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Causal relations between stock market returns and macroeconomic variables

Cointegration evidence from the Norwegian stock market

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Abstract

The purpose of this thesis is to investigate whether imperative results on relations between stock returns and macroeconomic variables arising from major markets are valid in a small, open economy such as the Norwegian. By utilizing the vector error correction model (VECM) on monthly data from January 2001 to June 2016, results show that the Oslo All-share index and the selected macroeconomic variables are cointegrated, i.e. there exists a long-run relationship between them. Similarly, six out of ten sectors also proved one cointegrating vector, at the 1% significance level. For the main index, we find negative relations with the NIBOR 3-month interest rate and the exchange rate (USD/NOK). In contrast, positive relations are found for the consumer price index, the industrial production and the price level of the S&P 500 index. Somewhat similar findings are reflected among the different sectors, but specific sectors deviate considerably – implicating a benefit from sector diversification. Especially, industrial production, aggregated consumption and the consumer price index are important determinants of the different sectors, in the long run.

The short-run findings suggest that the Oslo All-share index and most of its different sectors respond inaccurately to changes in important domestic real activity indicators such as aggregated consumption and industrial production. These findings correspond with the analysis conducted by Gjerde & Sættem on the Norwegian market in 1999. Although the applied methods are not entirely comparable, the results demonstrate that the same inaccuracies are still in existence almost 20 years later.

Similar to major markets such as the U.S. and Japan, the variance decomposition shows that the Norwegian stock market is largely driven by interest rate news. The sector analysis supports this statement. However, varying characteristics in the individual sectors affect the impact from changes in interest rates. Data suggests that the importance of interest rate news is high in sectors such as; Materials, Consumer staples, Health care, Information technology and Telecommunication services. Furthermore, the impulse response analysis reveals that, depending on their operational aspect, sectors react differently to shocks in the selected macroeconomic variables.

Lastly, the analysis shows no evidence of bidirectional relations between changes in the price of Brent oil and stock returns of the Oslo All-share index and the different sectors, except for the Energy index. Thus, the statement among practitioners that the stock market in Norway is driven by the development of oil is only to a lesser degree supported in our data.

Preface

The following thesis was written as a conclusion to our MSc in Economics and Business administration at the Norwegian School of Economics (NHH). We found great pleasure in writing this thesis, as we were given the opportunity to implement the expertise and understanding of finance acquired through the master's degree at NHH.

The process of writing this thesis has been both challenging and educational. In addition to applying knowledge from earlier studies, we have used this opportunity to extend our understanding within the field of econometrics and financial markets.

We would like to thank Professor Gunnar Stensland for technical guidance and given thoughts during an informative and rewarding process.

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Norwegian School of Economics

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1. Introduction

There have been a number of studies within financial economics exploring the relationship between macroeconomic variables and stock market returns. The vast majority of these studies showed a clear link between an excerpt of macroeconomic variables and corresponding stock returns. Still, much of the established literature have focused on how macroeconomic variables affect stock market returns, but how macroeconomic variables and stock market returns simultaneously affect one another have been less documented. Thus, in this thesis, the variables are treated symmetrically, and the aim is to reveal which systematic forces are most important.

In the western world, the Norwegian economy stands out as it is highly influenced by its commodity exports. Industries such as oil and gas, aquaculture and energy are key industries that benefits from the countries' natural resources. Yet, the oil industry is the largest, and as of 2015 the share of total Norwegian gross domestic product originating from the petroleum sector was ~15% (Meld. St. 2, 2015-2016). Among practitioners, it is commonly argued that the stock market in Norway is driven by the development of oil, but it still seems there is little data to support it (Næs, Skjeltorp, & Ødegaard, 2009). This study search to complement this area of research.

In regard to existing studies that document a significant relationship between macroeconomic variables and stock returns, only a few have been conducted on smaller, open economies such as the Norwegian. On the contrary, larger developed countries like the U.S., U.K. and Japan have been extensively researched. In U.S., Kim (2003) discovered that the S&P 500 index were positively related to industrial production but negatively related to real exchange rate, interest rate and inflation. The study also revealed that stock prices were largely driven by interest rate news. As with the US, Mukherjee & Naka (1995) and Naik & Pahdi (2012) found similar characteristics for the Japanese and Indian stock market, respectively. The most significant study on the Norwegian market is the well-cited paper by Gjerde & Sættem (1999). They discovered that stock prices had a positive response towards industrial production and a negative response to changes in real interest rates. However, although industrial production had a significant impact on stock returns, the opposite causality did not occur. These findings indicated some degree of inefficiency in the Norwegian stock market. In contrast, Aylward & Glen (2000) documented that stock markets in the G-7 countries served as leading indicators towards changes in real activity.

The outcome from the studies above indicated the existence of macroeconomic factors significantly related to stock returns in well-developed markets such as the U.S. and Japan. Still, when recognizing the lack of recent studies on the Norwegian market, this study search to extend the knowledge of macroeconomics dynamics in small open economies. The focus of this thesis relies on causal relations among stock returns and domestic macroeconomic variables. Compared to the studies in e.g. U.S. and Japan, the financial markets in Norway are less mature, and the previous study by Gjerde & Sættem have shown some degree of inefficiency. This thesis serves to investigate whether the inefficiencies uncovered by Gjerde & Sættem still exist almost 20 years later and also, which of the established results from the U.S.-, European- and Asian markets that are valid in Norway.

Previous studies mostly rely on the underlying notions developed by Engle and Granger (1987), which demonstrates how a certain class of error correcting models allows for a long-run equilibrium between the variables, and that they in the short run are allowed to deviate from this long-run equilibrium. The thesis extend this in the analysis, and employ the cointegration technique devised by Søren Johansen (1988) that allows one to model several nonstationary endogenous variables[1] similar to that of a vector autoregressive (VAR) framework[2]. It allows one to include the possibility of an existing linear combination of nonstationary variables that is a stationary series[3], in itself. This model is known as the vector error correction model (VECM) and it essentially makes one able to differentiate between long- and short-run equilibrium relationships between selected variables.

Specifically, this thesis focuses upon the dynamic relationships among the Oslo All-share index[4] and the following macroeconomic variables; the NIBOR 3-month interest rate, the exchange rate (USD/NOK), the price level of the S&P 500 index, the price of Brent oil, industrial production, the index of retail trade and the consumer price index. In addition, structural regularities among factors are analysed, by utilizing variance decomposition and impulse response simulations. The purpose is to gain knowledge on which systematic forces that are most important in determining innovations in stock returns.

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[1] Nonstationary variable: mean, covariance and variance are time-dependent. Endogenous variable: a variable that is explained by the relationships among functions within the specific model.
[2] These frameworks are further elaborated in section 4.2 and for a deeper understanding of the VAR-model, the originating paper by Cristopher Sims (1980) and other enlightening papers by M. W. Watson (1994) and Toda and Yamamoto (1995) are recommended.
[3] A stochastic process whose joint probability distribution is constant over time.
[4] The Oslo All-share index consists of all shares listed on the Oslo stock exchange, and is adjusted for dividend payments.

Recognizing the lack of relevant studies which includes the industry specific aspect, this thesis also includes an analysis of the dynamic relationship between selected macroeconomic variables and stock returns arising from the different sector indices at the Oslo stock exchange. By including the industry specific aspect, this thesis goes beyond the extent of studies conducted on the Norwegian market. The goal is to enrichen the understanding of macroeconomic factors and to reveal which are the most important in determining innovations in stock returns given the sectors operational aspect.

1.1. Objectives

The main scope of this thesis has been to examine the presence of long- and short-run causalities running from the chosen macroeconomic variables to the Oslo All-share index and its different sectors. The target was to determine systematic forces important in explaining innovations in stock returns and to what extent shocks in macroeconomic factors affected the Oslo stock exchange and its different sectors. Accordingly, the three research questions for this thesis were defined as:

1. Are there any long-run equilibrium relationships between selected macroeconomic variables and stock market returns in Norway at a national or sectorial level?
2. Are there any unidirectional or bidirectional[5] short-run causalities running between selected macroeconomic variables and stock market returns in Norway at a national or sectorial level?
3. How does the Norwegian stock market and its different sectors respond to shocks in any of the selected macroeconomic variables and to what extent do these shocks explain the variation in stock returns?

As part of achieving the primary objectives, the following tasks were completed:

- Extensive literature study within the fields of financial economics and the effects of macroeconomic factors
- Design of models with the use of Stata and Eviews
- Methodological validation of finalized models
- Evaluation of the results from the short- and long-run analysis

[5] Unidirectional causality: causality running from a dependent variable towards an explanatory variable. Bidirectional causality: causality running from a dependent variable towards an explanatory variable and from the explanatory variable towards the dependent variable.

- Impulse response simulation and forecasted error variance decomposition
- Conclusions and suggestions for future research

1.2. Thesis organization

In order to answer the research questions, the thesis was divided into seven chapters. Following the introduction, a chapter on the empirical framework will provide the content necessary to understand the surrounding dynamic relations between macroeconomic factors and stock market returns in different economies and also the underlying notions of equity pricing. In chapter 3, the data are described and discussed based on results from previous research. Chapter 4 present the empirical design and methodological process involved, while chapter 5 presents the results of the short- and long-run analysis between the selected macroeconomic variables and the Oslo All-share index. Forecasted error variance decomposition and impulse response simulations will also be presented in this chapter. Similarly, chapter 6 presents the results of the sector analysis and it includes joint discussions of the findings compared to that of the composite stock index. Validation of the simulation methodology will also be presented throughout chapter 5 and 6. Lastly, conclusions and implications for future research are given in chapter 7, followed by bibliography and appendices.

1.3. Limitations

The results presented in this thesis are most likely sensitive towards the chosen sample period and economy, as well as the choice of time-series model and variables. However, the explicit results will not change the implications of this analysis. The study demonstrates how important it is for investors not to only consider a direct cause and effect relation, because of the evidenced endogenous behaviour of the macroeconomic variables.

The VECM, either as employed by Johansen (1988) or Engle & Granger (1987), have been known to be sensitive to lag order. For that reason, results from the cointegration analysis were presented at the 1% significance level. Further, the sign of the coefficients in the system demonstrated robustness towards changes in lag structure for both the main analysis and the sector analysis. However, with a 1% criteria we were not able to detect cointegrating relations for all sectors, which would have yielded a better basis for comparison. In addition, the results from the different unit root tests are sensitive to lag lengths. For that reason, three different unit root tests were utilized in order to address the order of integration. Lastly, problems with normality were observed in the different models. The practical interpretation of this implies that the estimates are not efficient but still consistent.

2. Empirical framework

The following chapter will present the theoretical framework, which primarily consist of theories surrounding the efficiency of financial markets and other common approaches to equity pricing. Recognizing the lack of relevant studies on the Norwegian market, the literature review introduces the reader to findings from studies in other relevant markets.

2.1. Theoretical framework

Business cycle is considered one of the main characteristics of the capital economy and a lot of research have been carried out in order to understand and predict its nature. Many regard the stock market as the leading indicator of economic growth and a predictor of future profitability. However, according to the efficient market hypothesis (EMH), stock prices still remain unpredictable. The efficient market hypothesis, partially developed by Eugene Fama in the 1960s, stated that stock prices already contain all available information but distinguishes between the weak, semi-strong and strong form of EMH. The weak form of EMH only account for common publicly available information about past prices, volumes etc. The semi-strong form of EMH also take fundamentals of the companies into account. Such information could be information about management, products, balance sheet etc. Lastly, the strong form of EMH contains all previous information as well as information only available to insiders (Bodie, Kane, & Marcus, 2011).

The study of causal relations between macroeconomic indicators and stock prices tells us whether the given market exhibits informational efficiency. For instance, one can dismiss the weak-form hypothesis of EMH if there is a unidirectional causality running from macroeconomic variables to stock prices. This would suggest that the current stock prices do not reflect all information contained in the macroeconomic variables. Subsequently, the market participants could adopt a trading strategy that could lead to abnormal returns in the long run. On the contrary, the market could be considered efficient if stock returns are significant in explaining macroeconomic variables. In the case of no unidirectional causalities, the market is not necessarily inefficient. Nevertheless, this could also be caused by a misspecified model, as its chosen variables might not contain any useful information about the stock market development. The interpretation of cointegration, i.e. long-run equilibrium relationship, with respect to market efficiency, depends upon how one defines efficiency (Mukherjee & Naka, 1995). When defining efficiency as absence of predictability, Granger (1986) argued that stock prices can not be cointegrated in efficient markets. By defining efficiency as a lack of arbitrage opportunities, Dwyer & Wallace (1992) demonstrated that the presence of cointegration was consistent with the absence of abnormal returns. This means that the presence of a cointegration relation does not necessarily violate the notion of information efficiency defined by Fama (1991).

The capital asset pricing model (CAPM), introduced by William F. Sharpe (1964), John Lintner (1965) and Jan Mossin (1966) independently and derived from Markowitz's concept of diversification and modern portfolio theory (1952), is considered one of the most popular models in stock market pricing. CAPM has been recognized as a single-factor model since it only takes the market factor into account when determining stock returns. Investors are compensated either through the time value of money or the time value of risk. The time value of money is represented by the risk free rate which compensates an investor for placing money in any investment over a certain time. When investors have diversified portfolios, only the systematic risk is of interest. The sources of systematic risk derive from the risk premium that characterizes the entire market and can only be mitigated by hedging. For instance, wars, interest rates and recessions could all reflect sources of systematic risk factors as they affect the entire market (Bodie, Kane, & Marcus, 2011, p. 278).

An extension of CAPM and a form of multi-factor model known as arbitrage pricing theory or APT developed by Ross & Roll (Ross, 1976 and Roll & Ross, 1980), claimed that surprises, or shocks of multiple factors, can be used in order to determine stock returns. In other words, asset prices should depend on their exposure to state variables which describe the economy. This implies that – in the context of APT – an asset's return can be predicted by using the relationship between a given asset and a set of macroeconomic variables as a measure of economy wide risk factors (Burmeister & McElroy, 1988 and Chen, Roll, & Ross, 1986).

Another approach in explaining the effect of macroeconomic variables on stock prices is the present value model. The model first gained its popularity after the stock market crash in 1929, and Irving Fisher (1930) and John Burr Williams (1938) were the first to introduce the discounted cash flow method (DCF). The model stated that the current stock price is determined by expected future cash flows and an appropriate discount rate. Thus, the macroeconomic variables that affect either expected future cash flows or the discount rate are obligated to impact the current stock price. However, the set of macroeconomic variables that could affect the stock price have no decisive theoretical foundation.

2.2. Literature review

In financial economics, there have been a number of studies exploring the relationship between macroeconomic variables and stock returns. Results from these studies are inconclusive, but several works have discovered existing causalities between macroeconomic variables and the economy under survey. The literature review will start by looking at post-war studies from growth-leading economics in Asia, before presenting results from larger economies like the U.S. and Europe. Lastly, results from emerging markets and small open economies are elaborated.

Looking at the larger emerging/developed and growth-leading economies in Asia, several studies show a causal relationship between macroeconomic variables and stock prices. With a sample spanning from 1971-1990 and a VECM approach, Mukherjee & Naka (1995) discovered that the Japanese stock market (Tokyo stock exchange (TSE)) was cointegrated with a group of six variables. The signs of the long-term elasticity coefficients supported the earlier hypothesized equilibrium relations at the time. Industrial production, money supply (M2) and depreciation of yen against USD all had a positive effect on stock prices, while the relationship between stock returns and inflation was negative. Furthermore, they found a negative relation between stock returns and long-term government bonds. Naik & Pahdi (2012) discovered a similar behaviour in the Indian capital market using a sample from 1994 to 2011. They revealed a long-run equilibrium relationship between their chosen macroeconomic variables and stock returns. Similar to Mukherjee & Naka, they observed that both money supply and industrial production were positively related to stock prices while inflation had the opposite effect. However, the exchange rate and interest rate were insignificant in determining stock prices. In addition, their model exhibited bidirectional causality between industrial production and stock prices, while unidirectional causalities were found running from money supply to stock prices, stock prices to inflation and interest rates to stock prices. Similarly, by obtaining quarterly data from 1995 to 2008, Pal & Mittal (2011) found cointegration between macroeconomic variables and the Indian stock market. Inflation was shown to have a significant impact on both of the respective indices (BSE Sensex and the S&P Nifty) while foreign exchange rate and the interest rate only impacted one of the indices in the long run. More recently, Kotha & Sahu (2016) found that the Indian stock market still exhibited a long-run relation with exchange rate, interest rate and inflation as well as money supply (M3).

As with Asia, the American economy has also been extensively investigated, and amongst the first to analyse the relationship between macroeconomic variables and their effect on the stock prices were Chen, Roll & Ross with their paper “Economic forces and the stock market”, published in 1986. In this work, they tested whether innovations in macroeconomic variables serve as a beneficial risk in the stock market. Using a sample spanning from 1953 to 1983, U.S. data and a version of the Fama-Macbeth technique (1973) lying within the APT framework, their findings showed that, industrial production, changes in the risk premium, twists in the yield curve, unanticipated inflation and changes in expected inflation were significant in explaining expected stock returns. Using a VECM on monthly data from 1974-1998, Kim (2003) found that the S&P 500 were positively related to industrial production but negatively related to real exchange rate, interest rate and inflation. These results supported several of the findings in the Japanese and Indian markets. Additionally, error correction mechanism revealed that the industrial production level, stock prices and inflation rate adjusted in order to correct disequilibrium among the five variables. The variance decomposition revealed that stock prices to a considerable extent were driven by the innovation in interest rate. Humpe & Macmillian (2009) used U.S. data from the last 40 years and found one cointegrating vector, i.e. long-run relationship between the variables. Stock prices were negatively related to both inflation and long-term interest rate, while industrial production had a positive relationship, consistent with the findings of Kim (2003).

In Europe, Masuduzzaman (2012) showed a significant relationship (short- and/or long-run) between the variables: inflation, industrial production, exchange rate, interest rate and money supply and the corresponding stock market in both U.K. and Germany, with a sample spanning from 1999-2011. Significant relations were also found in a more recent study by Plihal (2016). He discovered unidirectional causalities running from the German stock market index (DAX) to industrial production, money supply and interest rate. Additionally, bidirectional causality emerged between stock market returns and money supply.

In the small, developed economy Singapore, Maysami & Koh (2000) examined the long-run equilibrium relationships between the Singapore stock exchange and chosen macroeconomic variables, as well as among stock indices in Japan and U.S. Using 20 years of data, they discovered a significant long-run relationship between the Singapore stock market and changes in the interest and exchange rates. Changes in inflation and money supply did not contribute significantly in their results. Furthermore, the study showed that stock market in Singapore was positively cointegrated with both the American and Japanese stock markets.

Closely related to the topic for this thesis, Gjerde & Sættem (1999) carried out an extensive analysis on the Norwegian market with a model utilizing up to seven variables. Data spanned from 1974-1994 and the multivariate Vector Auto Regressive (VAR) framework was used in order to analyse the short-run dynamics. Included variables, apart from stock returns, were; industrial production, consumption, inflation, exchange rate (USD/NOK), oil prices, interest rate and the OECD industrial production index. Similar to the studies in USA, India, Japan, Germany and U.K., Gjerde & Sættem found that stock returns had a positive response towards industrial production and a negative response to changes in real interest rates. In addition, their paper showed that changes in the real interest rate affect both inflation and stock returns. Finally, the stock price responded accurately towards changes in oil price.

Results from other emerging economies exhibit somewhat corresponding results. In Vietnam, Hussainey & Ngoc (2009) investigated the Vietnamese stock market using monthly data spanning from 2001-2008 and a multivariate regression approach first introduced by Nasseh & Strauss (2000) and Canova & De Nicoló (1995). Hussainey & Ngoc were the first to research the Vietnamese stock market and they found significant relationships among the money markets, the domestic production sector and stock prices in Vietnam. As with Singapore (Maysami & Koh, 2000), they found that US macroeconomic fundamentals significantly affected the stock price. Pilinkus (2009) used Lithuanian data spanning from 1999 to 2008 and a somewhat different approach considering the use of 40 different macroeconomic variables. Essentially, Pilinkus established that there existed a bidirectional causal relationship between stock market returns (OMXV index) and the index of durable consumer goods (CPI) and money supply (M1 & M2), in addition to several unidirectional causalities between the variables and stock returns. With the use of macroeconomic variables such as unemployment rate, interest rate and exchange rate, Tangjitprom (2012) examined the lead-lag effect on the stock market performance in Thailand. He found that all chosen variables were significant in explaining stock returns, but that stock returns were the leading indicator for future macroeconomic conditions.

After a thorough review of literature in the U.S., Europe and Asia, it is apparent that changes in macroeconomic factors impact the development of respective economies, however, the direction of causality differs across different sample periods and economies and also the choice of variables and time-series model affects the results.

The aim of this chapter has been to present the theoretical framework applicable to the objective approach. The chapter does not cover every aspect of the economic consideration, but the major economic models relevant to the topic have been discussed. Furthermore, the literature review has identified key findings from previous studies on other economies as well as the Norwegian one. The aim has been to provide an overview of previous findings, as well as point to differences between the applied method and investigated markets. In the next chapter the data used for the analysis in this thesis will be presented and variables defined.

3. Data

Compared to other VECM or VAR approaches, we have chosen a wider set of variables. These includes real sector variables (industrial production and aggregated consumption), domestic financial variables (the price level of the Oslo All-share index, the NIBOR 3-month interest rate and the consumer price index) and international factors (the exchange rate (USD/NOK), the price of Brent oil and the price of the S&P 500 Index).

Table 1: Definition of variables

Variable	Abbreviation	Source	Frequency	Data type	Publication date
Oslo All-share Index	OSE	Datastream	Monthly	Daily obs.	n/a
NIBOR 3-month interest rate	NIB	Datastream	Monthly	Daily obs.	n/a
S&P 500 Index	SP	Datastream	Monthly	Daily obs.	n/a
Exchange rate USD/NOK	EX	Datastream	Monthly	Daily obs.	n/a
The price of Brent oil	OIL	Datastream	Monthly	Daily obs.	n/a
Value index of retail trade (Consumption)	CON	Statistics Norway	Monthly	Average, SA*	End of next month
Consumer price index	CPI	Statistics Norway	Monthly	Average	The 10. of the following month
Norwegian Industrial Production	NIP	Statistics Norway	Monthly	Average, SA*	End of next month

*Seasonally Adjusted

This thesis makes use of monthly data spanning from January 2001 to July 2016, resulting in a total of 186 observations, which is considered sufficient for an efficient analysis. The data were collected from various sources. Data from domestic industrial production, consumption and the consumer price index were obtained from Statistics Norway while the data for the five remaining variables; stock prices of Oslo All-share index, stock prices of the S&P 500, the NIBOR 3-month interest rate, the price of Brent oil and the exchange rate (USD/NOK), were obtained from Datastream. All the chosen variables have a monthly frequency, however, some of the variables have different characteristics. Consumption, consumer price index and Norwegian industrial production are monthly averages and both consumption and Norwegian industrial production are seasonally adjusted. In addition, both consumption and Norwegian industrial production are published a month after their final observation while the consumer price index are published approximately half a month afterwards (see Table 1). Thus, we have chosen to led these three variables one period (month). The remaining five variables are treated as is.

3.1. Definition of variables

A total of eight variables enter the analysis and the dependent variable of the main model is the price level of the Oslo All-share index. This index includes all of Norway's noted companies, and this variable is chosen because it serves as the leading indicator of the state of the Norwegian economy. Also, we wanted to analyse the impact the chosen variables had on the economy as a whole, before looking at the different sectors separately.

3.1.1. Domestic financial variables

The NIBOR 3-month interest rate (NIB), or the Norwegian Interbank Offered Rate, serve as a reference for the money market rate between banks. Thus, the variable was included in this analysis in order to reflect the interest rate that most of the companies would comply with. In itself the interest rate is set on the basis of the Norwegian policy rate and a small interest rate premium to reflect the risk and liquidity relations involved. The main assumption of the discounted cash flow model states that, when holding all other things constant, a higher interest rate leads to a lower present value of future discounted cash flows. Still, the effect of an increased interest rate on the stock market is not apparent. For instance; if the higher interest rate is a result of an increased inflation without any significant growth in the economy, the effect would most likely be negative, holding all other things constant. On the contrary; if the increase in interest rate is caused by an improving economy that is growing at a pace which results in higher company earnings, the net-effect would not be negative. Further, to supplement the interest rate effect, we included the consumer price index (CPI) as a measure of actual changes in the prices for household services and goods (including charges and fees). Its differentiated form (CPI_t-CPI_{t-1}) serve as a proxy for inflation, and as per the money demand theory, an increased inflation is negatively related to economic activity, thus stock returns could also be negatively related to inflation, according to Eugene F. Fama (1981). This negative relation is supported by several researchers such as Gjerde & Sættem (1999), Mukherjee & Naka (1995), Kim (2003), Pal & Mittal (2011) and Humpe & Macmillian (2009). The purpose for including this variable was to examine whether this relation existed in a small, open economy such as the Norwegian.

3.1.2. International factors

S&P 500 (SP) is an American stock market index that includes 500 leading companies and approximately 80% of the available market capitalization in the country. The variable was included to incorporate the exogenous effect that a leading economy such as the U.S. might have on the Norwegian. Studies in Vietnam by Hussainey & Ngoc (2009) and in Singapore by Maysami & Koh (2000) showed that the US stock market significantly affected stock market returns in both of these economies. We included the price of Brent oil (OIL), noted in USD to look at how this affected the development of an oil dependent economy such as the Norwegian. Gjerde & Sættem (1999) included this variable and found that it had a significant impact on stock prices, but could not determine the direction of causality. As of 2015, the amount of exports from oil related services (excl. the supply industry) were approximately 40% (Meld. St. 2, 2015-2016). For that matter, the exchange rate of U.S. Dollar to Norwegian Kroner (EX) was included to embody the fact that most of the exports are paid in USD and to diminish the effect of USD notations in the price of Brent oil. The impact of exchange rate on an economy depends upon its trade balance and its level of international trade. A depreciation of local currency leads to an increase in demand for exports, thus increasing cash flows in to the country with the assumption of an elastic demand for exports. Thus, the impact of an exchange rate change depends upon whether the firm is export dominant or import dominant and in our case whether USD is their main traded currency. As for Norway, and its export dominant economy, we expected a depreciation of NOK against USD to have a positive impact on the economy. However, this effect would most likely vary across industries.

3.1.3. Real sector variables

The Norwegian industrial production (NIP) is represented by the index of industrial production for oil extraction, mining, manufacturing and electricity. This variable reflects the state of the production level and its objective is to monitor the development of added value in the industries covered. The vast majority of earlier studies, e.g., Gjerde & Sættem (1999), Mukherjee & Naka (1995), Pilinkus (2009) and Masuduzzaman (2012), have shown that an increased industrial production results in an increased activity which in turn makes for higher company earnings and stock returns. Thus, we expected an increased industrial production to have a positive effect on stock prices. Consumption (CON) is calculated by its value index of retail trade and the objective of this index is to describe the volume and value development in retail sales, excl. sales of motor vehicles. In fact, when calculating household consumption, retail sales serve as the main component. The reason for including this variable was to check if the implications of the consumption based asset pricing models hold, i.e. whether stock prices are priced according to their covariances with aggregate consumption (Balvers, Cosimano, & McDonald, 1990 and Campbell, 2003).

4. Methodology

The following chapter demonstrate the empirical design and methodological process involved. The subsequent results are presented in chapter 5 and 6.

4.1. Unit root testing

In standard regression methods such as ordinary least squares (OLS), variables need to be covariance stationary. A variable is said to be covariance stationary if its mean and all its autocorrelation are finite and do not change over time (Wooldridge, 2009, pp. 345-346). However, when variables do *not* meet the assumption of covariance stationarity, the cointegration methodology presents a framework for estimation, inference and interpretation.

In general, many economic time series are not covariance stationary. Hence, the first step in the analysis was testing stationarity properties of the variables, using a unit root test. If a time series have a unit root, the independence assumption of the ordinary least squares methodology will be violated and the results are not valid, i.e. there will be a spurious regression problem and the results might be incorrect and misleading[6]. The time series included in the model should be stationary. This means that the variance and mean should be constant over time and the covariance between two time periods should only depend on the distance between the two time periods and not the actual time at which the covariance is estimated. In stationary time series, the effect of a shock will be temporary and over time, the series will revert back to their long-run mean values. Nonstationary time series have variance and mean that depend on time.

The cointegrating analysis requires pre-testing of the data in order to examine the stationary properties of the time series. If the time series is stationary in level, it is a covariance-stationary process and if the variables become stationary after first differencing they are said to be integrated of order 1, or I (1) processes (Wooldridge, 2009, pp. 345-346). Generally, a process whose p^{th} difference is stationary, is an integrated process of order *p*, or I (*p*).

Only variables integrated of the same order may be cointegrated and to check the stationary nature of the series, we utilized the Augmented Dickey-Fuller (ADF), Philips-Perron (PP) and Kwiatkowski-Philips-Schmidt-Shin (KPSS) unit root tests (henceforth the ADF-, PP- and

[6] Spurious regression refers to a regression that provides statistical evidence of linear relation between independent non-stationary variables.

KPSS test). Similar to the ADF and PP test, the KPSS test may be conducted under the assumption that the series are trend- or level stationary.

The reason for utilizing three different unit root tests is to make a stronger point about the order of integration. While the ADF test is often criticized for low power, the PP test has been criticized for its poor size properties (Schwert, 1989). The PP test modifies the test statistics used in the ADF test and adopts a non-parametric method in order to control for serial correlation. This means that, compared to the Phillips-Perron test, the ADF test is considered less powerful, but it does not suffer from severe size properties.

The ADF and PP test, tests the null of a unit root against the alternative of stationarity, while the KPSS test has the opposite null; that the series being tested is stationary. The KPSS test is often viewed as complementary to the commonly employed tests, and is often used to confirm results from the ADF and PP test. Although commonly used, Maddala & Kim (1998) found in their study that the KPSS test is plagued by the same poor size and power properties as the traditional ADF and PP test. In literature, there is still no consensus, that determines the most powerful test. The different unit root tests may in fact yield different results about the stationary properties of the series.

The Augmented Dickey-Fuller and Philips-Perron test are conducted from the ordinary least squares estimates of the following equations, respectively[7]:

$$\Delta y_t = \alpha_0 + \beta T + \theta y_{t-1} + \sum_{i=1}^{N} \alpha_i \, \Delta y_{t-i} + \epsilon_t \tag{1}$$

$$\Delta y_t = \alpha_0 + \beta T + \theta y_{t-1} + \epsilon_t \tag{2}$$

where $\theta = (\rho - 1)$, y_t is the variable of interest, α_0 is the intercept, T is a linear time trend, Δ is the first difference operator, and ϵ_t is assumed to be identical and independently distributed (i.i.d.) with zero mean and constant variance. Depending on whether the underlying data generating process (DGP) is expected to have a drift and/or a linear time trend the specifications of the deterministic polynomial $(\alpha, \beta T)$ in the above equations change. The original DGP of

[7] Under equation (1) and (2) we test the null hypothesis H_0: $\theta = 0$ against H_1: $\theta < 0$. One can reject the null hypothesis if $t_{\hat{\theta}} < c$. Since the t-statistic does not have standard t-distribution in the ADF and PP test, MacKinnons' finite sample critical values were applied to determine the statistical significance (Wooldridge, 2009, p. 575).

macroeconomic time series is often unknown. Thus, in practice, a plausible DGP is assumed and the presence of unit root is tested.

A practical problem using the ADF test is selecting the optimal lag length, and the inclusion of the lagged changes in equation (1) is intended to eliminate any serial correlation in Δy_t (Wooldridge, 2009, p. 576). If too many lags are included, the small sample power of the test generally suffers, and by including too few; the size of the test will be incorect and asymptotical. The lag length is often dictated by the frequency of the data (e.g. for quarterly date we might include 4 lags, 12 for monthy etc.), however there is no given rule to follow in any case (Wooldridge, 2009, p. 577). Said & Dickey (1984) found in their survey that the order of lags set according to; $T^{(1/3)}$, where T equals number of observations + 1, was sufficient. Schwert (1989) discusses the same issue, and suggests that one should set the order of lags equal to:

$$p_{max} = 12(\frac{n}{100})^{0.25} \quad (3)$$

where n equals the sample size and p refers to the number of lags. Selection based on Schwert's rule of thumb results in a relativly large lag length with small samples (~100) and a modest when the sample size is large (~10,000). Other suggestions in litterature include using the Schwarz's Bayesian Information Criterion (BIC) and the Akaike's Information Criterion to ensure that the residuals in equation (1) are white noise (Enders, 2003). Given no universal rule, this thesis selected the lag order based on the AIC[8].

4.2. Johansen cointegration test

In bivariate analysis, two series are cointegrated if each is an I (1) process but a linear combination of the series is an I (0) process. Cointegration refers to the situation where non-stationary time series of the same order have a long-run relationship. Variables that are cointegrated share common stochastic trends and would not drift apart over time. The presence of cointegration improves long-run forecast accuracy and allows separation of short- and long-run relationship among variables. After determining the order of integration of each variable, we performed cointegrating tests to examine if there were any cointegrating relations present in the model.

[8] Somewhat simplified, the Akaike's Information Criteria can be expressed in the following multivariate form; $AIC = T * ln(residual\ sum\ of\ squares) + 2n$, where T equals sample size and n is the number of parameters included.

The identification of cointegrating vectors in multivariate time series is more involved compared to the bivariate analysis. Given that z_t is a $k\ x\ 1$ vector of I (1) variables and there is a vector β, so that βz_t is a vector of I (0) variables, then z_t is said to be cointegrated of order (1,0) with cointegrating vector β, where the parameters in β are the parameters in the cointegrating equation. In general, a vector of length k will have at most $k - 1$ cointegrating vectors (Enders, 2003, pp. 360-362).

Two popular cointegrating tests used in the empirical works are the Engle & Granger (1987) test (henceforth EG) and the Johansen test (1988, 1991 and 1995). This study employed the Johansen multivariate cointegration methodology to determine the number of cointegrating relations because of its merits over the EG test (Enders, 2003, pp. 347-348). The Johansen test has the advantage of not requiring a prior assumption of exogeneity or endogeneity of the variables in the system, while the EG test is more appropriate for bivariate analysis as it fails to detect multiple cointegrating relations. However, in practice most empirical applications analyse multivariate systems. The mathematical form of the Johansen cointegration test is as follows:

$$z_t = v + A_1 z_{t-1} + \ldots + A_p z_{t-p} + \mu_t \qquad (4)$$

where z_t is a $k\ x\ 1$ vector of endogenous variables, v is a $k\ x\ 1$ vector of parameters, μ_t is a $k\ x\ 1$ vector of normally and independently distributed error terms, and $A_1 - A_p$ are $k\ x\ k$ matrices of parameters. Equation (4) can be rewritten in VECM form as:

$$\Delta z_t = v + \prod z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + \mu_t \qquad (5)$$

where $\prod = \sum_{j=1}^{j=p} A_i - I_k$ (I_k is a $k\ x\ k$ identity matrix) and $\Gamma_i = -\sum_{j=i+1}^{j=p} A_j$. Both μ_t and v in equation (4) and (5) are identical.

To illustrate the matrix notation, we can assume that we only have two lagged terms ($p = 2$) and two endogenous variables ($y_t$and z_t). This gives us the following model:

$$\begin{bmatrix} \Delta y_t \\ \Delta z_t \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \Gamma_1 \begin{bmatrix} \Delta y_{t-1} \\ \Delta z_{t-1} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix} \qquad (6)$$

Given that the variables z_t are I (1), the matrix $\prod$ in equation (5) has a rank $0 \leq r < k$, where r is the number of linearly cointegrating vectors (Engle & Granger, 1987). The long-run relation among z_t will be decided by the rank of $\prod$. If r equals zero, equation (5) reduces to a VAR model of pth order[9], i.e. the variables in level do not have a cointegrating vector and a long-run relation among the endogenous variables is non-existing (Enders, 2003, pp. 352-354). Furthermore, if we assume that $\prod$ has a reduced rank, $0 < r < k$, there is a possibility of existing $k \; x \; r$ matrices namely α and β, which can be written as follows:

$$\prod = \alpha\beta' \qquad (7)$$

The matrix $\prod$ contains information regarding the long-run relationship in the VECM framework. From the decomposed matrix (7), β' is the long-run matrix of cointegrating parameters and α is the matrix of weights with which each cointegrating vector enters the k equation of the VECM (Enders, 2003, p. 355). α can be interpreted as the speed of adjustment to equilibrium coefficient.

In general, if the rank of $\prod$ is r, there are r cointegrating vectors. The number of distinct cointegrating vectors are found by the characteristic roots (eigenvalues) of $\prod$. The rank of $\prod$ is given by the number of characteristics roots that are different from zero. From the multivariate cointegrating methodology, the number of characteristic roots can be tested by considering the following Trace and Maximum Eigenvalue test:

$$Trace\ Test = \lambda_{trace}(r) = -T \sum_{j=r+1}^{k} ln(1 - \widehat{\lambda_j}\ ) \qquad (8)$$

$$Maximum\ Eigenvalue\ Test = \lambda_{max}(r, r+1) = -T\ ln(ln\big(1 - \widehat{\lambda_{r+1}}\big) \qquad (9)$$

where λ_j are the estimated values of characteristic roots (eigenvalues) retrieved from the matrix $\prod$. T is the total number of observations, and r equals the number of cointegrating vectors. The Trace test tests the null hypothesis that the number of cointegrating vectors is less than or equal to r, against the unspecified alternative hypothesis of more than r cointegrating relations. The Maximum Eigenvalue test tests the null hypothesis that the number of cointegrating vectors are

[9] Rank ($\prod$) $= 0$, implies that all z's are non-stationary. This means that there is no combination of variables that leads to stationarity, which implies that the model should be done in first difference (VAR). Furthermore, if the variables have reduced ranks (i.e. $0 < r < k$) a VAR in first difference is misspecified because it omits the lagged level term ($\prod y_t - 1$).

less than or equal to r, against the alternative of $r+1$ cointegrating vectors (Enders, 2003, pp. 350-354)[10].

If there exist a cointegrating vector between two variables, there is a possibility of either a bidirectional and/or a unidirectional Granger causality[11] among the variables in the system (Engle & Granger, 1987). However, the cointegration test fail to show the direction of the causality and for that matter, the estimation of the error correction model (ECM) is important. In addition, to determine the direction of causality, the VECM approach allow us to distinguish between short- and long-run causality, and essentially the ECM refers to the adjustment process between short-run disequilibrium and a long-run relationship. If we consider x_t (the stock market indices) and y_t (selected macroeconomic variables) as two different time series, the error correction model could generally be expressed the following way:

$$\Delta x_t = \pi_0 + \sum_{i=1}^{n} \pi_1 \Delta x_{t-1} + \sum_{i=1}^{m} \pi_2 \Delta y_{t-1} + \delta ECT_{t-1} + \epsilon_{1t} \tag{10}$$

$$\Delta y_t = \rho_0 + \sum_{i=1}^{n} \rho_1 \Delta y_{t-1} + \sum_{i=1}^{m} \rho_2 \Delta x_{t-1} + \lambda ECT_{t-1} + \epsilon_{2t} \tag{11}$$

where Δ is the first difference operator, n and m are the optimal lag lengths of the variables, δ and λ are the coefficients of the error correction term which represents the speed of adjustment to the long-run equilibrium, ECT_{t-1} are the residuals from the cointegrating equation and ϵ_{1t} and ϵ_{2t} are white noise[12] error terms where $E(\epsilon_{it}) = 0$ and $i = 1, 2$.

Equation (10) is used to test the causality running from y_t to x_t, while equation (11) test the causality running from x_t to y_t and as mentioned, causality can be divided into short-run and long-run relations. The significant coefficient of the lagged error correction term determines the long-run causality. For instance, a significant and negative ECT_{t-1} implies that there is a long-run causality running from the explanatory variables to the dependent variable. The

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[10] The test in deciding the number of cointegrating vectors are nested. Thus, the test should be performed by starting with the null hypothesis of zero cointegrating vectors. E.g., $H_{0,1}$: zero cointegrating vectors is tested against the alternative $H_{a,1}$: at least one cointegrating vector. If $H_{0,1}$ is rejected, the next test is $H_{0,2}$: one cointegrating vector against the alternative $H_{a,2}$: at least two cointegrating vectors and so forth.

[11] The general idea of Granger causality can be summarized as; a variable X Granger cause Y if past values of X and Y improves forecasting performance of Y (Enders, 2003, pp. 283-284)

[12] A sequence (ϵ_t) is a white-noise process if each value in the sequence has a mean of zero, a constant variance and is uncorrelated with all other realizations, i.e. $[E(\epsilon_t) = E(\epsilon_{t-1}) = \cdots = 0]$, $[var(\epsilon_t) = var(\epsilon_{t-1}) = \cdots = \sigma^2]$, $[cov(\epsilon_{t,}\, \epsilon_{t-s}) = cov(\epsilon_{t-j}, \epsilon_{t-j-s}) = 0]$ (Enders, 2003, p. 50).

coefficient of this lagged ECT represents the short-term percentage adjustment by which the long-run disequilibrium in the dependent variable is corrected in each period.

The short-run causality is tested either by the looking at the significance of each lagged explanatory variable, or by the corresponding joint significance for the set of all lagged explanatory variables[13]. If both the t-test and F-test are insignificant, it indicates that the dependent variable is strictly exogenous.

It is possible for a model to exhibit short-run causality without any long-run causality and vice versa. Hence, both tests were implemented.

4.3. Variance decomposing and impulse response function analysis

The VECM analysis interprets the in-sample period only. Thus, the variance decomposition is considered an important tool to make proper assumptions regarding the causal relationship beyond the in-sample period. The forecast error variance decomposition measures the percentage of variance of an endogenous variable that can be attributed to a shock in itself or to another endogenous variable. If these various shocks do not explain any of the forecast error variance of a given variable (y_t) at all forecast horizon, one can say that y_t is an exogenous variable. At the other extreme, if these shocks explain all of the forecast error variance of y_t at all forecast horizon, then y_t would be entirely endogenous (Enders, 2003, pp. 278-280).

To further analyse the dynamic properties of the variables, the impulse response function was utilized. The impulse response function measures how the dependent variable responds to a shock in itself or to a shock in another endogenous variable. Plotting the orthogonalized impulse response function[14] is a practical way to visually represent how a variable responds to various shocks in the endogenous variables, and through the impulse response function, one can examine the direction, magnitude and length of time that a variable is affected by a shock in itself or in another variable within the system, ceteris paribus (Lütkepohl, 2005, pp. 51-63).

[13] This is done by using the F-test (Wald X^2 test) and, as an example, the following null hypothesis; $H_0: \beta_{11} = 0, \dots, \beta_{1p} = 0$ is tested (Wooldridge, 2009, pp. 529-530).

[14] Disturbances may be contemporaneously correlated, thus these functions do not necessarily explain how a given variable reacts to a one-time increase in the innovation to variable j after s periods, ceteris paribus. For that matter, and to explain this issue, we start with orthogonalized innovations so that the assumption to hold everything else constant is in fact reasonable (Enders, 2003, pp. 272-274).

5. Oslo All-share analysis

The analysis in this chapter can be divided into four steps. The first step examines the stationarity properties of the time series, the second step tests for cointegration relations and the third step tests causalities by utilizing the Vector Error Correction Model (VECM). Finally, the variance decomposing and impulse response analysis are performed in order to analyse the dynamic properties of the variables, out-of-sample.

In order to diminish the issues of multicollinearity and heteroscedasticity, all variables were log-transformed. This implies, that from this point onwards, the abbreviation "OSE" refers to the natural logarithm of the Oslo All-Share Index. The same interpretation applies to the rest of the variables, and subsequently, all variables used in the VECM are differentiated (Δ). Thus, the transformation and corresponding economic interpretation of the finalized variables are described in Table 2.

Table 2: Definitions of variables and time-series transformation

Variables	**Definitions of variables**
OSE_t	Natural logarithm of the market-value weighted month-end closing price for the Oslo All-share index.
NIB_t	Natural logarithm of the month-end 3-month Interbank Offer Rate.
SP_t	Natural logarithm of the market-value weighted month-end closing price for the S&P 500 index.
EX_t	Natural logarithm of the month-end USD/NOK exchange rate.
OIL_t	Natural logarithm of the month-end price of Brent oil.
CON_t	Natural logarithm of the month-end value index of retail trade.
CPI_t	Natural logarithm of the month-end Consumer Price index.
NIP_t	Natural logarithm of the month-end Industrial Production index.
Transformation	**Definitions of transformations**
$\Delta OSE_t = OSE_t - OSE_{t-1}$	Monthly return on the Oslo All-share index (ex- dividend).
$\Delta NIB_t = NIB_t - NIB_{t-1}$	Monthly change on 3-month interbank market.
$\Delta SP_t = SP_t - SP_{t-1}$	Monthly return on the S&P 500 index (ex-dividend).
$\Delta EX_t = EX_t - EX_{t-1}$	Monthly change in exchange rate (USD/NOK).
$\Delta OIL_t = OIL_t - OIL_{t-1}$	Monthly change in the price of Brent oil.
$\Delta CON_t = CON_t - CON_{t-1}$	Monthly change in the value index of retail trade (consumption rate).
$\Delta CPI_t = CPI_t - CPI_{t-1}$	Monthly realized inflation.
$\Delta NIP_t = NIP_t - NIP_{t-1}$	Monthly growth rate of Industrial Production.

5.1. Stationarity test

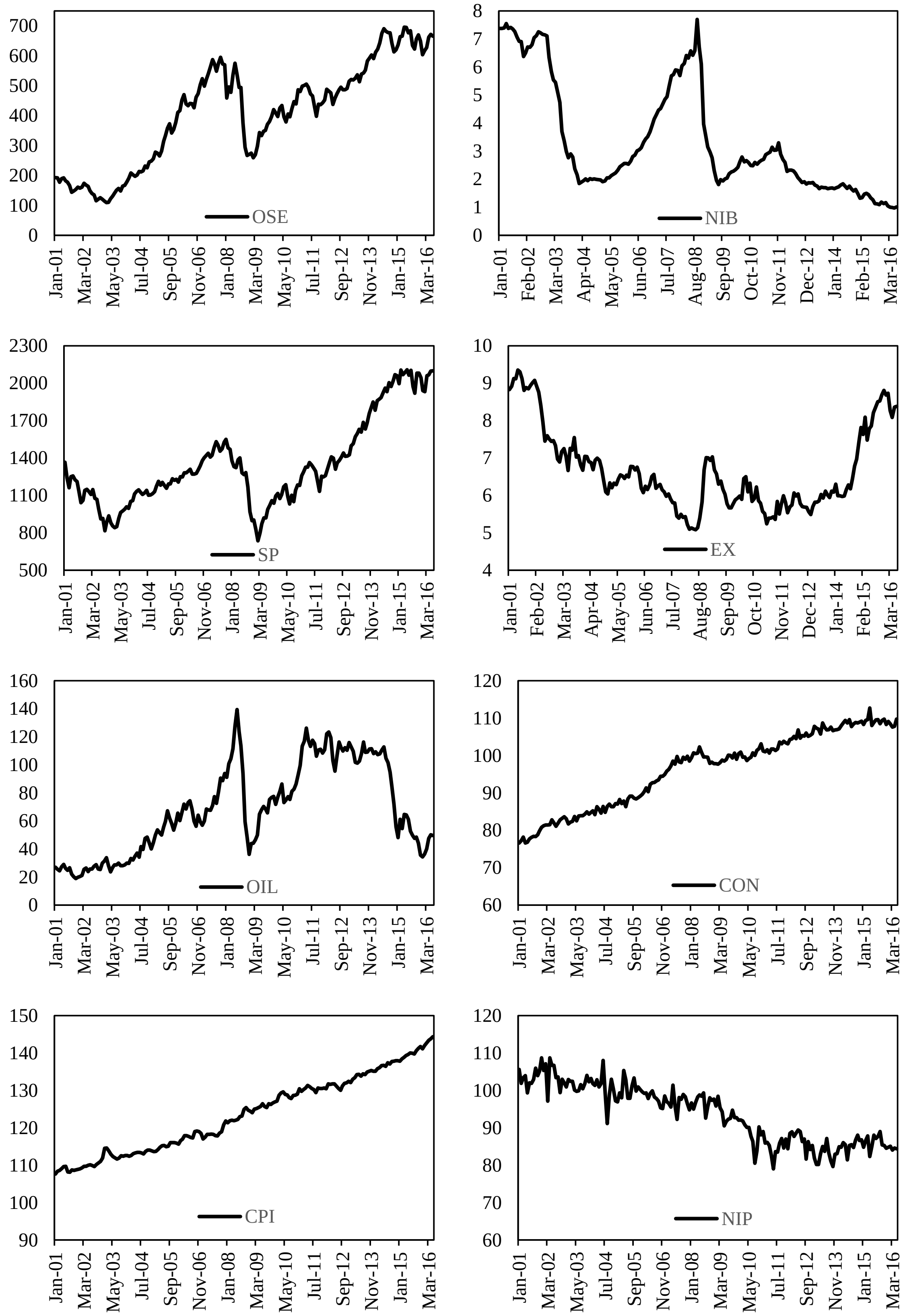
Many economic time series have a common tendency of growing over time and one must recognize that some series contain a time trend[15] in order to draw causal inference in time series analysis. Ignoring the fact that two series are trending may lead to false interpretation of the causal relationship (Wooldridge, 2009, pp. 329-332).

When testing the stationary properties of the variables in a model, one has to specify which model of the unit root test to utilize, i.e. whether to include a constant, a constant and a linear trend or neither a trend or a constant in the test regression. The critical values of the test statistics generally increase when including a time trend (Wooldridge, 2009, pp. 574-578).

The graphical plots of the different time-series from January 2001 until June 2016 are presented in Figure 1. In the sample-period, OSE, SP, CON and CPI exhibited trend characteristics, and for that reason, a trend and a constant were included when testing the stationary properties of these variables. In the remaining series, where trend characteristics were considered unclear, we have first implemented a model containing both a constant and a linear time trend, because this model is considered less restricted. If a unit root was rejected in the latter model, there was no reason to perform additional testing, due to the significant $\hat{\theta}$ (see equation (1) and (2)).

[15] A time trend is a persistent long-term movement of a variable over time. In time series data we often se either deterministic- or stochastic time trends (Wooldridge, 2009, p. 313).

Figure 1: Development of macroeconomic variables and the price level of OSE



The stationarity of the underlying data series were investigated by employing the ADF-, PP- and KPSS tests in Table 3. In levels, all series failed to reject the null of a unit root at the 5% level and after detrending[16] each series, we found strong evidence against the null hypothesis of unit root, i.e. all series were found to be individually integrated of order one.

Table 3: Unit root tests

Variable	Lags[a]	ADF: H_0: variable is non-stationary	PP: H_0: variable is non-stationary	KPSS: H_0: variable is stationary	Order of integration
OSE	2	-1,981	-1,791	0,953***	
ΔOSE		-6,599***	-10,693***	0,0972	I (1)
NIB	9	-1,762	-1,323	1,07***	
ΔNIB		-3,870***	-9,876***	0,0704	I (1)
SP	2	-1,913	-2,36	0,641***	
ΔSP		-6,722***	-11,686***	0,244	I (1)
EX	3	-2,157	-1,84	1,18***	
ΔEX		-6,383***	-13,232***	0,371*	I (1)
OIL	2	-2,066	-1,803	3,64***	
ΔOIL		-7,396***	-10,942***	0,181	I (1)
CON	3	-1,395	-1,854	0,849***	
ΔCON		-7,503***	-21,860***	0,335	I (1)
CPI	9	-1,974	-3,059	0,139*	
ΔCPI		-5,364***	-12,388***	0,158	I (1)
NIP	6	-0,555	-1,387	2,56***	
ΔNIP		-7,366***	-23,535***	0,054	I (1)
Critical values					
1%		-3,482	-3,482	0,739	
5%		-2,884	-2,884	0,463	
10%		-2,574	-2,574	0,347	
Critical values with trend					
1%		-4,012	-4,012	0,216	
5%		-3,439	-3,439	0,146	
10%		-3,139	-3,139	0,119	

*** implies significance at the 1% level, ** implies significance at the 5% level and * implies significance at the 10% level. Δ represents first difference operator.
[a] Optimal lags selected using the Akaike's Information Criteria (AIC).

5.2. Optimal lag length

An appropriate lag length has to be chosen before applying the cointegration technique. The model will be misspecified if the lag length is too small and over parameterized if the number of lags is too large (Wooldridge, 2009, p. 576). Lag order selection were based on the Likelihood ratio (LR) test and information criteria's such as; the Final Prediction error (FPE), Akaike's Information Criterion (AIC), Hanna-Quinn Information Criterion (HQIC) and

[16] When differencing a time series, any linear trend is removed.

Schwarz Criterion (SC). From Table 4, FPE, AIC, HQIC and SBIC all recommended a lag length of one, while the LR test suggested a lag length of six. The problem of varying lag length recommendations were handled by implementing the Lagrange Multiplier residual serial correlation test (LM test[17]).

Table 4: Lag order selection by different criteria's

Lags	LL	LR	FPE	AIC	HQIC	SBIC
0	1297.62		7.6e-17	-14.4091	-14.3514	-14.2667
1	3228.63	3862	6.7e-26*	-35.2696*	-34.7497*	-33.9875*
2	3289.93	122.61	6.9e-26	-35.2394	-34.2575	-32.8177
3	3331.34	82.828	9.0e-26	-34.9871	-33.543	-31.4258
4	3378.99	95.29	1.1e-25	-34.8044	-32.8982	-30.1034
5	3421.7	85.421	1.4e-25	-34.5665	-32.1982	-28.7259
6	3487.64	131.89*	1.5e-25	-34.5882	-31.7578	-27.608

* Indicates lag order selected by the LR test and information criterias. The LR test tests the null that all the coefficients on the p^{th} lags of the endogenous variables are zero and thus compares a VAR with p lags to a VAR with $p - 1$ lags. The LR sequence start by looking at the test for the model with the most lags (in our case a lag length of six) before proceeding up the table. Thus, the *first* test that rejects the null hypothesis is the lag order selected by this method (see Lütkepohl (2005, pp. 143-144)**)**. For FPE, AIC, HQIC and SBIC, the lag with the smallest value is the order selected by the criterion (elaborations of these criterions are omitted in this analysis).

The LM test includes all variables and is estimated for each of the lag length suggested by the different criteria's. Using a lag length of six, we failed to reject the null hypothesis of no residual serial correlation at the 5% level (panel (c) of Table 5). In other words, the lag length suggested by the LR test is recommended, and the VECM passes the diagnostic check.

Table 5: Diagnostic check for different lag lengths

Lags	Panel (a): one lag		Panel (b): four lags		Panel (c): six lags	
	LM-Stat	P-values	LM-Stat	P-values	LM-Stat	P-values
1	75.1614	0.16046	65.5380	0.42320	73.9591	0.18497
2	71.5147	0.24250	82.8957*	0.05626	54.8964	0.78425
3	77.1936	0.12456	76.0819	0.14336	65.1291	0.43719
4	60.9870	0.58371	50.1988	0.89625	54.5252	0.79476
5	84.5253**	0.04386	81.1840*	0.07233	62.2360	0.53914
6	66.7965	0.38116	74.2805	0.17817	72.3375	0.22198

Table 5 illustrate the LM-statistics for a lag length of one, four and six, and corresponding p-values for the null hypothesis of no serial correlation.** implies significance at the 5% level and * implies significance at the 10% level.

[17] The LM test at lag j can be formulated as follows:

$$LM_s = (T - d - 0{,}5)\ln\left(\frac{|\hat{\Sigma}|}{|\tilde{\Sigma}_s|}\right)$$

where T is the number of observations in the VECM, d is the number of coefficients, $\hat{\Sigma}$ is the maximum likelihood estimate of Σ from the variance-covariance matrix of the disturbances in the VECM, and $\tilde{\Sigma}_s$ is the maximum likelihood estimate of Σ from the augmented VECM. The asymptotic distribution of LM_s is X^2 with K^2 degrees of freedom (Davidson & MacKinnon, 1993, p. 358 and Johansen, 1995).

The test is performed at lags $j = 1, \ldots, n$. For each j, the null hypothesis of the test is that there is no autocorrelation at lag j.

5.3. Causality analysis

The results from the Johansen cointegration test in Table 6 indicated the presence of cointegrating vectors among the variables in the model. This means that the variables in the system adjusts in order to eliminate short-run deviations from the long-run equilibrium.

Table 6: Johansen cointegration test by different criteria's

Panel (a): Unrestricted Cointegration Rank Test based on Trace statistic Test			
Hypothesized No. of CEs	Eigenvalue	Trace statistic	0.01 Critical value
None*	.	207.5536	168.36
At most 1*	0.28760	146.8527	133.57
At most 2	0.24917	95.5545	103.18
At most 3	0.17329	61.4905	76.07
At most 4	0.14474	33.5037	54.46
At most 5	0.09895	14.8521	35.65
At most 6	0.04573	6.4739	20.04

Panel (b): Unrestricted Cointegration Rank Test based on Maximum Eigenvalue Test			
Hypothesized No. of CEs	Eigenvalue	Max-Eigen Statistic	0.01 Critical value
None*	.	60.7009	57.69
At most 1	0.28760	51.2982	51.57
At most 2	0.24917	34.0640	45.10
At most 3	0.17329	27.9869	38.77
At most 4	0.14474	18.6515	32.24
At most 5	0.09895	8.3782	25.52
At most 6	0.04573	6.3750	18.63

*denotes rejection of; $H_{0,0}$: no cointegrating equation ($r \leq 0$) and $H_{0,1}$: at most one cointegrating equation ($r \leq 1$), at the 1% level.

The Trace test suggested two cointegrating equations while the Max-eigenvalue test suggested one cointegration equation, at the 1% level. Both of these tests are based on the likelihood ratio (LR), but in the following analysis we have chosen to follow the result of the Max-eigenvalue (λ_{max}) test by reason of its stronger alternative hypothesis[18]. One should note that the evidence of cointegration excludes the possibility of the estimated relationship being spurious (Enders, 2003, p. 326).

Our initial intuition would be to include a linear deterministic trend in the model, because four out of eight variables increased in the sample period. However, after taking the first difference, any linear trends from the series will be removed. For that reason, a model that only includes an intercept will be used, and since all variables are in their natural logarithmic functional form, the finalized coefficients can be interpreted as long-term elasticities.

[18] According to Enders (2003, p. 354), the Max-eigenvalue test is usually favoured for deciding on the number of cointegration vectors. This perception is supported by Banerjee et al. (1993).

5.3.1. Long-run causalities

Augmenting equation (5) with respect to OSE, the corresponding model can be written as follows within the VECM framework:

$$\begin{aligned}\Delta OSE_t = \pi_0 &+ \sum_{i=1}^{6} \pi_1 \Delta OSE_{t-i} + \sum_{i=1}^{6} \pi_2 \Delta NIB_{t-i} + \sum_{i=1}^{6} \pi_3 \Delta SP_{t-i} \\ &+ \sum_{i=1}^{6} \pi_4 \Delta EX_{t-i} + \sum_{i=1}^{6} \pi_5 \Delta OIL_{t-i} + \sum_{i=1}^{6} \pi_6 \Delta CON_{t-i} \\ &+ \sum_{i=1}^{6} \pi_7 \Delta CPI_{t-i} + \sum_{i=1}^{6} \pi_8 \Delta NIP_{t-i} + \delta ECT_{t-1} + \epsilon_{1t}\end{aligned} \tag{12}$$

In this equation, the coefficient (δ) of the ECT_{t-1} represents OSE's speed of adjustment (SOA) to its long-run equilibrium, while $\pi_1, \ldots, \pi_8$ are the coefficients of the lagged short-run relationships for the different variables towards ΔOSE_t. The VECM for the other variables can be expressed similarly[19].

The parameters in the error correction term are retrieved from the cointegrating vector:

$$\begin{aligned}\delta ECT_{t-1} = \delta(&\beta_1 OSE_t + \beta_2 NIB_t + \beta_3 SP_t + \beta_4 EX_t + \beta_5 OIL_t + \beta_6 CON_t \\ &+ \beta_7 CPI_t + \beta_8 NIP_t)\end{aligned} \tag{13}$$

and normalisation with respect to OSE, yields the following cointegrating relationship[20]:

$$\begin{aligned}OSE_t = &-\underset{(0{,}001)}{0{,}454}\, NIB_t + \underset{(0{,}019)}{0{,}770}\, SP_t - \underset{(0{,}004)}{2{,}855}\, EX_t + \underset{(0{,}862)}{0{,}056}\, OIL_t \\ &- \underset{(0{,}336)}{2{,}526}\, CON_t + \underset{(0{,}001)}{14{,}935}\, CPI_t + \underset{(0{,}000)}{11{,}486}\, NIP_t - 106{,}216\end{aligned} \tag{14}$$

The coefficients of SP, CPI and NIP are positive and statistically significant at the 5% and 1% level, the coefficients of NIB and EX are negative and significant at the 1% level, while the two remaining variables (OIL and CON) are insignificant in explaining any long-run relationship. Further, the sign of the coefficients in the system were robust to changes in lag structure.

The cointegration result reveals that there is an inverse and significant long-run relationship between interest rates (NIB) and the Oslo All-share index. This is consistent with a number of studies such as Kim (2003), Maysami & Koh (2000), Tangjitprom (2012) and Nasseh & Strauss (2000), who found similar results for stock indices in U.S., Singapore, Thailand and Europe,

[19] For a complete overview of the VECM representation, see appendixVECM representation I.
[20] p-values in parenthesis (…).

respectively[21]. The inverse relation supports the main assumption of the discounted cash flow model; a higher interest rate leads to a lower present value of future discounted cash flows, which in turn decreases current market prices. On the contrary, a decreased interest rate reduces the borrowing cost for investors and firms. This may serve as an incentive for expansion through an increased investment capacity, which in turn leads to increased share prices. Maysami et al. (2004) also pointed out that when stocks are financed with borrowed funds, an increase in interest rate will impose a higher transaction cost, and investors will therefore require a higher rate of return before investing. This diminishes demand and leads to a price depreciation.

In line with the study of the Singapore stock market (Maysami & Koh, 2000), the Norwegian stock market also shares a positive long-term relation with the S&P 500 as a proxy for the U.S. stock market. Other studies have shown this relationship, but the direction of causality has been unclear (Hussainey & Ngoc, 2009)[22]. At a monthly frequency, the U.S. stock market seem to have a long-term structural effect on the Norwegian stock market, and from panel B in Table 7, the coefficient of the error correction term (δ) of SP is small and insignificant. This may suggest that the U.S. stock market is exogenous to changes in OSE, and that OSE, in the long run, tends to follow the direction of the U.S. stock market. These findings may have important implications for portfolio management. Chan et al. (1992) recommended equity portfolios to be diversified internationally to reduce domestic systematic risk, but the co-movement discovered in this study might indicate a somewhat limited benefit of portfolio diversification between the S&P 500 index and the Oslo All-Share index[23].

The depreciation of Norwegian kroner against U.S. dollar (EX) exhibits a negative relation with the Norwegian stock market. These findings are consistent with previous studies in Singapore (Maysami & Koh, 2000 and Maysami et al., 2004) and India (Pal & Mittal, 2011), while the opposite were found in Japan (Mukherjee & Naka, 1995) and the U. S. (Kim, 2003).

The result contradicts the initial hypothesis of a positive relationship between the exchange rate and stock returns. An explanation for this could be that a strong domestic currency limits imported inflation and lowers the cost of imported goods, which allows local producers to be

[21] Nasseh & Strauss looked at the following six European countries: Germany, UK, France, Netherland, Italy and Switzerland.
[22] Hussainey & Ngoc examined the Vietnamese stock market and found a similar relationship. However, the use of a multivariate regression approach, introduced by Nasseh & Strauss (2000) and Canova & de Nicolo (1995), failed to illustrate the direction of causality.
[23] Technological- and financial innovation and advancement of international trade and finance makes the geographical divide between equity markets less apparent. This could explain the integration between equity markets.

more competitive internationally. The portfolio balance approach also suggests a positive relation between a strong domestic currency and stock prices; appreciation of domestic currency induces investors to shift funds from foreign currency assets to domestic currency assets, increasing domestic stock prices and vice versa.

The cointegration result revealed that stock returns are positively related to inflation. Empirically the impact of inflation on stock prices differs, and several studies find a negative correlation between inflation and stock prices, e.g., Mukherjee & Naka (1995), Pal & Mittal (2011), Humpe & Macmillian (2009) and Kim (2003). These findings have previously supported Fama's proxy effect (1981); real activity is positively related with stock returns, but negatively related with inflation through the money demand theory. Thus, increased inflation might influence stock returns negatively. Increased inflation may also increase the nominal interest rate, thus increasing the discount rate. This would lead to descending stock prices, ceteris paribus.

On the contrary, Maysami & Koh (2000), Maysami et al. (2004), Ratanapakorn & Sharma (2007) and Kotha & Sahu (2016) supported this positive relationship. This suggests that, in some markets, equities could act as a good hedge against inflation in the long run. Furthermore, Marshall (1992) stated that if inflation is caused by money shock, it would decrease the interest rate and investors would shift their cash holdings towards bonds and stocks in order to maximize potential capital gains. In turn, increasing demand would raise stock prices.

The positive relationship between stock prices and industrial production (NIP) is consistent with several studies such as; Naik & Pahdi (2012), Kim (2003), Humpe & Macmillian (2009) and Nasseh & Strauss (2000). Increased industrial production expresses higher economic activity and increases expected earnings. Higher expected earnings enhance the present value through their impact on expected dividends (Maysami & Koh, 2000). This should in turn influence stock prices. High economic activity may also raise the national disposable income, which could increase capital flow to the stock market.

The cointegration results reported in Table 7 suggest the existence of a long-run relationship between the Norwegian stock market and the following variables; interest rate, the S&P 500 index, exchange rate, inflation and industrial production. The impact of oil price and aggregated consumption seems irrelevant from the cointegration point of view.

The VECM methodology allows the long-run behaviour of the endogenous variables to converge to their long-run equilibrium, while allowing a range of short-run deviations. The coefficient of the error correction term in determination of OSE carries the correct sign and is statistically significant at the 1% level, with the speed of convergence to equilibrium at ~4%. This suggest that ~4% of any previous disequilibrium in the long run will be corrected in the short run, consequently confirming the stability of the system. Large absolute values of the coefficient of the error correction term (ECT) indicates a large removal of disequilibrium in each period, i.e. the speed of adjustment is very rapid. Low absolute values of the coefficient of ECT indicates a slow speed of adjustment towards equilibrium. This implies that OSE's speed of adjustment towards equilibrium could be categorized as slow.

Table 7: Vector error correction (VEC) estimates

Panel A: Normalized cointegrating coefficients								
OSE	NIB(-1)	SP(-1)	EX(-1)	OIL(-1)	CON(-1)	CPI(-1)	NIP(-1)	Constant
1	0,454	-0,770	2,855	-0,0566	2,526	-14,935	-11,486	106,215
	(0,137)	(0,328)	(0,998)	(0,324)	(2,628)	(4,309)	(1,979)	
	[3,31]	[-2,34]	[2,86]	[-0,17]	[0,96]	[-3,47]	[-5,80]	
Panel B: Error correction coefficients								
ΔOSE	ΔNIB	ΔSP	ΔEX	ΔOIL	ΔCON	ΔCPI	ΔNIP	
-0,040	0,014	-0,014	-0,042	0,046	0,005	0,000	0,020	
(0,017)	(0,017)	(0,013)	(0,010)	(0,027)	(0,003)	(0,001)	(0,009)	
[-2,30]	[0,82]	[-1,08]	[-4,35]	[1,67]	[1,59]	[0,35]	[2,29]	

Standard errors in parenthesis (…) and t-values in brackets […]. For a complete overview of the VEC estimates, see appendix II.

5.3.2. Short-run causalities

In order to supplement the long-run relations, this section focuses on the short-run dynamics of the model. The results in Table 8 illustrate the causal relationship among the chosen variables for each equation in the VECM. It is worth mentioning that with as much as eight variables in the model, there is a high probability of a random effect occurring with a considerable explanatory power. For that reason, we chose to replace the ordinary 5% significance level with a more conservative 1% level for the t-statistics.

As can be seen from the adjusted R^2, ~16% of movements in stock returns are influenced by the chosen macroeconomic variables at a monthly frequency. Variation in NIB is the one best explained by the variables (~29%) while the variation in the S&P index (SP) receives the lowest explanatory power (~3%). The latter intuitively reflects that variation in the U.S. stock market is poorly explained by economic activity in Norway.

Table 8: Short-run causalities

VECM estimates of causal relations among stock returns on Oslo All-share index (ΔOSE), changes in the NIBOR 3-month interest rate (ΔNIB), stock returns of the S&P 500 index (ΔSP), changes in exchange rate USD/NOK (ΔEX), changes in the price of Brent oil (ΔOIL), changes in consumption (ΔCON), realized inflation (ΔCPI) and changes in Norwegian industrial production (ΔNIP).

Model estimates[i]		F-value[ii]	Adjusted R^2
(a) ΔOSE_t:	$+\underset{(0,002)}{1,699}\Delta CON_{t-1} + \underset{(0,001)}{2,102}\Delta CON_{t-2} + \underset{(0,005)}{1,878}\Delta CON_{t-3} - \underset{(0,009)}{0,600}\Delta NIP_{t-1}$	ΔCON: 21,77 (0,000)	0,160
(b) ΔNIB_t:	$+\underset{(0,006)}{0,229}\Delta NIB_{t-1}$	ΔNIB: 22,57 (0,000)	0,288
(c) ΔSP_t:			0,030
(d) ΔEX_t:	$-\underset{(0,001)}{0,256}\Delta OSE_{t-1} + \underset{(0,003)}{0,289}\Delta SP_{t-1} - \underset{(0,007)}{1,590}\Delta CPI_{t-1}$	ΔOSE: 14,61 (0,012) ΔNIB: 19,03 (0,002) ΔSP: 17,10 (0,004) ΔNIP: 14,22 (0,014)	0,201
(e) ΔOIL_t:	$+\underset{(0,002)}{0,691}\Delta OSE_{t-1}$	ΔOSE: 13,57 (0,018)	0,212
(f) ΔCON_t:	$+\underset{(0,000)}{0,06} - \underset{(0,000)}{0,529}\Delta CON_{t-1}$	ΔCON: 36,83 (0,000)	0,202
(g) ΔCPI_t:	$+\underset{(0,000)}{0,003} - \underset{(0,010)}{0,218}\Delta CPI_{t-4}$	ΔCPI: 14,22 (0,014)	0,032
(h) ΔNIP_t:	$-\underset{(0,008)}{0,311}\Delta NIP_{t-1} - \underset{(0,004)}{0,333}\Delta NIP_{t-2} - \underset{(0,008)}{0,282}\Delta NIP_{t-3}$		0,147

[i] VECM with 6 lags. *p*-values in parenthesis (…). Only endogenous variable estimates at a 1% level are reported. For a complete overview of the vector error correction estimates, see appendix II.
[ii] Corresponding joint significance/F-value for the set of all lagged variable with *p*-values in parenthesis (…). Only F-values at a 5% significance level are reported.

From equation (a) in Table 8, the model reveals several short-run relations. The first three lags of ΔCON are all positively related to current changes in ΔOSE, and the first lag of industrial production (ΔNIP) is negatively related to current changes. This means that we are unable to find supporting evidence of the consumption based asset pricing theory that consumption rates and stock returns are *negatively* related. Looking at the F-statistic, only the lagged values of ΔCON jointly affect the stock market. However, from equation (f) we find that ΔOSE does not jointly or independently cause ΔCON, i.e. there are no bidirectional relationship between these two variable sets. This is intuitive in Norway because stocks constitute only a minor part of total wealth. Thus, stock returns are not likely to have a considerable influence on aggregated consumption.

The findings that domestic real activity has a substantial influence on stock returns coincide with the approach by Gjerde & Sættem (1999). They found that industrial production had a significant impact on stock returns, yet the opposite causality did not occur. Our findings indicate that the Norwegian stock market still responds inaccurately to changes in domestic real activity. In contrast, the study done by Aylward & Glen (2000) on 23 countries for most of the post-war period, discovered a strong evidence of the view that stock markets, both emerging and developed, had a significant predictive ability to changes in real activity. The study also showed that the results were strongest among the G-7 countries.

Equation (d) reveals that ΔEX is significantly related to the first lags of ΔOSE, ΔSP and ΔCPI, as well as the joint set of lags of ΔNIB and ΔNIP. The latter two variables only jointly affect, while ΔCPI only independently affect ΔEX (with its first lag). The coefficients in equation (d) reveals that ΔOSE is negatively related to ΔEX. This is intuitive as an increased price of the stock exchange implicate an appreciation of NOK against USD in the short run. Consequently, the positive coefficient of ΔSP serve as a proxy for the opposite effect and thus a short run depreciation of the Norwegian currency, ceteris paribus. Both ΔSP and ΔOSE jointly cause ΔEX. The variables; ΔCPI, ΔNIB and ΔNIP serve to represent the status of the Norwegian economy, thus their impact on the Norwegian currency seem apparent.

These results illustrate the intricacy of exchange rate fluctuations. It is significantly affected by movements in all of the variables except its lagged self and the development of ΔCON. E.g., the unidirectional causality running from ΔOSE to ΔEX means that changes in stock returns are reflected in the current exchange rate. Additionally, there are no unidirectional causalities running from ΔEX to the other variables. In other words, ΔEX does not seem to cause movements in the other variables, at least in the short run. Equation (e) shows that the first lag and the joint set of lags for ΔOSE have a positive causal relationship with ΔOIL, supporting the results presented by Gjerde & Sættem (1999).

Ultimately, if one ignores the constant term and lagged variables of the explanatory variable, only lines (a), (d) and (e) present significant results. Table 9 illustrate all of the unidirectional causalities. The short-run analysis did not verify any bidirectional causalities among the chosen variables.

Table 9: Unidirectional causalities

Variable	*ΔOSE*	*ΔNIB*	*ΔSP*	*ΔEX*	*ΔOIL*	*ΔCON*	*ΔCPI*	*ΔNIP*
⟶	ΔEX ΔOIL	ΔEX	ΔEX	-	-	ΔOSE	-	ΔEX

Table 9 illustrates the unidirectional causalities for each variable from Table 8. For instance, in column 2, we see the causalities running from ΔOSE to ΔEX and ΔOSE to ΔOIL. The similar interpretation applies for the remaining columns.

The unidirectional causality running from ΔCON to ΔOSE and the significant lagged variable of ΔNIP and the stock market's delayed response to these variables, indicate a certain degree of inefficiency. However, the unidirectional causalities running from both ΔOSE to ΔEX and ΔOSE to ΔOIL supports market efficiency.

5.4. Out-of-sample analysis

The impulse response analysis and the variance decomposition were implemented to examine how shocks to macroeconomic variables bounce back in the system. The primary focus was to examine how OSE responded to one positive standard deviation (S.D) shock in OSE, and the other macroeconomic variables. Further, the latter part of the analysis examined how macroeconomic variables (and OSE) responded to one S.D shock in OSE.

The diagnostic check of the system ensured that the VECM was stable, i.e. the residuals were white noise and the null hypothesis of no heteroscedasticity could not be rejected at the 5% level. An additional stability check ensured that there were no roots lying outside the unit circle[24]. This all indicated that the model was well-specified, and we could employ the impulse response and variance decomposition analysis with consistent estimates.

Through the orthogonalized impulse response function, one can examine the direction, magnitude and length of time that a variable is affected by a shock of another variable in the system, while keeping all other variables constant. The I (1) variables modelled in a cointegrating VECM are not mean reverting, implying that some shocks will not die out over time. In other words, a one-time shock may have a permanent effect that shifts the system to a new equilibrium. The shock is said to be permanent when the effect of a shock does not die out over time. If the effect of a shock dies out over time, the shock is said to be transitory. One should note that the impulse response functions were constructed using the estimated coefficients. This means that if important variables are omitted from the model, their effects enter the residuals, and therefore may lead to considerable distortions in the impulse responses and the structural interpretations of the output (Enders, 2003, p. 277). In order to allow for adequate responses in the long run, a time period of 4 years (48 months), for both the impulse response analysis and the variance decomposition, are reported.

[24] The companion matrix of a VECM with K endogenous variables and r cointegrating equations has $K - r$ unit eigenvalues. If the process is stable, the moduli of the remaining eigenvalues are strictly less than one (Lütkepohl, 2005). See appendix III.

5.4.1. Impulse response analysis

Figure 2a)-h), illustrates the response of the Oslo All-share index (OSE) to one standard deviation shock in OSE and the remaining seven variables. A shock in OSE immediately increases OSE by exactly one S.D[25]. The shock marginally continues its positive effect but reverts back to its initial shock after five periods. One explanation for this could be that stock prices exhibit price momentum in the short run and are mean-reverting in the long run. OSE has a negative response to shocks in both interest rate and inflation. Increased inflation may increase the nominal interest rate, which increases the investors cost of capital, leading to descending stock prices. The shock in interest rate is permanent, while the shock in inflation is transitory. This may indicate that stocks serve as a good hedge against inflation in the long run, in line with the results from the in-sample period (equation (14)).

OSE have a positive and somewhat permanent effect to a shock in CON. Increased aggregated demand by an increase in e.g. consumer optimism or government spending, provides indications of higher expected earnings that could have a positive effect on the stock market. Similar to CON, OSE also have a positive and somewhat permanent effect to a shock in NIP. One interpretation of this could be that a positive shock in industrial production indicates improvement in the overall economy, increasing growth prospects and stock prices. OSE exhibits very little response to a shock in EX and OIL. This is supported by their insignificant explanatory power in the variance decomposition in section 5.4.2 (Table 10). However, a shock in SP have a positive and modest effect on OSE. This confirms the causality result, which indicated that the Norwegian stock market tends to follow the direction taken by the U.S. stock market.

[25] The initial standard deviation in OSE is equal to 0.056, depicted in Table 10.

Figure 2: The response of OSE to one (positive) orthogonalized standard deviation shock in each variable at a monthly frequency

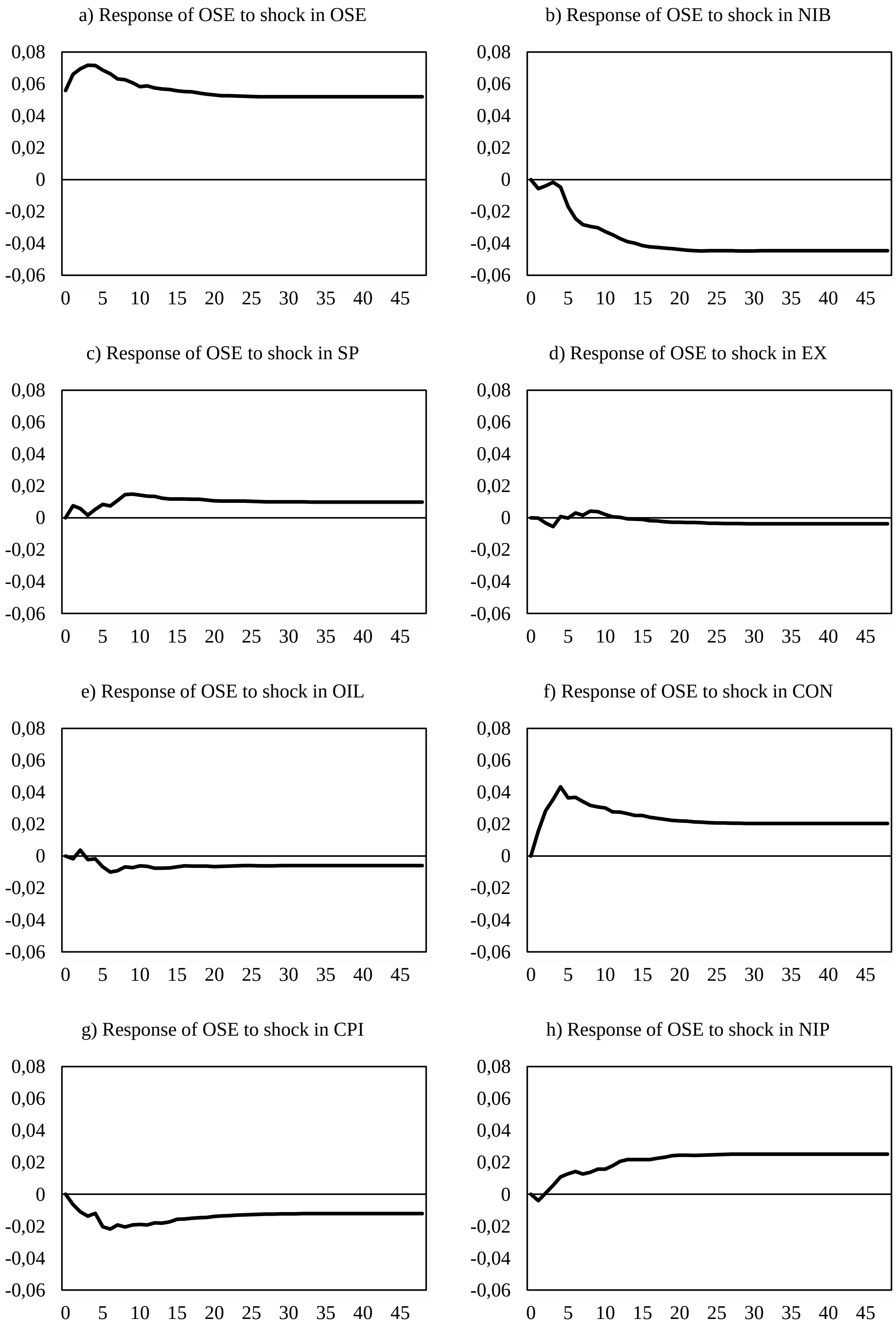


Figure 3a)-h), shows how OSE and the macroeconomic variables responds to one standard deviation shock in OSE. Both NIB and SP have a positive and permanent response to a shock in OSE. SP responds immediately to the shock, confirming the co-movement between the Norwegian and U.S. stock market. As with OSE, the U.S. stock market seems to exhibit price momentum in the short-run and is mean-reverting in the long run.

In Figure 3d), the exchange rate immediately appreciates to a shock in OSE, but diminishes after 5 months before stabilizing at the level originally caused by the innovation. The price of Brent oil has a positive and permanent response to a shock in OSE, confirming the short-run unidirectional causality running from OSE to OIL. The remaining variables; CON, CPI and NIP were not affected by a shock in OSE. This confirms the low explanatory power from Table 11 of section 5.4.2., i.e. that changes in stock returns does not seem to signal changes in real activity, but rather the other way around as depicted in Figure 2f) and h).

In Figure 4a)-c), the unidirectional causalities that did not include OSE are illustrated (see Table 9). We see that a shock in NIB increase volatility in EX approximately up until the 15^{th} horizon, after which there is no volatility observed. Ultimately, the long-run effect (>15 months) of an interest rate shock is a modest appreciation of the Norwegian currency against the USD. The response of EX to a shock in SP is positive and permanent. One possible explanation for this relationship is foreign investment; the appreciation of U.S. dollar incentives investors to shift funds from domestic currency assets to foreign currency assets, causing U.S. indices to increase in value. The fact that an increase in the U.S. dollar affects stock prices seems intuitive, as U.S. dollars are needed to purchase stocks listed in the U.S. Finally, EX have a positive and permanent response to a shock in NIP.

Figure 3: The response of each variable to one (positive) orthogonalized standard deviation shock in OSE at a monthly frequency

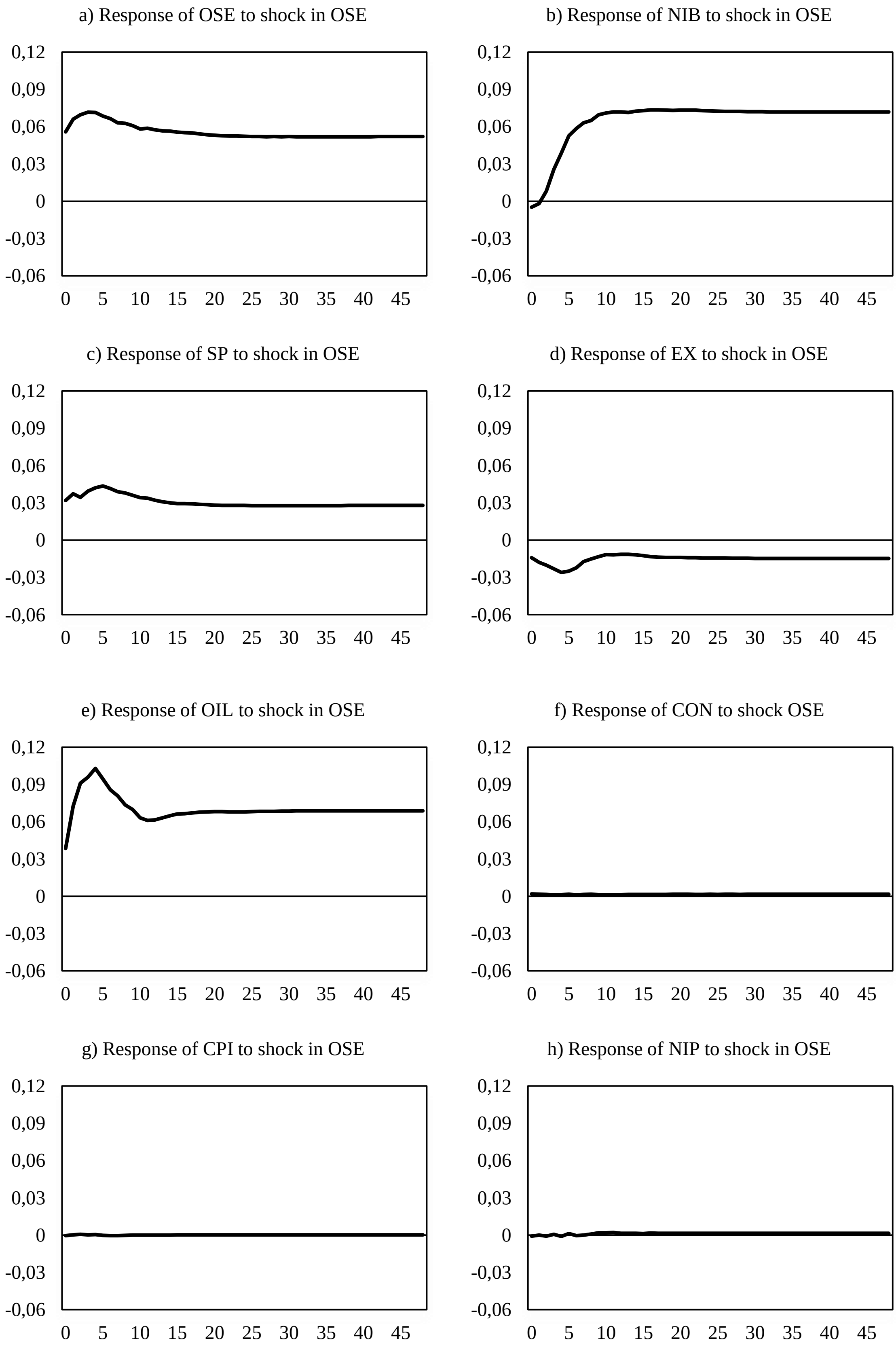
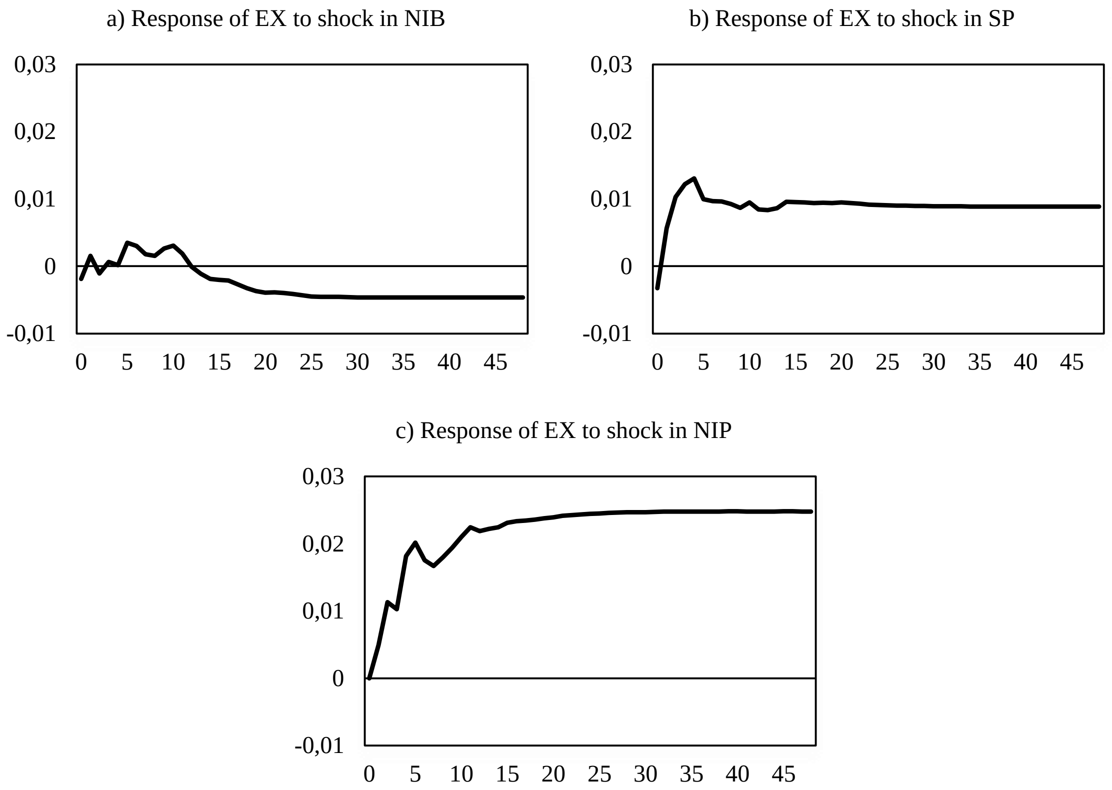


Figure 4: The response of EX to one (positive) orthogonalized standard deviation shock in NIB, SP and NIP at a monthly frequency



5.4.2. Variance decomposition

In order to elaborate upon the findings of the VECM and to reinvestigate the out-of-sample impact of the impulse response functions, the following section is dedicated to the results from the variance decomposition analysis.

Table 10 and Table 11 display the dynamic interaction between the Oslo All-share index (OSE) and the chosen variables. More specifically, Table 10 display the decomposed variance of OSE that can be attributed to its own shock and shocks in the remaining variables, whereas Table 11 display the percentage of movements in macroeconomic variables and OSE that is attributed to a shock in OSE. In order to illustrate the short, medium and long effect, the corresponding results are given for the time samples; 1 month, 6 months, 12 months, 24 months and 48 months. Please note that the decomposed variance only takes into account the amount by which a shock in a given variable explain movements in itself or in the remaining variables. The magnitude of the shock and the effect on itself and the other variables were examined in the previous impulse response analysis.

Table 10: Variance decomposition for OSE

Step	S.D.	OSE	NIB	SP	EX	OIL	CON	CPI	NIP
1	0,056	100,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
6	0,186	78,57 %	1,04 %	0,56 %	0,12 %	0,21 %	15,91 %	2,63 %	0,95 %
12	0,272	67,49 %	7,77 %	1,60 %	0,13 %	0,59 %	15,72 %	4,42 %	2,29 %
24	0,386	57,44 %	18,14 %	1,86 %	0,10 %	0,66 %	12,35 %	4,08 %	5,37 %
48	0,542	51,21 %	25,40 %	1,76 %	0,16 %	0,63 %	9,68 %	3,30 %	7,86 %

Table 10 reports the decomposed variance of OSE that can be attributed to its own shock (column 3) and shocks in the remaining variables (column 4-10). The steps in column 1 are forecasting months. For a complete overview of the variance decomposition analysis, see appendix IV.

As shown in the impulse response analysis, the results from Table 10 support the statement that movements in OSE can be explained by innovations in some of the variables in the model. In the first month, all of the variability of OSE is explained by its own innovation before declining to 51,21% at the end of the forecast horizon (48 months). This indicates that for longer horizons, the variation in OSE might be caused by other variables and especially by NIB, CON and NIP. Both NIB and NIP increases their explanatory power throughout the horizon, while CON diminishes towards the end of the 48-month mark.

Movements in industrial production (NIP) explain a significant proportion of the variation in the stock market at the end of the horizon (7,86%), and indicate that OSE yields a delayed response to changes in real domestic activity. Furthermore, the insignificant explanatory power of OSE's innovation (1,78% (Table 11)) on variation in NIP support the statement that changes in stock returns does not signal changes in industrial production, but rather the other way around. To underpin this, consumption (CON) exhibit the similar behaviour as changes in this variable significantly explain the variation in OSE, although declining slightly towards the end of the period (from 15,91% → 9,68%). Conversely, the innovation of OSE affect the variation in consumption to a smaller degree (~4% for the whole period (Table 11)). These results are consistent with the unidirectional causality running from ΔCON to ΔOSE and the significant lagged variable of ΔNIP and its effect on ΔOSE from the short-run analysis (line (a), Table 8).

Similar, but opposite interpretations can be made from the unidirectional causalities running from ΔOSE to ΔEX and ΔOSE to ΔOIL in line (d) and (e) of Table 8. The variance decomposition in Table 11 reflect that movements in both EX and OIL are significantly affected by a shock in OSE, but not the other way around.

Nevertheless, as for movements in OSE, a shock in NIB explain most of its changes, at least in the long run. The explanatory power increases towards 25,40% after 48 months, implying that the stock market is largely driven by interest rate news. These findings are consistent with a similar study done on the U.S. stock market, by Kim (2003).

Table 11: Percentage of forecast error variance (FEV) explained by the innovation of OSE

Step	OSE	NIB	SP	EX	OIL	CON	CPI	NIP
1	100,00 %	0,72 %	56,66 %	20,42 %	18,93 %	4,13 %	1,04 %	0,10 %
6	78,57 %	9,92 %	57,38 %	34,52 %	50,04 %	4,76 %	0,72 %	0,35 %
12	67,49 %	18,75 %	48,19 %	29,31 %	49,57 %	4,31 %	0,60 %	0,87 %
24	57,44 %	22,39 %	38,24 %	22,64 %	47,93 %	4,31 %	0,47 %	1,39 %
48	51,21 %	23,91 %	32,90 %	19,76 %	47,29 %	4,41 %	0,47 %	1,78 %

Table 11 reports the percentage of movements in macroeconomic variables and OSE that is attributed to a shock in OSE (column 2-9). The steps in column 1 are forecasting months For a complete overview of the variance decomposition analysis, see appendix IV.

Table 11 illustrate the effect of a shock in OSE on the other variables. A shock in OSE highly influence NIB, SP, EX and OIL but, a shock in the stock market does not signal changes in domestic real activity (NIP and CON). In addition, CPI is insignificantly affected by a shock in OSE.

When examining the decomposed variance of the remaining variables in appendix IV, NIB is clearly dominated by changes in OSE and CON, while SP is mostly influenced by changes in OSE and NIB. EX and OIL seem to be the most endogenous variables of the model, with an explanatory power of 21,03% and 15,93% attributed to its own shock at the end of the horizon, respectively. They are both highly influenced by changes in the stock market, but EX is largely dominated by changes in industrial production. CON, CPI and NIP however, seem to be the most exogenous of the chosen variables. CON is mostly driven by changes in CPI and NIP, whereas CPI is largely driven by interest rate news. Finally, industrial production is dominated by innovations in inflation and exchange rate.

The fact that OSE for the most part signals changes in macroeconomic variables is a sign of efficiency in the Norwegian stock market, i.e. OSE can be considered the leading indicator of the economy. The findings from the variance decomposition also supplement the underlying notions of the previous impulse response analysis. At last, one should note that the increasing standard errors depicted in Table 10 suggests a lack of estimating efficiency in the latter part of the forecasting horizon. This should be taken into consideration during assessment of the results from both this decomposition and the impulse response analysis.

6. Sector analysis

The majority of previous studies have examined the relation of macroeconomic variables on the composite stock index of the market under study. Hence, a void in literature relates to the study of short- and long-run relationships between macroeconomic variables and the stock market's sector indices. This study aims to complement the literature in this area, by analysing the dynamic relationship between macroeconomic factors and stock returns of the different sector indices at the Oslo stock exchange.

Table 12: Sector development in the sample period and ending market capitalization

GICS code	Sector	2001-2015	2016	Market Cap.
10	Energy	41	50	34,6 %
15	Materials	5	8	9,3 %
20	Industrials	34	34	5,9 %
25	Consumer discretionary	12	9	3,6 %
30	Consumer staples	9	9	13,2 %
35	Health care	7	8	0,5 %
40	Financials	27	15	19,3 %
45	Information technology	22	20	2,4 %
50	Telecommunication services	2	2	9,8 %
55	Utilities	3	3	1,4 %

Column 3 and 4 illustrates the average number of listed companies for different periods in each sector, while column 5 illustrates the total market cap. as a percentage of the Oslo All-share index. Market cap. denoted as of the 24. of November 2016. We have chosen not to report the end of in-sample market cap. since the relative differences were insignificant.

Table 12, illustrate the development of comprising companies in the different indices, as well as the total market capitalization of each sector. As the Real estate sector (OSE60) was not initiated before September 2016, it has not been included in the analysis. A complete overview of the different companies of each sector is listed in appendix V.

6.1. Methodology

The methodological procedure in this chapter is similar to the main analysis of the Oslo All-share index in chapter 5. From Table 13, all series failed to reject the null of a unit root at the 5% level. After differencing each series, we found strong evidence against the null hypothesis of a unit root, i.e. all series were found to be individually integrated of order one.

Table 13: Unit root tests

Variable	Lags[a]	ADF: H_0: variable is non-stationary	PP: H_0: variable is non-stationary	KPSS: H_0: variable is stationary	Order of integration
OSE10	3	-1,502	-1,323	0,756***	
ΔOSE10		-6,410***	-11,834***	0,168	I (1)
OSE15	3	-2,875	-2,707	0,404***	
ΔOSE15		-6,010***	-11,313***	0,0476	I (1)
OSE20	2	-1,655	-1,686	0,605***	
ΔOSE20		-7,459***	-11,386***	0,0907	I (1)
OSE25	7	-2,134	-2,036	0,257***	
ΔOSE25		-4,828***	-11,659***	0,125	I (1)
OSE30	3	-2,808	-2,115	0,262***	
ΔOSE30		-6,240***	-10,097***	0,132	I (1)
OSE35	1	-2,374	-2,499	0,597***	
ΔOSE35		-10,753***	-13,590***	0,0912	I (1)
OSE40	3	-2,799	-2,316	0,215***	
ΔOSE40		-5,981***	-11,043***	0,0509	I (1)
OSE45	4	-2,061	-1,993	1,86***	
ΔOSE45		-5,719***	-12,893***	0,16	I (1)
OSE50	5	-2,912	-2,612	0,148**	
ΔOSE0		-4,395***	-12,429***	0,068	I (1)
OSE55	3	-1,372	-1,342	0,727***	
ΔOSE55		-6,093***	-11.262***	0,141	I (1)
Critical values					
1%		-3,482	-3,482	0,739	
5%		-2,884	-2,884	0,463	
10%		-2,574	-2,574	0,347	
Critical values with trend					
1%		-4,012	-4,012	0,216	
5%		-3,439	-3,439	0,146	
10%		-3,139	-3,139	0,119	

*** implies significance at the 1% level, ** implies significance at the 5% level and * implies significance at the 10% level. Δ represents the first difference operator.

[a] Optimal lags selected using the Akaike's Information Criteria (AIC)

The Lagrange Multiplier residual serial correlation test (LM test) was utilized in order to choose the appropriate lag length. Using a lag length of four, for OSE10, OSE30 and OSE55, the null hypothesis of no residual serial correlation could not be rejected at the 5% level. Similarly, the null could not be rejected for OSE15, OSE25, OSE40, OSE45 and OSE50 using a lag length of six, and for OSE20 and OSE35 using a lag length of three and five, respectively.

In addition, several diagnostic tests were conducted to ensure that the models were well specified. The results from the diagnostic test in Table 14 indicated that the null of normally distributed errors could be rejected at the 5% level. However, the errors were independently and identically distributed. Thus, with models that were considered acceptably well specified, the analysis proceeded under the assumption that non-normality would not affect the results[26].

Table 14: Results from diagnostic tests

Model:	LM-test[i)]		Breusch-Pagan test[ii)]	Jarque-Bera test[iii)]
	P-value:	Optimal lag	P-value:	P-value:
a) OSE10	0,6408	4	0,1044	0,0103*
b) OSE15	0,1650	6	0,1044	0,0046*
c) OSE20	0,7851	3	0,1805	0,0000*
d) OSE25	0,1396	6	0,5125	0,0011*
e) OSE30	0,2771	4	0,0518	0,0000*
f) OSE35	0,9741	5	0,8689	0,0000*
g) OSE40	0,7926	6	0,0759	0,0000*
h) OSE45	0,9236	6	0,0807	0,0019*
i) OSE50	0,1876	6	0,0705	0,0000*
j) OSE55	0,9921	4	0,1699	0,0000*

* Significant at the 5% level.
[i)] Lagrange Multiplier serial correlation test (LM test): H_0: No autocorrelation, H_1: Autocorrelation
[ii)] Breusch-Pagan test for heteroscedasticity: H_0: Homoscedasticity, H_1: Heteroscedasticity
[iii)] Jarque-Bera test for Normality: H_0: Normally distributed, H_1: Non-normally distributed.

6.2. Causality analysis

The main motivation for utilizing the VECM was to avoid the potential misspecification bias inherent in the VAR in first difference. The VAR is incapable of exploring long-term relations, and is also deficient in determining short-term relations in the presence of cointegration. In the sector analysis, the result from the Johansen cointegration tests, indicated that there was no combination of variables leading to stationarity for the following sector indices; OSE25, OSE35, OSE40 and OSE50. For that reason, we utilized the VAR in first difference in order to analyse the short-run causal relations between these sector indices and the chosen macroeconomic variables. In the remaining indices; OSE10, OSE15, OSE20, OSE30, OSE45 and OSE55, we found evidence of one cointegrating vector at the 1% level.

6.2.1. Long-run causalities

For the different cointegration relationships, the same procedure as with equations (12) - (14) was employed, and each of the following equations ((15) - (20)) represents the normalized long-run causalities with respect to each sector. In this analysis, we have chosen to interpret only the

[26] Technically, normality is necessary for hypothesis test to be valid and estimation of the parameters only requires that the errors are identically and independently distributed. The central limit theorem leads to an approximate normal distribution when sample size gets sufficiently large (Wooldridge, 2009, p. 174). In literature, there is still no consensus that determines how big the sample size must be before the approximation is good enough. With a sample size of $n = 183$, we are under the impression that the central limit theorem delivers a useful approximation.

cointegrating coefficients significant at the 5% level Table 15 illustrate the speed of adjustment coefficients for each sector.

Table 15: Error correction coefficients

	ΔOSE10	ΔOSE15	ΔOSE20	ΔOSE30	ΔOSE45	ΔOSE55
δ_i	**-0,066**	**-0,032**	**0,024**	**-0,055**	**0,031**	**-0,028**
S.E	(0,028)	(0,015)	(0,007)	(0,023)	(0,018)	(0,013)
t-statistic	[-2,39]	[-2,11]	[3,23]	[-2,36]	[-1,68]	[-2,17]

Table 15 illustrate the speed of adjustment coefficients for each sector. For the complete table of normalized cointegrating equations and speed of adjustment coefficients, see appendix VII.

6.2.1.1. Energy (OSE10)

In equation (15), the coefficient of NIB is negative and statistically significant at the 5% level, the coefficients of OIL, CON and NIP are positive and significant at the 1% level, while the two remaining variables (SP and EX) are insignificant in explaining any long-run relationship. Only the significant relations with NIB and NIP are similar to what we found in the main analysis.

$$\begin{aligned} OSE10_t = & -\underset{(0,018)}{0,169}\, NIB_t - \underset{(0,101)}{0,304}\, SP_t + \underset{(0,520)}{0,350}\, EX_t + \underset{(0,002)}{0,576}\, OIL_t \\ & + \underset{(0,000)}{5,409}\, CON_t + \underset{(0,287)}{2,361}\, CPI_t + \underset{(0,000)}{5,548}\, NIP_t - 55,779 \end{aligned} \tag{15}$$

The positive relation between oil prices and the Energy sector is meaningful as the comprising companies in this sector are closely connected to the oil- and oil service industry. In general, corporate profits reflect the level of economic activities. Rising oil prices increases expectations about future corporate performance, which have a positive influence on stocks in this sector. OSE10 also have a positive relation to both CON and NIP. Increased aggregated demand by an increase in e.g. government spending and rising domestic real activity, are indications of improvements in the overall economy which rise expectations for corporate profits and stock prices. The coefficient of the error correction term (Table 15) in determination of OSE10 carries the correct sign and is significant at the 5% level, which confirms the stability of the system.

6.2.1.2. Materials (OSE15)

In equation (16), the coefficients of EX, OIL and CON are negative and significant at the 5% level, while the coefficients of CPI and NIP are positive and significant at the 1% level. The impact of NIB and SP seem irrelevant from the cointegration point of view.

$$\begin{aligned} OSE15_t = & -\underset{(0,265)}{0,212}\, NIB_t + \underset{(0,115)}{0,833}\, SP_t - \underset{(0,000)}{7,653}\, EX_t - \underset{(0,005)}{1,397}\, OIL_t \\ & - \underset{(0,026)}{9,226}\, CON_t + \underset{(0,000)}{27,570}\, CPI_t + \underset{(0,000)}{18,867}\, NIP_t - 119,751 \end{aligned} \tag{16}$$

The relationship between OSE15 and EX, CPI and NIP are similar to the composite stock index (OSE). In addition, OSE15 is significantly affected by OIL and CON in the long run. The negative relation to OIL could be explained through Hydro (NHY) and Yara's (YAR) sensitivity to increased commodity prices, as these two constitute for approximately 94% of the market capitalization in the OSE15 index[27]. Both NHY and YAR's profits are negatively affected by an increased price of raw materials such as fuel oil, coal, petroleum coke and natural gas[28], and it is shown that natural gas and residual fuel oil prices tend to respond to movements in the international oil market (Hartley, Medlock III, & Rosthal, 2007).

The coefficient of the error correction term is negative and significant at the 5% level (Table 15). This suggests that 3,2% of any previous disequilibrium in the long run will be corrected in the short run, confirming the stability of the system.

6.2.1.3. Industrials (OSE20)

In equation (17), the coefficients for NIB, CPI and NIP are positive and significant at the 1% level, while the coefficients for EX and CON are negative and significant at the 1% and 5% level, respectively.

$$\begin{aligned} OSE20_t = &+ \underset{(0{,}001)}{0{,}940}\, NIB_t + \underset{(0{,}116)}{1{,}161}\, SP_t - \underset{(0{,}033)}{4{,}570}\, EX_t - \underset{(0{,}272)}{0{,}794}\, OIL_t \\ &- \underset{(0{,}000)}{24{,}791}\, CON_t + \underset{(0{,}000)}{58{,}643}\, CPI_t + \underset{(0{,}000)}{29{,}268}\, NIP_t - 300{,}547 \end{aligned} \quad (17)$$

The relationship between the Industrials sector and the macroeconomic variables are similar to OSE, except for NIB, CON and SP, which depicts an insignificant relationship. However, the coefficient of the error correction term is *positive* and significant at the 5% level. This implies that any system disturbances will result in divergence from equilibrium and the system would be unstable (Table 15). Due to this model misspecification, the sector is not further commented.

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[27] See appendix V.

[28] NHY's operating profits are generally affected by price developments in aluminum, alumina, bauxite and power, and of raw materials including commodities such as fuel oil, coal and petroleum coke. An increased price of raw materials, such as fuel oil will have a negative impact on Hydro's profit margin, ceteris paribus (Hydro, 2016, p. 154). YAR's operating profits are primarily affected by price developments in ammonia, urea and other fertilizers that may generally be classified as commodities, and in raw materials including natural gas and electricity. Keeping other things constants, an increase in raw materials, such as gas prices will have a negative effect on Yara's operating income (Yara, 2016, p. 117).

6.2.1.4. Consumer staples (OSE30)

In equation (18), the coefficients of CPI and NIP are positive and significant at the 1% level, while the coefficient of OIL is negative and significant at the 5% level. The coefficients of NIB, SP, EX and CON are insignificant at the 5% level.

$$\begin{aligned} OSE30_t = & -\underset{(0{,}703)}{0{,}042}\, NIB_t + \underset{(0{,}073)}{0{,}492}\, SP_t - \underset{(0{,}280)}{0{,}888}\, EX_t - \underset{(0{,}019)}{0{,}632}\, OIL_t \\ & + \underset{(0{,}244)}{2{,}413}\, CON_t + \underset{(0{,}002)}{10{,}232}\, CPI_t + \underset{(0{,}000)}{5{,}188}\, NIP_t - 76{,}870 \end{aligned} \quad (18)$$

Among market players, there seems to be a perception that oil price affects the Norwegian currency. According to Akram (2000), a sustained increase in the price of oil for an oil exporting economy provides more favourable terms of trade, which strengthens the domestic currency, ceteris paribus. Thus to a certain degree, OIL can serve as a proxy for the strengthening of NOK against foreign currency. The Consumer staples sector mainly consists of companies within the aqua culture. One of the biggest systematic risk factor to these corporations is currency fluctuation, as most of their revenues are in foreign currency and most of their costs in NOK. Within the Norwegian aqua culture, EUR is currently the main traded currency, and accounted for approximately 52% of export earnings in 2013 (Nyrud, Bendiksen, & Dreyer, 2016). Therefore, any appreciation of NOK against EUR will most likely have a material effect on the company's profit margins. The coefficient of the error correction term carries the correct sign, which confirms the stability of the system (Table 15).

6.2.1.5. Information technology (OSE45)

In equation (19), the coefficients of EX and CON are negative and significant at the 1% level, while the coefficient for CPI and NIP are positive and significant at the 1% level.

$$\begin{aligned} OSE45_t = & +\underset{(0{,}355)}{0{,}179}\, NIB_t + \underset{(0{,}154)}{0{,}745}\, SP_t - \underset{(0{,}000)}{5{,}718}\, EX_t - \underset{(0{,}131)}{0{,}791}\, OIL_t \\ & - \underset{(0{,}001)}{14{,}755}\, CON_t + \underset{(0{,}000)}{34{,}4991}\, CPI_t + \underset{(0{,}000)}{10{,}792}\, NIP_t - 136{,}350 \end{aligned} \quad (19)$$

However, from the 95% confidence interval, we could not reject the null hypothesis of a significant coefficient of the error correction term different from zero[29]. In other words, this cointegrating equation can not significantly explain any long-run relations in OSE45, if any.

[29] If a parameter is significantly different from zero at the 5% level, the 95% confidence interval will not contain the value of zero. Generally, all values in the confidence interval are plausible values of the estimated parameter, whereas values outside the confidence interval are rejected as plausible values of the estimated parameter (Wooldridge, 2009, p. 138). Using the fact that $(\hat{\beta}_j - \beta_j)/se(\hat{\beta}_j)$ has a t-distribution with $n-k-1$ degrees of freedom, the 95% confidence interval is given by: $\hat{\beta}_j \mp c * se(\hat{\beta}_j)$. The confidence interval for $\Delta OSE45$ is given by: $[-0.066\,, 0.0051]$ (Table 15).

6.2.1.6. Utilities (OSE55)

In equation (20), the coefficient of CPI and NIP are positive and significant at the 1% level. The remaining variables are insignificant in explaining any long-run relationship.

$$\begin{aligned} OSE55_t = &+ \underset{(0,425)}{0,128}\, NIB_t - \underset{(0,164)}{0,588}\, SP_t - \underset{(0,070)}{2,254}\, EX_t - \underset{(0,105)}{0,673}\, OIL_t \\ &+ \underset{(0,058)}{6,058}\, CON_t + \underset{(0,002)}{15,870}\, CPI_t + \underset{(0,000)}{13,525}\, NIP_t - 148,761 \end{aligned} \tag{20}$$

From Table 15, we observe that the coefficient of the error correction term carries a negative sign and is significant at the 5% level, with the speed of convergence to equilibrium at ~2%.

6.2.2. Short-run causalities

In this section, only the first equation of the respective models are analysed, similar to that of equation (a) in Table 8. These equations are interpreted as the short-run dynamics of the different sector error correction models[30]. Only the complete set of lagged variables (F-values in second column of Table 16) that have an effect on the different sectors are commented, unless mentioned otherwise. To see if there were any bidirectional causalities, joint significance tests were performed on the corresponding variables that did show a unidirectional causality towards the given sector. Ignoring the constant term (which is not included her) and the lagged variables of the explanatory variable, all of the lines in Table 16, except line (c), presents significant results[31].

From Table 16, we observe that ΔOSE50 (Telecommunication services[32]) and ΔOSE30 (Consumer staples) are the ones best explained by the chosen variables with an adjusted R-squared of ~21% and ~23%, respectively. The ones poorest explained by the variables are ΔOSE20 (Industrials) and ΔOSE35 (Health Care), with an explanatory power of ~5% and ~7%, respectively.

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[30] Since we only utilize one equation from the respective VECM outputs, equations (a)-(j) are denoted as error correction models, or ECM.

[31] Except $\Delta OSE20_{t-i}$ on itself, only the second lagged variable of Brent oil (ΔOIL_{t-2}) were significant in explaining any causal relation towards ΔOSE20, but only at the 10 % level (see appendix VII).

[32] This index consists only of Telenor (TEL) and NextGenTel Holding (NGT), with TEL making up for approximately all of the market cap. of the index (~99,7%). This essentially means that the Telecommunication sector represents the development of TEL throughout the time horizon.

Table 16: Short-run causalities among sector indices

Short-run estimates of causal relations among stock returns of the respective indices (ΔOSE(*XX*)), changes in the NIBOR 3-month interest rate (ΔNIB), stock returns of the S&P 500 index (ΔSP), changes in exchange rate USD/NOK (ΔEX), changes in the price of Brent oil (ΔOIL), changes in consumption (ΔCON), realized inflation (ΔCPI) and changes in Norwegian industrial production (ΔNIP).

Model estimates[i]		F-value[ii]	Adjusted R^2
(a) $\Delta OSE10_t$:	$-\ 0{,}241\Delta OIL_{t-3}$ (0,001)	ΔOIL: 10,57 (0,014) ΔSP: 8,09 (0,044) ΔOSE10 8,04 (0,045)	0,083
(b) $\Delta OSE15_t$:	$+\ 0{,}309\Delta NIB_{t-3} - 0{,}588\Delta SP_{t-2} + 2{,}251\Delta CON_{t-1}$ (0,010) (0,006) (0,004) $+\ 3{,}078\Delta CON_{t-2} + 2{,}550\Delta CON_{t-3}$ (0,001) (0008)	ΔCON:15,08 (0,010) ΔNIB: 12,97 (0,023) ΔOSE15:12,85 (0,024)	0,166
(c) $\Delta OSE20_t$:			0,051
(d) $\Delta OSE25_t$:	$+\ 0{,}668\Delta SP_{t-1} - 3{,}982\Delta CPI_{t-1} - 3{,}765\Delta CPI_{t-5}$ (0,001) (0,004) (0,005)	ΔSP: 13,51 (0,035) ΔCPI: 14,97 (0,020) ΔNIB: 13,19 (0,040)	0,125
(e) $\Delta OSE30_t$:	$+\ 0{,}237\Delta OSE30_{t-1} + 0{,}247\Delta OSE30_{t-2}$ (0,007) (0,006)	ΔOSE30:18,53 (0,000) ΔCON:8,09 (0,044)	0,209
(f) $\Delta OSE35_t$:	$+\ 0{,}410\Delta SP_{t-2} - 0{,}239\Delta NIB_{t-5}$ (0,007) (0,008)	ΔOSE35:18,28 (0,000) ΔSP:19,42 (0,001) ΔNIB: 11,51 (0,042)	0,072
(g) $\Delta OSE40_t$:		ΔNIB: 15,28 (0,018) ΔOIL: 12,95 (0,043)	0,107
(h) $\Delta OSE45_t$:	$-\ 4{,}828\Delta CPI_{t-1}$ (0,007)	ΔNIP: 11,69 (0,039)	0,111
(i) $\Delta OSE50_t$:	$-\ 0{,}256\Delta OSE50_{t-5} + 0{,}662\Delta SP_{t-5} + 1{,}955\Delta CON_{t-1}$ (0,009) (0,001) (0,002) $-\ 0{,}416\Delta NIB_{t-1} + 0{,}297\Delta NIB_{t-2}$ (0,000) (0,004)	ΔOSE50:21,14 (0,001) ΔNIB:35,04 (0,000) ΔSP:18,78 (0,004) ΔNIP:15,43 (0,017) ΔCON:15,21 (0,018)	0,232
(j) $\Delta OSE55_t$:	$+\ 0{,}186\Delta OIL_{t-2} + 2{,}297\Delta CON_{t-2}$ (0,006) (0,000)	ΔOIL: 9,01 (0,029) ΔCON: 13,04 (0,004)	0,155

[i] Equations (a), (b), (c), (e), (h) and (j) are ECM with *p* lags, while equation (d), (f), (g) and (i) are VAR (*p*) models, where *p* represents the lag order. The latter equations utilize the VAR methodology, as there are no combination of variables leading to stationarity, implying no cointegrating relation. *p*-values in parenthesis (…). Only variable estimates at a 1% significance level are reported.
[ii] Corresponding joint significance/F-value for the set of all lagged variables with *p*-values in parenthesis (…). Only F-values at a 5% significance level are reported.

From the Energy sector in line (a), we find unidirectional causalities running from ΔOIL and ΔSP to ΔOSE10. This means that changes in the price of Brent oil and the price of the S&P 500 index seem to cause changes in OSE10. Oil is a central factor and its effect on the development of this sector seems apparent, while an increased performance of the S&P 500 index could indicate a healthy economy that could lead to strong growth and increased economic activity in the Energy sector.

From line (b), we observe that ΔOSE15 are significantly related to changes in aggregated consumption (ΔCON) and changes in interest rate (ΔNIB). This sector comprises of companies that manufacture chemicals, construction materials, glass and paper as well as metal, mining and minerals companies. In other words, the sector is subject to a high capital tie, which makes the effect of an interest rate change apparent and most likely negative. This effect is supported in the subsequent impulse response analysis (section 6.3.1).

Changes in the Consumer discrepancy index (OSE25) are significantly related to ΔSP, ΔNIB and ΔCPI. Initially, we expected a causality running from ΔCON to ΔOSE25 as this sector consists mainly of consumption based retail companies such as; XXL, KID and Ekornes (EKO). Still, approximately half of the sector's market capitalization comes from Schibsted (Media group), which might explain the conflicting result.

Similar to the result of the Oslo All-share index (ΔOSE), the Consumer staples sector (ΔOSE30) shares a unidirectional causality running from ΔCON, exclusively. This sector comprises aquaculture companies such as; Marine Harvest (MHG), SalMar (SALM) and Lerøy (LSG), as well as the leading supplier of branded goods; Orkla (ORK). For the most part, these companies supply retail chains with goods for purchase, which supports the unidirectional finding.

From line (f), we see that the Health care sector (ΔOSE35) shares a causal relationship with both ΔSP and ΔNIB. This sector is small in size (~0,5% of total market cap.) and the comprising companies mostly rely on their future growth prospects that could potentially arise from new patents, medical innovations and other scientific innovations. Thus, much of their market value consists of their present value of growth opportunities (PVGO) and therefore any interest rate change will have a material effect when valuing these companies.

The Financial sector (ΔOSE40) show a causal relationship with the differentiated lagged set of variables from OIL and NIB. The effect of interest rate changes is intuitive as this sector for the most part consists of companies that base their entire operation on the gain from interest rate margins. Further, the Financial sector is closely related to the oil industry through its largest customers. This makes the relationship with the price of oil reasonable, and although this does not apply to all the customers, it serves as an indication of Norway's oil dependency.

As with Health care, the IT sector (ΔOSE45) mostly contain small cap. companies, and from line (h) we find a unidirectional causality running from ΔNIP to this sector.

This unidirectional causality is supported for the Telecommunication services sector (ΔOSE50). Additionally, this sector is causally related to changes in SP, CON and NIB. With the highest adjusted R-squared of our models, the chosen variables seem to explain this sector best at a monthly frequency, which might explain the many causalities attained.

From line (j), both ΔOIL and ΔCON show a unidirectional causality towards the Utilities sector (ΔOSE55). This sector includes the companies; Hafslund (HNA & HNB), Scatec Solar (SSO) and Arendal Fossekompani (AFK) and their operating margins rely on the development of commodities such as electricity prices. A survey done by Frydenberg et al. (2014) showed the existence of a long-run relation between European electricity prices and alternative energy sources coal, gas and oil. This might support the causality running from ΔOIL to ΔOSE55.

6.2.2.1. Bidirectional causalities

Table 17 illustrates the bidirectional causalities for each sector. We find that ΔOIL have a bidirectional causality with ΔOSE10 as opposed to only a unidirectional causality running from ΔOSE to ΔOIL in the main model. This is intuitive for the Energy sector (ΔOSE10) as it mainly consists of companies within the oil- and oil service industry. For that reason, changes in the price of oil should be reflected in the price level of this sector continuously.

Table 17: Bidirectional causalities

Sector	*ΔOSE10*	*ΔOSE15*	*ΔOSE20*	*ΔOSE25*	*ΔOSE30*	*ΔOSE35*	*ΔOSE40*	*ΔOSE45*	*ΔOSE50*	*ΔOSE55*
⟷	ΔOIL	ΔNIB	-	ΔNIB	-	-	ΔNIB	-	ΔNIB ΔCON ΔSP	-

Table 17 illustrates the bidirectional causalities for each sector from Table 16. For instance, in column 2 we see that there is a bidirectional causality running from ΔOSE10 to ΔOIL and from ΔOIL to ΔOSE10. The similar interpretation applies for the remaining columns.

Contrary to ΔOSE, we also find that changes in interest rate have a significant bidirectional relationship with changes in the price level of OSE15, OSE25, OSE40 and OSE50. This confirms the importance of interest rate expectations on different industries. Given the operational aspect of the Financial sector (ΔOSE40) and the high capital tie of the Materials sector (ΔOSE15), as stated above, the result is intuitive as changes in interest rates should be reflected in the price level of these sectors immediately. In addition, ΔOSE50 shares a bidirectional relationship with both ΔCON and ΔSP.

Unlike the main model, this section reveals several bidirectional causalities between the macroeconomic variables and the different sectors. These results do not violate the efficient market hypothesis but rather confirms that the market is efficient. This means that the respective macroeconomic variables incorporate some important information relevant to the stock market and that investors are able to grasp the information quickly so that it is reflected in stock prices.

6.3. Out-of-sample analysis

The out-of-sample analysis examines how the different sector indices respond to one positive standard deviation shock in the chosen variables.

As mentioned in section 5.4, the I (1) variables modelled in a cointegrating VECM are not mean reverting, and consequently some shocks will therefore have a permanent effect. On the contrary, each variable in a stationary VAR has a time-invariant mean and finite, time-invariant variance. This means that the effect of a shock to one variable in this system must be transitory, so that the variable can return to its mean. In other words, only the immediate response of an innovation is of interest and the effect of a shock are therefore not directly comparable between the two models.

Accordingly, in Figure 5, only the sectors that showed evidence of a cointegration relation at the 1% level are included. Figure 5a)-g) illustrate the response of the respective index to one standard deviation shock in each of the seven macroeconomic variables.

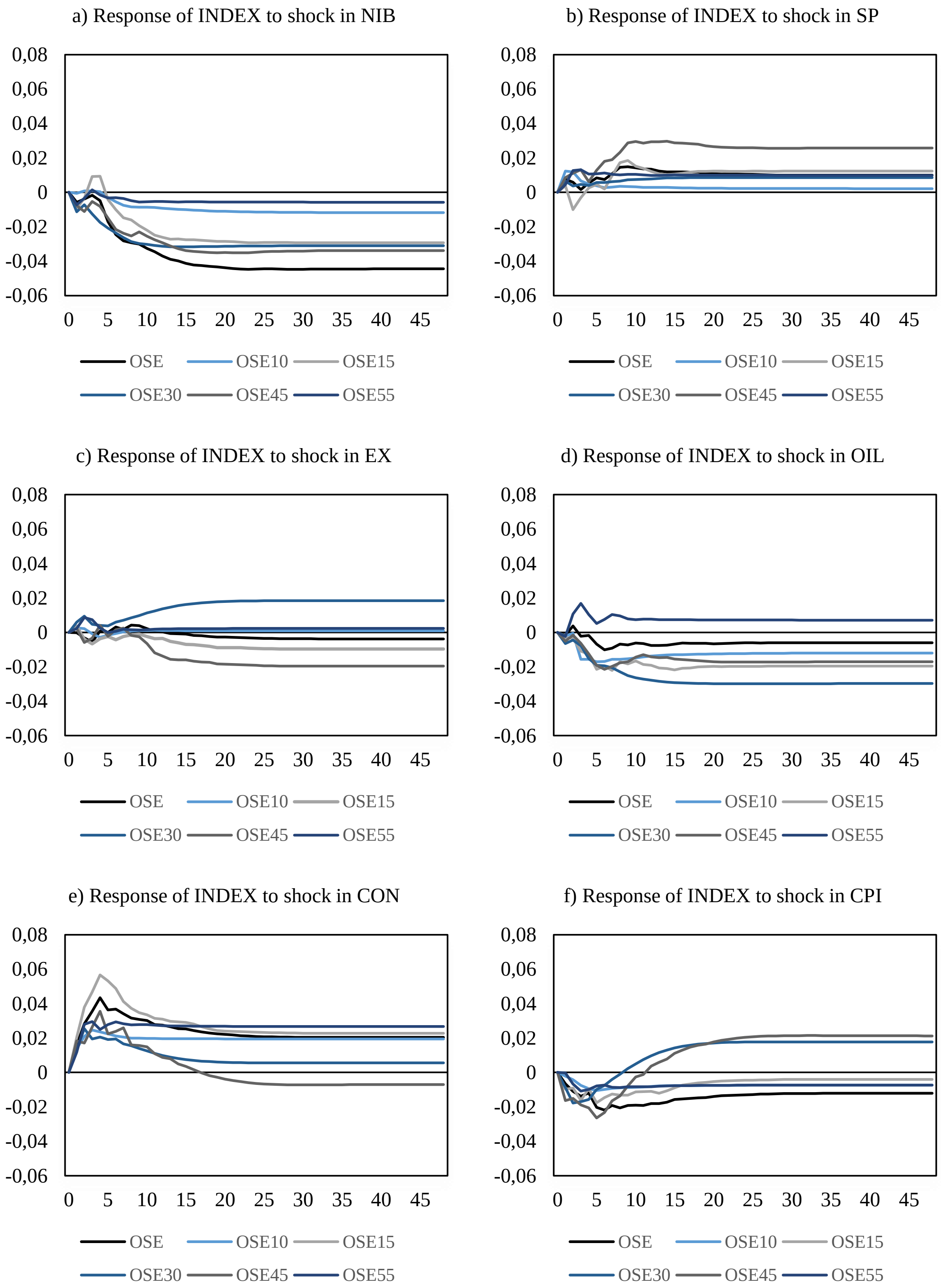
6.3.1. Impulse response analysis

From Figure 5a), we see that, except OSE40, all sectors (including the Oslo All-share index (OSE)) have a negative response to a shock in interest rate. OSE40 depicts an immediate positive response (appendix VIII). One possible explanation for this can be attributed to the financial sectors' sensitivity of net interest income to interest rate innovations. The belief is that an increased interest rate would boost net interest income, which is based on the assumption that banks can raise their lending rates by more than the increase in deposit rates.

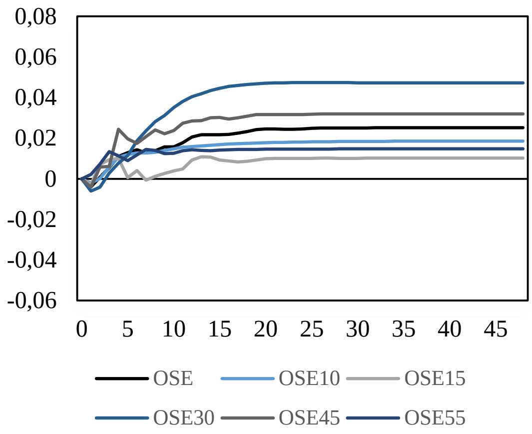
OSE10 and OSE55 are impacted the least by an innovation in NIB. Still, a shock in NIB increases the volatility in OSE10 and OSE55 up until the 5^{th} horizon, after which there is no volatility observed.

Similar to OSE, all sectors have a positive response to one standard deviation shock in SP. These results support the findings from the main analysis, i.e. the Norwegian stock market tends to follow the direction taken by the U.S. stock market.

Figure 5: The response of INDEX to one (positive) orthogonalized standard deviation shock in each variable at a monthly frequency



g) Response of INDEX to shock in NIP



From Figure 5c), we observe that OSE10 and OSE55 exhibits an insignificant response to one standard deviation shock in EX, which is similar to OSE. OSE25 and OSE35 depicts an immediate positive response (appendix VIII), while the response of OSE30 is positive and permanent. The latter relation is intuitive as the majority of firms in this sector are export dominant. A depreciation of local currency will make exports more competitive, hence increasing export earnings. On the contrary, the response of OSE15 and OSE45 is negative. One possible explanation for this relation can be attributed to currency risk. E.g., the fertilizer and aluminium business of the Materials sector (OSE15) is essentially a U.S. dollar business. Both Yara and Hydro's most important products and raw materials are either determined or denominated in US-dollars and the accounting and reporting currency is the Norwegian kroner. As a result of these exposures, the relative value of NOK, USD and EUR are of high importance to the operating results (Yara, 2016, p. 42 and Hydro, 2016, p. 154). However, one should note that a geographically diversified portfolio reduces the company's sensitivity to overall currency risk. This might explain why the Informational technology sector (OSE45) seem more sensitive to a shock in EX, than OSE15. As noted in the main analysis, the different characteristics of each sector leads to distinctive responses to an exchange rate shock.

We see that a shock in OIL, from Figure 5d), yields a positive response for OSE55, while the remaining indices responds negatively. The negative response of OSE10 contradicts both our initial expectations and the positive long-run relation found in section 6.2.1.1. One explanation for the short-run effect could be the negative relationship from equation (a) in Table 16, but perhaps more notably, the positive long-run relation shifts the effect upwards after horizon four. One should note that the convergence towards equilibrium is slow because of the low absolute value of the error correction coefficient (see Table 15).

The shock in CON is transitory, while the shock in NIP is permanent for all sectors. These results indicate that also the different sectors share a positive relation to an increase in domestic real activity, similar to the findings in the main analysis. A shock in CPI leads to an immediate negative response for all sectors, including OSE. The effect of the shock in CPI have transitory characteristics, but for OSE30 and OSE45, the response goes from negative to positive in the 9^{th} and 12^{th} period, respectively. These results might indicate that stocks serves as a good hedge against inflation in the long run, in line with the in-sample findings.

6.3.2. Variance decomposition

In this section, we decompose each sectors variance attributed to a shock in itself and/or a shock in the other variables. The effect of each shock is only shown after 12 and 48 months.

Table 18 illustrates how a shock in a given variable explains the variance of the chosen sector. The results from column 4 of Table 18 are not surprising as stock return is explained the most by its own innovation. Still, for an increasing horizon, movements in each index seem to be caused by movements in other variables than itself. Most of the variables increase their explanatory power throughout the period. This is in line with the results from the main analysis and reveals the importance of macroeconomic variables' impact on stock returns.

The bold numbers in Table 18 represents the highest observation for each row, excl. the index itself. As with OSE and not looking at the effect of a shock on itself, most of the variance in OSE10, OSE15, OSE45 and OSE55 are attributed to a shock in CON after a year. For OSE30, OSE35 and OSE50, a shock in NIB explain most of the variation after 12 months, whereas a shock in NIP, CPI and OIL explain most of the variation in OSE20, OSE25 and OSE40, respectively.

Towards the end of the out-of-sample period, we only observe minor deviations. Now, most of the variance in OSE30 is explained by the shock in NIP, contrary to NIB earlier. However, the impact of NIB is still considerable. As for OSE45, we observe a shift; with most of its variance now being explained by NIB and NIP, compared to CON after 12 months, and the explanatory power of CON has decreased significantly.

Table 18: Variance decomposition after 12 and 48 months

	Step	S.D.	INDEX	NIB	SP	EX	OIL	CON	CPI	NIP
OSE	12	0,272	67,49 %	7,77 %	1,60 %	0,13 %	0,59 %	**15,72 %**	4,42 %	2,29 %
	48	0,524	51,21 %	**25,40 %**	1,76 %	0,16 %	0,63 %	9,68 %	3,30 %	7,86 %
OSE10	12	0,277	86,93 %	0,52 %	0,56 %	0,04 %	2,89 %	**6,19 %**	0,99 %	1,88 %
	48	0,523	82,55 %	1,84 %	0,23 %	0,02 %	2,81 %	**6,72 %**	1,01 %	4,82 %
OSE15	12	0,333	75,09 %	2,11 %	1,18 %	0,13 %	2,59 %	**16,98 %**	1,64 %	0,28 %
	48	0,574	67,96 %	9,79 %	1,99 %	0,93 %	5,15 %	**12,10 %**	0,90 %	1,18 %
OSE20	12	0,317	80,37 %	1,18 %	0,27 %	0,38 %	0,09 %	1,78 %	6,86 %	**9,07 %**
	48	0,663	76,42 %	1,33 %	0,11 %	0,44 %	0,09 %	2,22 %	8,78 %	**10,62 %**
OSE25	12	0,101	71,59 %	4,56 %	4,91 %	2,90 %	3,13 %	3,68 %	**7,35 %**	1,87 %
	48	0,102	70,09 %	4,72 %	5,10 %	2,93 %	3,31 %	4,36 %	**7,32 %**	2,17 %
OSE30	12	0,344	82,11 %	**4,97 %**	0,34 %	0,59 %	3,45 %	2,82 %	1,00 %	4,71 %
	48	0,576	42,25 %	12,31 %	0,91 %	3,67 %	10,73 %	1,41 %	3,47 %	**25,25 %**
OSE35	12	0,084	74,93 %	**6,76 %**	3,97 %	4,06 %	2,91 %	3,66 %	2,54 %	1,18 %
	48	0,085	74,51 %	**6,77 %**	4,09 %	4,08 %	2,97 %	3,79 %	2,56 %	1,23 %
OSE40	12	0,088	73,45 %	3,69 %	2,69 %	2,82 %	**6,26 %**	6,17 %	2,98 %	1,94 %
	48	0,090	72,38 %	3,77 %	2,68 %	2,91 %	6,35 %	**6,66 %**	3,02 %	2,22 %
OSE45	12	0,365	82,39 %	3,08 %	3,22 %	0,21 %	1,81 %	**3,87 %**	2,28 %	3,14 %
	48	0,662	62,68 %	**10,41 %**	6,72 %	2,97 %	2,87 %	1,52 %	3,75 %	9,08 %
OSE50	12	0,100	62,03 %	**11,91 %**	7,97 %	1,59 %	3,17 %	5,99 %	3,75 %	3,58 %
	48	0,102	60,90 %	**11,97 %**	7,97 %	1,93 %	3,22 %	6,36 %	3,86 %	3,78 %
OSE55	12	0,294	85,35 %	0,25 %	1,43 %	0,18 %	1,12 %	**9,12 %**	0,84 %	1,72 %
	48	0,589	84,22 %	0,40 %	1,37 %	0,10 %	0,82 %	**9,68 %**	0,78 %	2,64 %

Table 18 reports the decomposed variance of INDEX that can be attributed to its own shock (column 4) and shocks in the remaining variables (column 5-11). The steps in column 2 are forecasting months and standard deviations are illustrated in column 3.

Table 18 confirms the statement that each industry is sensitive to macroeconomic variables differently. Similar to OSE, an interest rate shock increases its explanatory power on all indices throughout the out-of-sample period. However, the importance of interest rate news is high for industries such as: Materials, Consumer staples, Health care, Information technology and Telecommunication services. This might be explained by the high capital investments in the Materials, Consumer staples and Telecommunication sectors, whereas interest rates are important when determining the value of growth opportunities for industries such as Health care and Information technology.

When analysing the percentage of movements in macroeconomic variables attributed to a shock in each index (Table 19), the bold numbers indicate that a shock in the respective indices significantly explains movements in SP. An interpretation of this is that since most of the macroeconomic variables do well in reflecting domestic activities, these do not necessarily reflect changes in the development of the U.S. stock market. For that reason, it is likely that the indices better explain movements in SP within the models. Nevertheless, a shock in OSE10 explain as much as 61,92% of variation in OIL after 12 months, before increasing towards 65,09% after 48 months. This means that OSE10 signal changes in OIL, which is according to the bidirectional finding in Table 17. Similarly, a shock in OSE15, OSE25, OSE40 and OSE50 explain a significant proportion of the variation in NIB, also in line with the bidirectional findings.

Table 19: Percentage of forecast error variance (FEV) explained by the innovation of INDEX after 12 and 48 months

	Step	INDEX	NIB	SP	EX	OIL	CON	CPI	NIP
OSE	12	67,49 %	18,75 %	48,19 %	29,31 %	**49,57 %**	4,31 %	0,60 %	0,87 %
	48	51,21 %	23,91 %	32,90 %	19,76 %	**47,29 %**	4,41 %	0,47 %	1,78 %
OSE10	12	86,93 %	17,65 %	37,49 %	30,98 %	**61,92 %**	8,03 %	0,45 %	2,33 %
	48	82,55 %	24,08 %	31,17 %	35,96 %	**65,09 %**	15,25 %	0,67 %	11,69 %
OSE15	12	75,09 %	19,71 %	**33,58 %**	21,45 %	21,39 %	6,08 %	0,69 %	1,29 %
	48	67,96 %	**23,80 %**	15,03 %	20,58 %	19,13 %	7,45 %	0,74 %	1,79 %
OSE20	12	80,37 %	1,07 %	**47,75 %**	4,38 %	15,63 %	0,69 %	0,26 %	4,44 %
	48	76,42 %	1,65 %	**48,04 %**	4,87 %	16,59 %	0,73 %	0,27 %	2,82 %
OSE25	12	71,59 %	12,84 %	**41,56 %**	2,31 %	2,82 %	2,76 %	3,98 %	1,53 %
	48	70,09 %	12,68 %	**41,00 %**	2,46 %	2,87 %	2,84 %	3,99 %	1,62 %
OSE30	12	82,11 %	32,70 %	**48,12 %**	18,48 %	26,25 %	10,89 %	0,70 %	2,85 %
	48	42,25 %	**46,46 %**	34,18 %	19,36 %	21,13 %	22,75 %	0,28 %	14,15 %
OSE35	12	74,93 %	2,14 %	**14,45 %**	0,90 %	2,40 %	5,14 %	6,00 %	1,72 %
	48	74,51 %	2,16 %	**14,39 %**	0,96 %	2,44 %	5,24 %	6,01 %	1,76 %
OSE40	12	73,45 %	22,41 %	**49,54 %**	16,12 %	20,18 %	3,50 %	8,78 %	4,35 %
	48	72,38 %	22,12 %	**49,10 %**	15,93 %	20,04 %	3,69 %	8,98 %	4,64 %
OSE45	12	82,39 %	11,94 %	**27,79 %**	6,72 %	15,31 %	3,24 %	1,09 %	0,65 %
	48	62,68 %	14,93 %	13,05 %	8,32 %	**18,08 %**	3,17 %	4,99 %	1,15 %
OSE50	12	62,03 %	12,32 %	**31,03 %**	3,18 %	7,34 %	5,97 %	5,15 %	3,53 %
	48	60,90 %	12,83 %	**31,11 %**	3,23 %	7,36 %	6,05 %	5,19 %	3,54 %
OSE55	12	85,35 %	12,37 %	**29,83 %**	6,92 %	6,84 %	7,95 %	1,16 %	2,99 %
	48	84,22 %	19,49 %	**26,04 %**	11,23 %	8,10 %	14,79 %	1,42 %	16,87 %

Table 19 reports the percentage of movements in macroeconomic variables and INDEX that is attributed to a shock in INDEX (column 3-10). The steps in column 2 are forecasting months.

When comparing the variance decomposition in Table 18 with the results from Table 19, a shock in CON seem to signal changes in both OSE15 and OSE40 (to some degree), rather than the other way around. The explanatory power attributed to a shock in CON on the respective indices is higher than that of a shock in the indices on CON, e.g., a shock in CON explain 16,98% of the variation in OSE15, while a shock in OSE15 explain 6,08% of the variation in CON, after 12 months. Similar to OSE, these findings uncover a certain degree of inefficiency. Additionally, the shock in domestic industrial production (NIP) seem to signal changes in the price level of the following indices: OSE20, OSE30 and OSE45, rather than the opposite. For instance, a shock in NIP explain 9,07% of movements in OSE20, while a shock in OSE20 explain only 4,44% of movements in NIP, after 12 months. Furthermore, the innovations seem to exhibit delayed responses for each sector as the explanatory power increases over time. This supports the findings from the main analysis. The explanatory signalling of CON and the delayed responses of NIP to the different indices indicate a somewhat cyclical behaviour, especially for the Materials, Industrials and Consumer staples sectors.

The variance decomposition presents several interesting findings. First, stock returns are explained the most by its own innovation. The practical interpretation of this implies that the use of macroeconomic variables in predicting stock returns need cautioning. Secondly, the analysis shows that except stock returns own innovation, interest rates seem to be the most consistent factor in determining innovations. Thirdly, the analysis supports our initial statement that the sectors' operational aspect severely effect which factors are important in explaining stock returns. Lastly, the different indices serve as a leading indicator of movements in the chosen variables. This is at least true for the variables; NIB, SP, EX and OIL. To a lesser degree, similar interpretations applies for the variables from domestic real activity (CON and NIP) and CPI, except the few exceptions stated above. In other words, the stock market seems to signal changes in macroeconomic variables, instead of the opposite. The fact that different sectors for the most part signal changes in macroeconomic variables is a sign of market efficiency.

7. Concluding remarks

As stated in our first research question, we find evidence of one cointegrating vector both at a national and sectorial level. In addition to the Oslo All-share index, the Energy-, Materials-, Industrials-, Consumer staples-, Information technology- and Utilities sector all showed a significant long-term relationship with the selected macroeconomic variables.

Data suggests that the Oslo All-share index are positively related to the S&P 500 index, the consumer price index and industrial production, but negatively related to the NIBOR 3-month interest rate and the exchange rate (USD/NOK), in the long run. As with the Oslo All-share index, all the different sectors are positively related to industrial production and most sectors share a significant long-run relation with both the consumer price index and aggregated consumption. Still, some of the sectors deviate considerably. This implies that there are underlying benefits from diversification between sectors and opens the possibility of superior returns based on "stock picking".

The short-run analysis reveal several unidirectional and bidirectional causalities, and when examining the composite stock index, we find unidirectional causalities running from stock returns to changes in both exchange rate and the price of Brent oil. This means that changes in stock returns seem to cause changes in these variables. However, changes in exchange rate does not cause movements in any of the variables in the main model. In addition to stock returns of the Oslo All-share index also changes in interest rates, industrial production and stock returns of the S&P 500 significantly affect the development of exchange rate. This illustrates the intricacy of exchange rate fluctuations and reveals the endogenous properties of this variable.

Contrary to the Oslo All-share index, there are several bidirectional causalities for the different sectors. The Energy sector shares a bidirectional relationship with changes in the price of Brent oil, which is intuitive because of the sector's operational aspect. Thus, changes in the price of oil should be reflected in the price level of this sector continuously. Further, the Materials-, Consumer discretionary-, Financials- and Telecommunication services sector, all share a bidirectional relationship with changes in interest rates. This confirms the importance of interest rate expectations across different industries.

Perhaps most notably, this study finds that in the short run, the Oslo All-share index and most of its different sectors responds inaccurately to changes in important domestic real activity indicators such as aggregated consumption and industrial production. The fact that these inaccuracies occur might implicate a certain degree of inefficiency in the Norwegian stock market. The variance decomposition underpins the delayed response of innovations in aggregated consumption and industrial production and from the impulse response analysis, we find that a shock in aggregated consumption and industrial production severely affects the Oslo All-share index and the different sectors, but not the opposite. These findings coincide with the study by Gjerde & Sættem on the Norwegian stock market in 1999, and demonstrates that these inaccuracies still exist almost 20 years later.

The variance decomposition reveal that the Norwegian stock market is largely driven by interest rate news. The same effect is evident for the different sectors, but the varying characteristics seem to affect to what extent. The importance of interest rate news are high in sectors such as Materials, Consumer staples, Health care, Information Technology and Telecommunication Services. Further, the impulse response analysis reveal that except the Financial sector, all sectors have a negative response to an interest rate shock.

Data suggests that the Norwegian stock market tends to follow the direction taken by the U.S. stock market and the impulse response analysis illustrates how market shocks in larger economies such as the U.S., tends to be transmitted to smaller, open economies. These findings confirm the integration between equity markets and may have important implications for portfolio management as they signal a somewhat limited diversification benefit between the S&P 500 and the Oslo All-share index. In addition, both the short- and long-run analysis reveal that except a unidirectional causality running from stock returns to changes in the price of Brent oil, there are no significant relationship between the price of Brent oil and the Oslo All-share index. Thus, the statement among practitioners that the stock market in Norway is driven by the development of oil is only to a lesser degree supported in our data.

Lastly, the impulse response analysis demonstrates that the majority of innovations arising from macroeconomic variables are significant in explaining movements in the stock market, but that each sector's sensitivity to these innovations are different depending on the nature of the industry. Nonetheless, the use of macroeconomic variables in predicting stock returns needs cautioning, as selected macroeconomic variables only explain little of the variance in stock returns. The results from the variance decomposing of both the composite stock index and the different sectors show that stock return is explained the most by its own innovation. Moreover, the variance decomposition imply that macroeconomic variables are less capable in signalling movements in the stock market, rather than the other way around. This demonstrates the predictive ability and efficiency of the Norwegian stock market.

7.1. Implications for further research

The effects of macroeconomic policy decisions in other countries fall outside the scope of this thesis. This analysis has been limited to only compensate for the effect of foreign equity markets on the Norwegian stock market. A case study of the effect of foreign macroeconomic variables on Norwegian stock returns in the VECM framework, would be very interesting to investigate. Another valuable approach would be to employ the VECM methodology on data from other countries and/or with other variables than ours to enrichen the understanding of macroeconomic dynamics in different economies. For instance, the lesser researched Nordic economies such as Denmark, Sweden and Finland serve as natural candidates.

Moreover, the analysis discovered some degree of inefficiency as the Norwegian stock market responded inaccurately to news from domestic real activities. A natural extension and interesting approach, would be to investigate if factor exposure to these inefficiencies could yield abnormal returns in the long run.

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9. Appendices

I. VECM representation

Augmenting equation (5) with respect to OSE and chosen macroeconomic variables yields the following VECM representation:

$$\Delta OSE_t = \pi_0 + \sum_{i=1}^{6}\pi_1\Delta OSE_{t-i} + \sum_{i=1}^{6}\pi_2\Delta NIB_{t-i} + \sum_{i=1}^{6}\pi_3\Delta SP_{t-i} + \sum_{i=1}^{6}\pi_4\Delta EX_{t-i} + \sum_{i=1}^{6}\pi_5\Delta OIL_{t-i} + \sum_{i=1}^{6}\pi_6\Delta CON_{t-i} + \sum_{i=1}^{6}\pi_7\Delta CPI_{t-i} + \sum_{i=1}^{6}\pi_8\Delta NIP_{t-i} + \delta ECT_{t-1} + \epsilon_{1t} \quad \text{(a)}$$

$$\Delta NIB_t = \pi_0 + \sum_{i=1}^{6}\pi_1\Delta OSE_{t-i} + \sum_{i=1}^{6}\pi_2\Delta NIB_{t-i} + \sum_{i=1}^{6}\pi_3\Delta SP_{t-i} + \sum_{i=1}^{6}\pi_4\Delta EX_{t-i} + \sum_{i=1}^{6}\pi_5\Delta OIL_{t-i} + \sum_{i=1}^{6}\pi_6\Delta CON_{t-i} + \sum_{i=1}^{6}\pi_7\Delta CPI_{t-i} + \sum_{i=1}^{6}\pi_8\Delta NIP_{t-i} + \delta ECT_{t-1} + \epsilon_{1t} \quad \text{(b)}$$

$$\Delta SP_t = \pi_0 + \sum_{i=1}^{6}\pi_1\Delta OSE_{t-i} + \sum_{i=1}^{6}\pi_2\Delta NIB_{t-i} + \sum_{i=1}^{6}\pi_3\Delta SP_{t-i} + \sum_{i=1}^{6}\pi_4\Delta EX_{t-i} + \sum_{i=1}^{6}\pi_5\Delta OIL_{t-i} + \sum_{i=1}^{6}\pi_6\Delta CON_{t-i} + \sum_{i=1}^{6}\pi_7\Delta CPI_{t-i} + \sum_{i=1}^{6}\pi_8\Delta NIP_{t-i} + \delta ECT_{t-1} + \epsilon_{1t} \quad \text{(c)}$$

$$\Delta EX_t = \pi_0 + \sum_{i=1}^{6}\pi_1\Delta OSE_{t-i} + \sum_{i=1}^{6}\pi_2\Delta NIB_{t-i} + \sum_{i=1}^{6}\pi_3\Delta SP_{t-i} + \sum_{i=1}^{6}\pi_4\Delta EX_{t-i} + \sum_{i=1}^{6}\pi_5\Delta OIL_{t-i} + \sum_{i=1}^{6}\pi_6\Delta CON_{t-i} + \sum_{i=1}^{6}\pi_7\Delta CPI_{t-i} + \sum_{i=1}^{6}\pi_8\Delta NIP_{t-i} + \delta ECT_{t-1} + \epsilon_{1t} \quad \text{(d)}$$

$$\Delta OIL_t = \pi_0 + \sum_{i=1}^{6}\pi_1\Delta OSE_{t-i} + \sum_{i=1}^{6}\pi_2\Delta NIB_{t-i} + \sum_{i=1}^{6}\pi_3\Delta SP_{t-i} + \sum_{i=1}^{6}\pi_4\Delta EX_{t-i} + \sum_{i=1}^{6}\pi_5\Delta OIL_{t-i} + \sum_{i=1}^{6}\pi_6\Delta CON_{t-i} + \sum_{i=1}^{6}\pi_7\Delta CPI_{t-i} + \sum_{i=1}^{6}\pi_8\Delta NIP_{t-i} + \delta ECT_{t-1} + \epsilon_{1t} \quad \text{(e)}$$

$$\Delta CON_t = \pi_0 + \sum_{i=1}^{6}\pi_1\Delta OSE_{t-i} + \sum_{i=1}^{6}\pi_2\Delta NIB_{t-i} + \sum_{i=1}^{6}\pi_3\Delta SP_{t-i} + \sum_{i=1}^{6}\pi_4\Delta EX_{t-i} + \sum_{i=1}^{6}\pi_5\Delta OIL_{t-i} + \sum_{i=1}^{6}\pi_6\Delta CON_{t-i} + \sum_{i=1}^{6}\pi_7\Delta CPI_{t-i} + \sum_{i=1}^{6}\pi_8\Delta NIP_{t-i} + \delta ECT_{t-1} + \epsilon_{1t} \quad \text{(f)}$$

$$\Delta CPI_t = \pi_0 + \sum_{i=1}^{6}\pi_1\Delta OSE_{t-i} + \sum_{i=1}^{6}\pi_2\Delta NIB_{t-i} + \sum_{i=1}^{6}\pi_3\Delta SP_{t-i} + \sum_{i=1}^{6}\pi_4\Delta EX_{t-i} + \sum_{i=1}^{6}\pi_5\Delta OIL_{t-i} + \sum_{i=1}^{6}\pi_6\Delta CON_{t-i} + \sum_{i=1}^{6}\pi_7\Delta CPI_{t-i} + \sum_{i=1}^{6}\pi_8\Delta NIP_{t-i} + \delta ECT_{t-1} + \epsilon_{1t} \quad \text{(g)}$$

$$\Delta NPI_t = \pi_0 + \sum_{i=1}^{6}\pi_1\Delta OSE_{t-i} + \sum_{i=1}^{6}\pi_2\Delta NIB_{t-i} + \sum_{i=1}^{6}\pi_3\Delta SP_{t-i} + \sum_{i=1}^{6}\pi_4\Delta EX_{t-i} + \sum_{i=1}^{6}\pi_5\Delta OIL_{t-i} + \sum_{i=1}^{6}\pi_6\Delta CON_{t-i} + \sum_{i=1}^{6}\pi_7\Delta CPI_{t-i} + \sum_{i=1}^{6}\pi_8\Delta NIP_{t-i} + \delta ECT_{t-1} + \epsilon_{1t} \quad \text{(h)}$$

For all models (a-h), the parameters in the error correction term (ECT) are retrieved from the cointegration vector:

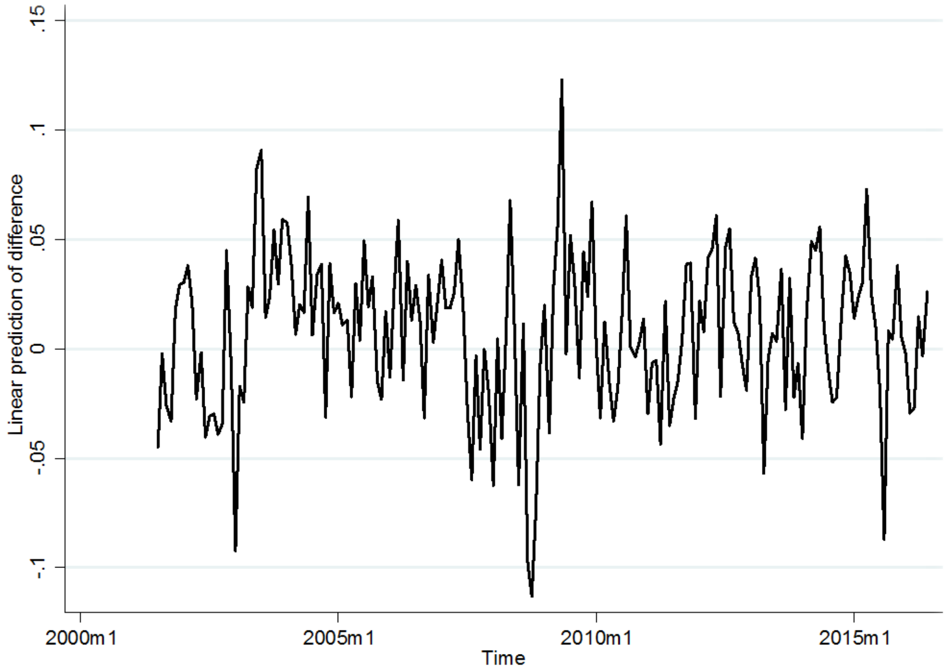
$$\delta ECT_{t-1} = \delta(\beta_1 OSE_t + \beta_2 NIB_t + \beta_3 SP_t + \beta_4 EX_t + \beta_5 OIL_t + \beta_6 CON_t + \beta_7 CPI_t + \beta_8 NIP_t)$$

II. VECM output, excl. cointegrating equations

Explanatory Variable	ΔOSE_t	ΔNIB_t	ΔSP_t	ΔEX_t	ΔOIL_t	ΔCON_t	ΔCPI_t	ΔNIP_t
δ_i	-0,040**	0,014	-0,014	-0,042***	0,046*	0,005	0,000	0,020**
ΔOSE_{t-1}	-0,020	0,008	0,067	-0,256***	0,691***	-0,013	0,005	0,046
ΔOSE_{t-2}	-0,023	0,218	-0,055	-0,135*	0,349	0,039	-0,010	0,033
ΔOSE_{t-3}	0,066	0,273*	-0,037	-0,043	0,422*	-0,031	0,010	0,062
ΔOSE_{t-4}	-0,030	-0,125	-0,027	-0,031	0,039	0,010	0,006	0,006
ΔOSE_{t-5}	-0,103	-0,015	0,009	0,115	-0,066	0,028	-0,005	0,036
ΔNIB_{t-1}	-0,107	0,229***	-0,065	0,086*	-0,228*	0,002	-0,007	-0,057
ΔNIB_{t-2}	0,049	0,187**	0,026	-0,018	0,099	-0,015	0,010	-0,019
ΔNIB_{t-3}	0,126	-0,097	0,034	0,051	0,047	-0,011	0,003	-0,039
ΔNIB_{t-4}	-0,027	0,038	-0,036	0,055	-0,015	0,021	-0,004	0,010
ΔNIB_{t-5}	-0,144*	0,138	-0,120**	0,088**	-0,189	0,001	0,009	0,058
ΔSP_{t-1}	0,226	0,078	0,006	0,289***	-0,220	0,021	0,011	0,002
ΔSP_{t-2}	-0,013	-0,275	-0,087	0,261**	-0,411	-0,068**	0,023	0,008
ΔSP_{t-3}	-0,066	-0,254	0,102	0,109	-0,613**	0,047	-0,029*	-0,030
ΔSP_{t-4}	0,145	0,300	0,106	-0,028	0,446	-0,024	-0,002	0,004
ΔSP_{t-5}	0,109	0,268	0,064	-0,183*	-0,293	-0,003	-0,008	0,011
ΔEX_{t-1}	0,065	-0,022	0,114	-0,084	-0,305	0,003	-0,009	0,016
ΔEX_{t-2}	0,002	0,127	0,021	0,039	-0,474	-0,045	0,018	0,001
ΔEX_{t-3}	-0,065	-0,176	-0,027	-0,048	-0,508*	-0,041	-0,010	0,015
ΔEX_{t-4}	0,342**	0,100	0,164	-0,115	0,292	-0,015	-0,015	0,026
ΔEX_{t-5}	-0,034	0,186	-0,064	-0,099	-0,292	0,014	-0,014	-0,037
ΔOIL_{t-1}	0,005	0,006	0,011	0,011	-0,059	0,017	0,000	-0,047
ΔOIL_{t-2}	0,051	0,127*	0,057	-0,047	-0,069	-0,022**	0,006	-0,032
ΔOIL_{t-3}	-0,058	0,000	0,028	-0,039	-0,233**	-0,003	-0,005	0,002
ΔOIL_{t-4}	0,024	-0,007	0,010	-0,058	0,068	0,000	-0,001	0,009
ΔOIL_{t-5}	-0,066	0,107	-0,040	-0,047	-0,036	-0,008	-0,008	0,019
ΔCON_{t-1}	1,699***	0,726	0,931**	-0,359	0,455	-0,529***	-0,027	-0,142
ΔCON_{t-2}	2,102***	1,042	0,865*	-0,318	1,415	-0,263**	-0,032	-0,035
ΔCON_{t-3}	1,878***	0,647	1,069**	-0,392	0,434	-0,125	-0,060	0,349
ΔCON_{t-4}	1,563**	0,034	0,747	-0,117	-0,049	0,003	-0,061	0,086
ΔCON_{t-5}	-0,352	-0,264	-0,018	0,225	-0,071	-0,053	-0,013	0,153
ΔCPI_{t-1}	-2,020*	2,157**	-0,917	-1,590***	4,233**	-0,315*	0,096	0,182
ΔCPI_{t-2}	-0,722	-0,033	0,488	-0,776	1,252	-0,195	-0,068	0,412
ΔCPI_{t-3}	-1,060	2,466**	-0,330	-0,280	0,464	0,035	-0,156*	0,174
ΔCPI_{t-4}	0,420	-0,755	-0,531	-1,123*	1,097	-0,074	-0,218***	0,142
ΔCPI_{t-5}	-1,793*	1,428	-1,574*	-0,739	3,395**	-0,123	0,052	-0,318
ΔNIP_{t-1}	-0,600***	0,046	-0,231	-0,302**	-0,126	0,023	-0,004	-0,311***
ΔNIP_{t-2}	-0,324	0,092	-0,192	-0,145	0,033	0,053	0,006	-0,330***
ΔNIP_{t-3}	-0,161	0,142	-0,108	-0,212*	0,318	-0,011	0,017	-0,282***
ΔNIP_{t-4}	0,067	0,044	-0,026	0,076	0,160	0,012	0,001	-0,161*
ΔNIP_{t-5}	0,060	0,134	-0,032	0,123	0,500*	0,016	0,018	-0,142*
Constant	-0,013	-0,016*	-0,007	-0,002	-0,011	0,006***	0,003***	0,001
R2	0,363	0,468	0,257	0,386	0,395	0,405	0,340	0,345
Adj. R2	0,160	0,288	0,030	0,201	0,212	0,202	0,032	0,147
Obs.	179	179	179	179	179	179	179	179

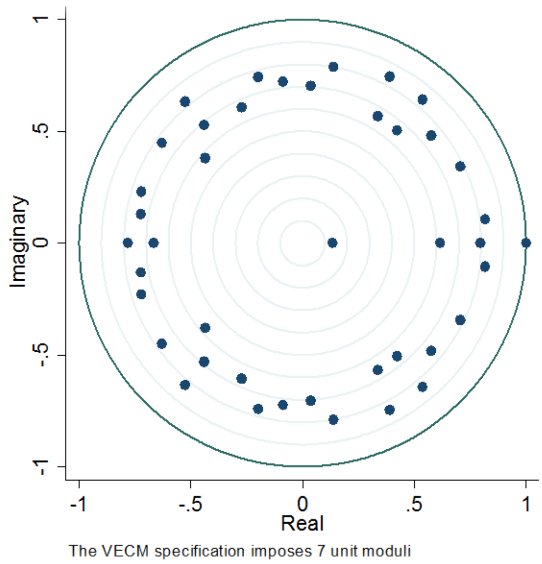
III. Supplementing diagnostic tests

Figure 6: Stationary properties of the cointegration equation



Notes: The inference on the parameters in the ECT depends on the stationarity of the cointegration equations, meaning that the stationary properties of the system are essential for consistent estimates. The visualization of the cointegrating equation shows that a linear combination of the series in the model is an I (0) process. I.e. the cointegration equation is a stationary process, which serves as confirmation of no model misspecification.

Figure 7: Roots of the companion matrix



Notes: The companion matrix of a VECM with K endogenous variables and r cointegration equations have $K - r$ unit eigenvalues. Generally, if the moduli of the remaining eigenvalues are strictly less than one the process is defined as stable. In the model, all of the remaining eigenvalues are less than one, meaning that the stability check does not give indications of model misspecification and the system is considered well specified.

IV. Complete variance decomposition of all different variables

	Step	S.D.	OSE	NIB	SP	EX	OIL	CON	CPI	NIP
OSE	1	0,055	**100,00%**	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
	6	0,186	**78,57 %**	1,04 %	0,56 %	0,12 %	0,21 %	15,91 %	2,63 %	0,95 %
	12	0,272	**67,49 %**	7,77 %	1,60 %	0,13 %	0,59 %	15,72 %	4,42 %	2,29 %
	24	0,386	**57,44 %**	18,14 %	1,86 %	0,10 %	0,66 %	12,35 %	4,08 %	5,37 %
	48	0,542	**51,21 %**	25,40 %	1,76 %	0,16 %	0,63 %	9,68 %	3,30 %	7,86 %
NIB	1	0,056	0,72 %	**99,28 %**	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
	6	0,225	9,92 %	**82,03 %**	0,61 %	0,34 %	1,20 %	3,95 %	1,38 %	0,58 %
	12	0,411	18,75 %	**69,01 %**	0,23 %	0,14 %	0,85 %	9,80 %	0,55 %	0,68 %
	24	0,653	22,39 %	**62,19 %**	0,16 %	0,09 %	0,55 %	13,44 %	0,32 %	0,87 %
	48	0,959	23,91 %	**59,37 %**	0,15 %	0,07 %	0,43 %	14,90 %	0,26 %	0,90 %
SP	1	0,042	56,66 %	0,00 %	**43,34 %**	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
	6	0,123	57,38 %	1,26 %	**30,90 %**	0,17 %	0,36 %	8,41 %	1,45 %	0,07 %
	12	0,188	48,19 %	9,00 %	**29,71 %**	0,09 %	0,23 %	8,76 %	3,85 %	0,16 %
	24	0,267	38,24 %	19,98 %	**30,54 %**	0,09 %	0,18 %	6,18 %	4,06 %	0,73 %
	48	0,373	32,90 %	26,87 %	**30,70 %**	0,14 %	0,13 %	4,42 %	3,61 %	1,23 %
EX	1	0,031	20,42 %	0,36 %	1,09 %	**78,12 %**	0,00 %	0,00 %	0,00 %	0,00 %
	6	0,089	34,52 %	0,24 %	7,11 %	**40,22 %**	0,35 %	4,66 %	0,45 %	12,44 %
	12	0,115	29,31 %	0,38 %	7,47 %	**33,55 %**	0,28 %	5,24 %	1,35 %	22,42 %
	24	0,167	22,64 %	0,58 %	7,54 %	**26,75 %**	0,19 %	4,82 %	2,37 %	35,10 %
	48	0,240	19,76 %	1,16 %	6,92 %	**21,03 %**	0,16 %	5,38 %	3,36 %	42,24 %
OIL	1	0,088	18,93 %	1,43 %	4,30 %	16,47 %	**58,87 %**	0,00 %	0,00 %	0,00 %
	6	0,295	50,04 %	0,35 %	7,08 %	14,03 %	**21,04 %**	5,20 %	0,43 %	1,82 %
	12	0,390	49,57 %	0,56 %	8,97 %	12,13 %	**17,69 %**	7,11 %	0,52 %	3,46 %
	24	0,517	47,93 %	0,35 %	10,39 %	11,12 %	**16,83 %**	7,23 %	0,56 %	5,60 %
	48	0,714	47,29 %	0,19 %	10,92 %	10,04 %	**15,93 %**	7,74 %	0,66 %	7,23 %
CON	1	0,009	4,13 %	0,66 %	0,08 %	0,48 %	0,27 %	**94,38 %**	0,00 %	0,00 %
	6	0,016	4,76 %	0,91 %	1,58 %	0,96 %	2,64 %	**79,54 %**	7,37 %	2,24 %
	12	0,022	4,31 %	1,23 %	0,94 %	1,22 %	2,37 %	**75,30 %**	9,79 %	4,83 %
	24	0,034	4,31 %	1,85 %	0,49 %	1,61 %	2,33 %	**71,30 %**	11,67 %	6,44 %
	48	0,049	4,41 %	2,19 %	0,27 %	1,84 %	2,31 %	**69,07 %**	12,70 %	7,20 %
CPI	1	0,004	1,04 %	0,36 %	0,17 %	0,88 %	1,39 %	3,54 %	**92,62 %**	0,00 %
	6	0,010	0,72 %	1,77 %	1,30 %	1,93 %	2,09 %	6,34 %	**85,53 %**	0,32 %
	12	0,014	0,60 %	4,09 %	0,86 %	1,64 %	1,66 %	6,46 %	**84,28 %**	0,42 %
	24	0,019	0,47 %	8,36 %	0,54 %	1,43 %	1,25 %	5,28 %	**82,26 %**	0,41 %
	48	0,026	0,47 %	11,08 %	0,43 %	1,21 %	1,02 %	4,39 %	**80,93 %**	0,48 %
NIP	1	0,028	0,10 %	0,28 %	0,21 %	0,29 %	2,68 %	0,03 %	0,52 %	**95,89 %**
	6	0,036	0,35 %	3,55 %	0,71 %	6,63 %	2,33 %	1,43 %	2,16 %	**82,85 %**
	12	0,044	0,87 %	2,62 %	0,81 %	9,28 %	1,80 %	3,47 %	4,36 %	**76,79 %**
	24	0,056	1,39 %	1,65 %	0,96 %	12,47 %	1,27 %	6,41 %	7,53 %	**68,33 %**
	48	0,075	1,78 %	0,95 %	1,11 %	14,89 %	0,89 %	8,52 %	9,96 %	**61,90 %**

Notes: The steps in column 2 are forecasting months. The first row reports the decomposed variance of **OSE** that can be attributed to its own shock **(bold numbers**, column 4) and shocks in the remaining variables (column 5-11). The second row illustrates the decomposed variance of **NIB** that can be attributed to its own shock (**bold numbers**, column 5) and shocks in the remaining variables (column 4, and 6-11). The same interpretation applies for the remaining variables.

V. Complete company overview for each sector and total market capitalization

OSE10	Weight	OSE15	Weight	OSE20	Weight	OSE25	Weight	OSE30	Weight	OSE35	Weight	OSE40	Weight	OSE45	Weight	OSE50	Weight	OSE55	Weight
AKA	0,50 %	AVM	0,06 %	AFG	12,32 %	EKO	5,43 %	AUSS	6,27 %	BIONOR	3,31 %	ASC	0,60 %	APP	0,36 %	NGT	0,34 %	AFK	24,16 %
AKERBP	6,81 %	BOR	0,11 %	AKVA	1,78 %	EPR	8,78 %	BAKKA	6,71 %	BIOTEC	5,95 %	AGA	0,01 %	ASETEK	3,09 %	TEL	99,66 %	HNA	38,22 %
AKSO	1,54 %	BRG	4,70 %	AMSC	1,31 %	GYL	0,83 %	GSF	3,50 %	COV	4,49 %	AKER	6,37 %	ATEA	18,71 %			HNB	26,54 %
AQUA	0,02 %	INC	0,07 %	BEL	0,16 %	KID	1,83 %	LSG	10,65 %	MEDI	15,58 %	AXA	0,83 %	BOUVET	2,82 %			SSO	11,08 %
ARCHER	0,05 %	ITX	0,06 %	BMA	0,46 %	KOA	3,46 %	MHG	26,76 %	NAVA	1,66 %	B2H	1,34 %	CXENSE	2,33 %				
ATLA NOK	0,01 %	NHY	45,98 %	RISH	0,50 %	POL	1,30 %	NRS	3,40 %	NANO	48,17 %	DNB	54,83 %	DAT	2,05 %				
AVANCE	0,18 %	NSG	0,47 %	GOGL	3,33 %	SCHA	28,26 %	ORK	30,50 %	PHO	10,48 %	GJF	18,88 %	FUNCOM	0,93 %				
BERGEN	0,01 %	YAR	48,57 %	GOD	0,14 %	SCHB	29,79 %	SALM	11,57 %	WEIFA	10,37 %	INSR	0,09 %	GIG	5,99 %				
BON	0,33 %			HYARD	0,20 %	XXL	20,31 %	SSC	0,64 %			NOFI	3,96 %	IDEX	7,97 %				
BWLPG	0,57 %			HEX	3,99 %							PROTCT	1,61 %	ITE	0,89 %				
BWO	0,54 %			JIN	0,56 %							SKBN	2,04 %	KIT	2,41 %				
DESSC	0,05 %			KOG	13,06 %							SKI	0,10 %	NAPA	1,26 %				
DNO	1,22 %			MULTI	2,40 %							SRBANK	3,75 %	NEXT	4,85 %				
DOF	0,17 %			NEL	1,22 %							STB	5,54 %	NOD	13,00 %				
EIOF	0,03 %			NAS	8,27 %							VVL	0,06 %	OPERA	17,75 %				
EMGS	0,02 %			NRC	2,31 %									QFR	1,45 %				
EMAS	0,02 %			NTS	0,59 %									REC	5,49 %				
FAR	0,04 %			ODF	1,44 %									STRONG	1,29 %				
FOE	0,14 %			ODFB	0,43 %									TECH	1,36 %				
FRO	1,53 %			RENO	0,40 %									THIN	6,02 %				
HAVI	0,01 %			SAS	4,04 %														
HLNG	1,04 %			SSI	0,55 %														
IMSK	0,01 %			SOLV	0,55 %														
IOX	0,02 %			SNI	4,82 %														
KVAER	0,41 %			TEAM	1,87 %														
NOR	0,10 %			TIDE	0,57 %														
OCY	1,53 %			TOM	1,20 %														
OTS	0,00 %			TRE	3,01 %														
ODL	0,40 %			TTS	0,30 %														
PEN	0,03 %			VEI	14,85 %														
PGS	0,92 %			WWASA	5,49 %														
PDR	0,02 %			WWI	5,55 %														
PLCS	0,02 %			WWIB	1,82 %														
PRS	0,29 %			ZAL	0,50 %														
QEC	0,12 %																		
RAKP	0,22 %																		
REACH	0,03 %																		
SBX	0,00 %																		
SDRL	1,74 %																		
SEVDR	0,01 %																		
SEVAN	0,14 %																		
SIOFF	0,24 %																		
SOFF	0,12 %																		
SONG	0,32 %																		
SPU	0,20 %																		
STL	70,42 %																		
SUBC	5,04 %																		
TIL	0,17 %																		
TGS	2,60 %																		
WRL	0,06 %																		
SUM	100 %		100 %		100 %		100 %		100 %		100 %		100 %		100 %		100 %		100 %
SUM/TOTAL	35 %		9 %		6 %		4 %		13 %		0,5 %		19 %		2 %		10 %		1 %

VI. Normalized cointegrating equations and speed of adjustment coefficients

Panel A: Normalized Co-integrating Coefficient								
OSE10(-1)	NIB(-1)	SP(-1)	EX(-1)	OIL(-1)	CON(-1)	CPI(-1)	NIP(-1)	C
1	0,169	0,304	-0,350	-0,576	-5,409	-2,361	-5,548	55,779
	(0,071)	(0,185)	(0,544)	(0,183)	(1,406)	(2,217)	(1,015)	
	[2,36]	[1,64]	[-0,64]	[-3,15]	[-3,85]	[-1,07]	[-5,47]	
Panel B: Error correction term								
ΔOSE10	ΔNIB	ΔSP	ΔEX	ΔOIL	ΔCONS	ΔCPI	ΔNIP	
-0,066	0,052	0,031	0,023	0,010	0,018	-0,003	0,042	
(0,028)	(0,025)	(0,019)	(0,015)	(0,040)	(0,004)	(0,002)	(0,012)	
[-2,39]	[2,10]	[-1,66]	[-1,55]	[0,26]	[4,80]	[-1,23]	[3,47]	
Panel C: Normalized Co-integrating Coefficient								
OSE15(-1)	NIB(-1)	SP(-1)	EX(-1)	OIL(-1)	CON(-1)	CPI(-1)	NIP(-1)	C
1	0,212	-0,833	7,653	1,397	9,226	-27,570	-10,867	119,751
	(0,190)	(0,528)	(1,554)	(0,501)	(4,144)	(6,869)	(3,058)	
	[1,11]	[-1,57]	[4,92]	[2,78]	[2,23]	[-4,01]	[-3,55]	
Panel D: Error correction term								
ΔOSE15	ΔNIB	ΔSP	ΔEX	ΔOIL	ΔCONS	ΔCPI	ΔNIP	
-0,032	0,014	-0,020	0,021	0,001	0,003	0,001	0,007	
(0,015)	(0,011)	(0,008)	(0,006)	(0,018)	(0,002)	(0,001)	(0,006)	
[-2,11]	[1,28]	[-2,51]	[-3,41]	[-0,05]	[1,88]	[1,35]	[1,31]	
Panel E: Normalized Co-integrating Coefficient								
OSE20(-1)	NIB(-1)	SP(-1)	EX(-1)	OIL(-1)	CON(-1)	CPI(-1)	NIP(-1)	C
1	-0,941	-1,161	4,570	-0,794	24,791	-58,643	-29,268	300,547
	(0,282)	(0,739)	(2,140)	(0,723)	(5,437)	(8,515)	(3,795)	
	[-3,33]	[-1,57]	[2,14]	[-1,1]	[4,56]	[-6,89]	[-7,71]	
Panel F: Error correction term								
ΔOSE20	ΔNIB	ΔSP	ΔEX	ΔOIL	ΔCONS	ΔCPI	ΔNIP	
0,024	0,003	0,011	-0,013	0,027	0,002	0,001	0,014	
(0,007)	(0,006)	(0,004)	(0,003)	(0,009)	(0,001)	(0,000)	(0,003)	
[3,23]	[0,56]	[2,58]	[-3,8]	[2,96]	[1,96]	[1,51]	[5,01]	
Panel G: Normalized Co-integrating Coefficient								
OSE30(-1)	NIB(-1)	SP(-1)	EX(-1)	OIL(-1)	CON(-1)	CPI(-1)	NIP(-1)	C
1	0,042	-0,492	0,888	0,632	-2,413	-10,232	-5,188	76,870
	(0,109)	(0,274)	(0,823)	(0,269)	(2,069)	(3,227)	(1,466)	
	[0,38]	[-1,79]	[1,08]	[2,35]	[-1,17]	[-3,17]	[-3,54]	
Panel H: Error correction term								
ΔOSE30	ΔNIB	ΔSP	ΔEX	ΔOIL	ΔCONS	ΔCPI	ΔNIP	
-0,055	0,071	-0,004	-0,016	-0,005	0,012	-0,001	0,025	
(0,023)	(0.017)	(0,013)	(0,010)	(0,028)	(0,003)	(0,002)	(0,009)	
[-2,36]	[4.10]	[-0,33]	[-1,54]	[-0,17]	[4,13]	[-0,49]	[2,76]	
Panel I: Normalized Co-integrating Coefficient								
OSE45(-1)	NIB(-1)	SP(-1)	EX(-1)	OIL(-1)	CON(-1)	CPI(-1)	NIP(-1)	C
1	-0,179	-0,745	5,718	0,791	14,755	-34,991	-10,792	136,350
	(0,194)	(0,522)	(1,580)	(0,524)	(4,407)	(6,924)	(3,040)	
	[-0,92]	[-1,43]	[3,62]	[1,51]	[3,35]	[-5,05]	[-3,55]	
Panel J: Error correction term								
ΔOSE45	ΔNIB	ΔSP	ΔEX	ΔOIL	ΔCONS	ΔCPI	ΔNIP	
0,031	0,021	-0,015	-0,025	0,019	0,004	0,001	0,006	
(0,018)	(0,011)	(0,008)	(0,006)	(0,018)	(0,002)	(0,001)	(0,006)	
[-1,68]	[1,99]	[-1,86]	[-4,05]	[1,1]	[2,21]	[1,46]	[1,06]	
Panel K: Normalized Co-integrating Coefficient								
OSE55(-1)	NIB(-1)	SP(-1)	EX(-1)	OIL(-1)	CON(-1)	CPI(-1)	NIP(-1)	C
1	-0,128	0,588	2,254	0,673	-6,058	-15,870	-13,525	148,761
	(0,160)	(0,422)	(1,244)	(0,416)	(3,201)	(5,057)	(2,312)	
	[-0,80]	[1,39]	[1,81]	[1,62]	[-1,89]	[-3,14]	[-5,85]	
Panel L: Error correction term								
ΔOSE55	ΔNIB	ΔSP	ΔEX	ΔOIL	ΔCONS	ΔCPI	ΔNIP	
-0,028	0,022	0,010	0,013	-0,001	0,007	-0,001	0,022	
(0,013)	(0,011)	(0,008)	(0,007)	(0,018)	(0,002)	(0,001)	(0,005)	
[-2,17]	[1,99]	[-1,18]	[-2,04]	[-0,06]	[4,29]	[-1,03]	[4,02]	

VII. Sector ECM output excl. cointegrating equations

Explanatory Variable	$^{a)}\Delta OSE10_t$	$^{b)}\Delta OSE15_t$	$^{c)}\Delta OSE20_t$	$^{d)}\Delta OSE25_t$	$^{e)}\Delta OSE30_t$	$^{f)}\Delta OSE35_t$	$^{g)}\Delta OSE40_t$	$^{h)}\Delta OSE45_t$	$^{i)}\Delta OSE50_t$	$^{j)}\Delta OSE55_t$
δ_i	-0,066**	-0,032**	0,024***	-	-0,05**	-	-	-0,030*	-	-0,028**
$\Delta OSE_{p,t-1}$	0,053	0,100	-0,042	-0,132	0,24***	-0,120	-0,116	-0,020	-0,064	0,164*
$\Delta OSE_{p,t-2}$	0,210*	0,240**	-0,247**	-0,051	0,25***	-0,118	-0,131	-0,029	-0,041	-0,145
$\Delta OSE_{p,t-3}$	0,261**	-0,170	-	-0,017	0,073	0,068	0,060	0,183*	0,200**	0,145
$\Delta OSE_{p,t-4}$	-	0,039	-	0,096	-	0,145*	-0,028	0,046	0,092	-
$\Delta OSE_{p,t-5}$	-	-0,195*	-	0,176	-	-0,181**	0,069	-0,071	-0,26***	-
$\Delta OSE_{p,t-6}$	-	-	-	-0,153	-	-	0,182*	-	0,180*	-
ΔNIB_{t-1}	0,013	-0,188	-0,113	-0,119	-0,171	-0,067	0,096	-0,141	-0,42***	-0,115
ΔNIB_{t-2}	0,034	0,132	0,003	-0,050	0,107	-0,101	-0,125	-0,055	0,297***	0,113
ΔNIB_{t-3}	0,068	0,309***	-	0,243**	-0,013	0,178*	0,049	0,210	0,164	0,111
ΔNIB_{t-4}	-	-0,098	-	-0,139	-	-0,020	-0,169*	-0,039	-0,204*	-
ΔNIB_{t-5}	-	-0,259**	-	-0,166	-	-0,24***	-0,166*	-0,093	-0,203**	-
ΔNIB_{t-6}	-	-	-	-0,072	-	-	-0,059	-	-0,030	-
ΔSP_{t-1}	0,316**	0,058	0,296	0,668***	0,116	0,337**	0,420**	0,272	0,467**	0,112
ΔSP_{t-2}	-0,072	-0,59***	0,155	0,077	-0,139	0,410***	0,135	-0,011	-0,196	0,197
ΔSP_{t-3}	-0,239	0,306	-	0,402*	-0,028	-0,115	0,018	0,303	-0,203	-0,149
ΔSP_{t-4}	-	0,119	-	-0,091	-	-0,017	0,027	-0,386	-0,050	-
ΔSP_{t-5}	-	0,147	-	-0,221	-	0,250	-0,007	0,292	0,662***	-
ΔSP_{t-6}	-	-	-	-0,009	-	-	-0,353*	-	-0,220	-
ΔEX_{t-1}	0,015	0,248	0,051	0,237	0,131	-0,085	-0,010	0,129	0,055	0,073
ΔEX_{t-2}	-0,082	-0,176	0,100	-0,064	0,153	0,327*	0,046	-0,131	-0,285	0,456**
ΔEX_{t-3}	-0,317*	-0,028	-	0,001	-0,147	-0,026	0,033	0,212	0,188	0,087
ΔEX_{t-4}	-	0,164	-	0,039	-	0,049	0,324*	0,133	0,371*	-
ΔEX_{t-5}	-	-0,059	-	-0,359*	-	-0,063	-0,047	-0,211	-0,175	-
ΔEX_{t-6}	-	-	-	-0,015	-	-	-0,201	-	-0,262	-
ΔOIL_{t-1}	-0,045	0,016	0,028	-0,005	-0,022	-0,153**	0,044	-0,028	0,018	-0,009
ΔOIL_{t-2}	-0,040	-0,007	0,114*	0,021	0,075	0,032	0,107	0,030	-0,006	0,186***
ΔOIL_{t-3}	-0,24***	-0,023	-	0,132*	-0,002	0,020	-0,005	-0,017	0,064	0,064
ΔOIL_{t-4}	-	0,016	-	-0,093	-	-0,117*	-0,045	-0,106	0,068	-
ΔOIL_{t-5}	-	-0,132	-	-0,107	-	0,027	-0,116*	-0,067	-0,185**	-
ΔOIL_{t-6}	-	-	-	-0,061	-	-	-0,16**	-	0,056	-
ΔCON_{t-1}	1,227**	2,251***	-0,664	0,441	1,132*	0,170	1,208**	2,026**	1,955***	1,181**
ΔCON_{t-2}	1,232**	3,078***	-0,100	0,782	1,745**	0,197	1,222*	1,004	1,854**	2,297***
ΔCON_{t-3}	0,782	2,550***	-	0,126	0,046	1,257*	0,638	1,669	1,418*	1,330**
ΔCON_{t-4}	-	2,124**	-	-0,126	-	0,423	0,297	1,142	0,764	-
ΔCON_{t-5}	-	0,291	-	-1,391*	-	-1,041*	-0,744	-0,803	-0,629	-
ΔCON_{t-6}	-	-	-	0,115	-	-	0,711	-	-1,029*	-
ΔCPI_{t-1}	-0,582	-3,162**	-0,248	-3,98***	-2,382*	-2,230*	-1,247	-4,83***	-1,596	-0,521
ΔCPI_{t-2}	-0,034	0,445	-0,326	-0,520	-1,196	0,580	-0,971	0,449	0,958	-1,287
ΔCPI_{t-3}	-0,629	-1,874	-	0,084	0,526	-1,328	-0,948	-2,632	-1,734	-0,630
ΔCPI_{t-4}	-	1,539	-	-2,002	-	-0,501	0,488	-0,736	2,366*	-
ΔCPI_{t-5}	-	-2,074	-	-3,76***	-	-1,073	-0,931	-2,314	-2,608**	-
ΔCPI_{t-6}	-	-	-	1,210	-	-	2,210*	-	1,093	-
ΔNIP_{t-1}	-0,443**	-0,448*	0,263	-0,083	-0,50**	0,073	-0,270	-0,477	-0,409**	-0,307
ΔNIP_{t-2}	-0,246	-0,076	0,156	0,163	-0,308	-0,075	-0,261	-0,122	-0,079	-0,132
ΔNIP_{t-3}	-0,041	-0,140	-	0,064	-0,016	-0,080	-0,162	-0,183	-0,100	0,162
ΔNIP_{t-4}	-	-0,016	-	0,441*	-	0,140	-0,121	0,599**	0,393*	-
ΔNIP_{t-5}	-	-0,250	-	0,000	-	0,049	0,004	-0,165	-0,127	-
ΔNIP_{t-6}	-	-	-	-0,030	-	-	-0,068	-	-0,272	-
Constant	-0,007	-0,010	0,007	0,019	-0,006	0,009	-0,002	-0,006	-0,003	-0,005
R2	0,211	0,358	0,141	0,357	0,319	0,275	0,344	0,315	0,436	0,237
Adj. R2	0,083	0,166	0,051	0,125	0,209	0,072	0,107	0,110	0,232	0,115
Obs.	181	179	182	178	181	179	178	179	178	181

VIII. VAR models – Impulse response analysis

Figure 8: The response of INDEX to one standard deviation shock in selected macroeconomic variables (VAR models)

		INDEX	NIB	SP	EX	OIL	CONS	CPI	NIP
OSE25	1	1,06 %	-0,38 %	1,41 %	0,65 %	-0,12 %	0,68 %	-1,45 %	-0,20 %
	6	-1,11 %	-0,85 %	-0,49 %	0,36 %	-0,64 %	0,61 %	0,02 %	0,32 %
	12	-0,08 %	-0,34 %	0,02 %	0,11 %	0,24 %	-0,39 %	-0,02 %	0,28 %
	24	0,07 %	0,03 %	-0,04 %	-0,06 %	0,00 %	0,03 %	-0,01 %	-0,05 %
	48	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
OSE35	1	-0,23 %	-0,52 %	1,04 %	0,48 %	-1,03 %	0,31 %	-0,84 %	0,18 %
	6	0,08 %	-0,63 %	0,16 %	0,43 %	0,09 %	0,35 %	-0,15 %	-0,28 %
	12	0,03 %	-0,15 %	-0,14 %	0,13 %	-0,17 %	-0,25 %	0,02 %	0,14 %
	24	0,01 %	0,02 %	0,01 %	0,00 %	0,00 %	0,00 %	0,01 %	0,00 %
	48	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
OSE40	1	0,90 %	0,47 %	0,92 %	-0,06 %	0,06 %	1,05 %	-0,52 %	-0,62 %
	6	-0,38 %	-0,45 %	-0,32 %	0,66 %	-1,25 %	0,59 %	0,64 %	0,38 %
	12	0,20 %	-0,20 %	0,10 %	-0,10 %	0,15 %	-0,09 %	0,11 %	0,32 %
	24	0,05 %	0,09 %	0,01 %	-0,06 %	0,03 %	0,02 %	-0,01 %	0,00 %
	48	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
OSE50	1	1,04 %	-1,91 %	1,28 %	0,05 %	-0,17 %	1,61 %	-0,64 %	-0,98 %
	6	0,16 %	-0,32 %	-0,61 %	0,24 %	-0,55 %	-0,63 %	-0,24 %	-0,31 %
	12	-0,08 %	-0,31 %	-0,22 %	0,34 %	-0,10 %	-0,26 %	0,19 %	0,36 %
	24	-0,06 %	0,00 %	0,00 %	-0,03 %	0,01 %	-0,05 %	0,03 %	-0,02 %
	48	0,00 %	-0,01 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %

Notes: The impulse response functions of the VAR(p) models are utilized in order to analyse the short-run dynamics of the variables. Generally, only the the immediate response (step 1) caused by innovation is of interest because of the models transitory properties. The first column in figure 8 represents the given sector and the second column are forecasting months (step 1-48). Column 3-10 represents the effect of a shock in the selected variable. OSE25, OSE40 and OSE50 are VAR (6) models, while OSE35 is represented by a VAR (5). Model specification for each sector were based on diagnostic test (details omitted here).