adjustments to disequilibrium and β is the matrix of the long-run coefficients that represents up to n-1 cointegration relationships and ensures that z_ts converge to their long-run steady state (Maysami, Howe, Hamzah, 2004).

Further in estimating VECM we take the following steps. First, we would test whether all variables are integrated by order one, that is, the variables are stationary. The test we are going to use for stationarity are the augmented Dickey-Fuller (ADF). Cointegration required that all the variables would be of the same order. ADF does this by finding out if a unit root exists. If a time series have a unit root, the independence assumption of the ordinary least square methodology would be violated. To see if unit root exists we would use the ADF, which will test the null hypothesis:

$H_0 : \gamma = 0$ in

$\Delta y_t = a_0 + \gamma y_{t-1} + \Sigma \beta_i \Delta y_{t-i+1} + \varepsilon_t$

Other tests that finds out if the time-series are stationary is Phillips-Perron (PP) and Kwiatkowski-Philips-Schmidt-Shin (KPSS) unit root test. This might also be used to get a stronger result that the time-series doesn't exhibit a unit root and are stationary.

After that, we need to find the appropriate and optimal lag length. Here we can apply Akaike's information criterion (AIC) or Schwarz's Bayesian information criterion (BIC). Previous research as (Maysami et al., 2004; Maysami & Koh, 1998) uses AIC to find the optimal lag length. We are most likely to also use AIC.

Next step, as Mukherjee & Naka (1995) explained, are to regress ΔY_t against the lagged differences of ΔY and ΔY_{t-k} and estimate the eigenvectors (cointegrating vectors) from the Canonical residuals from these regression equations. Here we need further investigation to understand and how to do it. Last and final step of VECM are to determine the order of cointegration.

In the end of the thesis we would conduct variance decomposition and impulse response function. We want to use the variance decomposition to measure the percentage change of variance in the dependent variable that can be explained to a shock in its own variable or to another dependent variable. The impulse response function measure how the dependent variable responds to a shock in its own variable or to a shock in another dependent variable.

5.0 Data

In our research, we want to use six independent economic variables to explain the long-term equilibrium relationship with the five selected stock exchange indices. Our dependent variable will be Oslo stocks exchange benchmark index, which are a value-weighted index. We will also test our independent variables on four different sector indices on the Oslo stock exchange. In our thesis, we will use time-series variables as, gross domestic production (GDP), consume price index (CPI) and industrial production (IP) which we have been provided by our supervisor. These variables will be monthly observations. We will also need to provide the monthly data on the NIBOR 3-months interest rate and monthly data on the exchange rate (USD/NOK) and monthly oil price (Brent oil) to our model. We have not yet collected data on these three variables, but we are confident that we will be able to do so. We will use the same methodology and variables to test them on different sector indices on the Oslo stock exchange. The selected sector indices will be OSE10 Energy, OSE15 Materials, OSE20 Industrials and OSE40 Financials. Data from the different indices will we hopefully provide through the Oslo stock exchange website. Sample of the data would be around 2000 until today. Presented below are four different indices from Oslo Stock exchange. To show that different indices are sensitive to different factors. We hope to find some explanatory results that can shed light to this occurrence.

6.0 Thesis progression

In the road to completion of our Master Thesis, the first matter that would need to be handled is the gathering of the remaining data to employ our regression model. We also need to collect all the data of the relevant stock indices on the Oslo stock exchange. Further, we also need to collect the remaining data on our selected economic variables, namely exchange rate (USD/NOK), Brent oil prices and the 3-month NIBOR. In order to estimate and analyze the data correctly, we would have to go further into the understanding of the appropriate methodology. When we have the adequate understanding, we can start building our regression model and finally test our hypotheses. Our hope is that this will provide us with the answers we need in order to conclude on the characteristics of the relationship between the stock market indices and the selected macroeconomic variables.

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