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**To Grow or not to Grow under
Macroeconomic Uncertainty
– the case of the European oil industry**

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Abstract

Title	To Grow or not to Grow under Macroeconomic Uncertainty – the case of the European oil industry
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Authors	Jonas Hellström, Lucas Mynde, Ken Söderman
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Five Key words	Macroeconomic risk exposure, internal cash flow, growth, oil industry, multiple regression
Purpose	To investigate the predicted relation between macroeconomic risk exposure and growth in the context of the European oil industry.
Methodology	Multiple regression analysis
Theoretical Perspectives	Macroeconomic uncertainty, Financial constraints, The hierarchy of Finance, Fundamentals of hedging
Empirical Foundation	225 observations have been included to determine a beta coefficient of -2.83 corresponding to the influence that macroeconomic risk exposure has on firm growth, defined as the alteration in total assets. In combination with the control variable “size”, macroeconomic risk exposure explain approximately 40 percent of the growth rate among oil producing firms in Europe.
Conclusions	Strong empirical support to the hypothesis regarding the relationship between macroeconomic risk exposure and firm growth is found, where macroeconomic risk exposure has a negative impact on growth within the European oil industry.

Sammanfattning

Titel	To Grow or not to Grow under Macroeconomic Uncertainty – the case of the European oil industry
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Författare	Jonas Hellström, Lucas Mynde, Ken Söderman
Handledare	Jens Forssbaeck, Lars Oxelheim
Fem nyckelord	Makroekonomisk riskexponering, internt tillförda medel, tillväxt, oljeindustrin, multipel regression
Syfte	Att utröna det antagna sambandet mellan makroekonomisk riskexponering och tillväxt, tillämpat på den europeiska oljeindustrin
Metod	Multipel regressionsanalys
Teoretiska Perspektiv	“Macroeconomic uncertainty”, “Financial constraints”, Finansiell hierarki, Grundantaganden avseende hedging
Empiri	225 observationer genererar en negativ betacoefficient om -2.83, vilket motsvarar effekten makroekonomisk riskexponering har på företagets tillväxttakt, här definierad som den årliga förändringen av totala tillgångar. Tillsammans med kontrollvariabeln ”företagsstorlek” förklarar makroekonomisk riskexponering cirka 40 procent av tillväxten inom den europeiska oljeindustrin.
Slutsats	I enlighet med hypotesen avseende makroekonomisk riskexponering och tillväxt uppnås starka empiriska resultat för ett negativt samband mellan makroekonomisk riskexponering och tillväxt för europeiska oljeproducerande företag.

Wordlist

Barrel (BBL)	1 Barrel = 42 US gallons = 158,9873 liters
EIA	Energy Information Administration
Downstream	Transport, refining and petrochemical process of petroleum
ICE	InterContinental Exchange
IEA	International Energy Agency
IMF	The International Monetary Fund
IPE	International Petroleum Exchange, U.K. based
LNG	Liquefied Natural Gas
NYMEX	New York Mercantile Exchange, U.S. based
OECD	Organization for Economic Cooperation and Development
Offshore	Extraction of oil from any depth in the ocean
Oil	Petroleum; could refer to crude oil or the finished (refined) product
Onshore	Extraction of oil from fields on land
OPEC	Organization of the Petroleum Exporting Countries
Sour / Sweet Crude	Measure of the degree of sulphur content in a crude oil. Sour equals high sulphur, sweet low sulphur content
Upstream	Exploration, drilling and production of petroleum
Viscosity	Thickness of fluids
WTI	West Texas Intermediate (North America)

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1. Introduction

In this section, an introduction to the subject is presented as well as the purpose of the study. In addition, a briefing of related studies is provided

1.1 Problem discussion and working hypothesis

There is a consensus among financial economics literature as of late that there is a correlation between internal cash flow and investment expenditure.¹ The higher the business risk, i.e. the volatility in future expected returns of a company, the higher the cash flow sensitivity of investment. This is due to the significant difference between costs of external and internal capital faced by companies experiencing high cash flow volatility.² Investment is the source of growth, which is value creating as long as the return on new invested capital exceeds the firm's weighted average cost of capital.³ These findings imply that companies engage in expected profitable investment opportunities with subsequent growth as long as they are not subject to financial constraints.

A couple of decades ago, much of the economics literature did not recognize the availability of internal finance as an important investment factor. Instead, the level of investment was theoretically determined in a well-functioning capital market. The only relevant financial consideration to make was at which price firms could obtain funds for investment. This model of a "well-functioning" capital market neglected any taxes or transaction costs that might make one source of finance more expensive than another as well as neglecting any differences in the information available to decision-makers within the firm and to potential outside investors.⁴ However, contemporary research into the behaviour of markets characterised by imperfect information restore to the idea that external financing may only be available on less favourable terms, if available at all. The idea that external sources of

¹ Hovakimian & Hovakimian, 2009, p. 47

² *Ibid*, p. 48

³ (RONIC>WACC), Koller *et al*, 2005, p. 56-68

⁴ Bond & Meghir, 1994, p. 2

finance may be more expensive than internal sources is the foundation of the “pecking order” approach to corporate finance, which implicates that investment expenditure may be constrained by a shortage of internal funds.⁵ This phenomenon is referred to as the *underinvestment* problem.

Hence, it should be imperative for firms to maintain stable cash flows and profits in order to be able to engage in profitable investments. Recently, increased attention has been drawn to the relationship between individual firm performance and changes in macroeconomic price variables. In particular, the work of scholars Lars Oxelheim & Lars Wihlborg should be mentioned, as they stress the importance of conducting sensitivity analysis to multiple, (correlated) macroeconomic price variables when implementing a risk management strategy on a specific firm.

If there is indeed correlation between macroeconomic risk exposure and firm performance on the one hand, and a correlation between internal funds and investment on the other, there should also be a linkage between macroeconomic risk exposure and growth rate. This notion forms the theoretical hypothesis of the study.

The purpose of the present study is to test above outlined hypothesis in the context of the European oil industry;

“Is there a relation between macroeconomic risk exposure and growth in the European oil industry?”

1.2 Arguments for the oil industry

Several characteristics and features in the oil industry make it suitable indeed for the purpose of the present study. Overall, the industry is highly exposed to different aspects of uncertainty. Moreover, the performance and value of oil producing firms is to a large extent driven by commodity prices, making any macroeconomic effects unlikely to be diluted by

⁵ Bond & Meghir, 1994, p. 3

marketing, product diversification or consumer preferences. This suggests the relevance of studying the impact of macroeconomic price variables on firms operating in the oil industry.⁶

First, more than any commodity, historically there has been high volatility in oil-prices. In particular, the last five years have seen extreme fluctuations where the 70 percent drop between July 2008 and mid December 2008 marks the biggest drop ever in such a short time period. Naturally, such fluctuations pose problems for price taking oil producing firms, greatly increasing the volatility of expected returns. Oil prices are highly sensitive to overall, global economic performance and trends. IMF estimates an unexpected decrease in global economic growth of one percent to decrease the oil price by approximately 10 percent. This is much due to the fact that oil-intensive industries such as manufacturing, construction and transportation are very sensitive to unfavourable economic conditions. Furthermore, in the short run, the oil price-sensitivity of demand and supply tends to be low, resulting in greater price-fluctuations than normally would have been required in order for demand and supply to meet. This inefficiency is mainly caused by subsidies on oil-related products in developing countries.⁷ Since the oil price is sensitive to global macroeconomic factors, the oil industry is deemed to be highly vulnerable to global economic turmoil such as the Asian crisis of the 90's, the aftermath of September 11 and the current economic crisis.

Second, oil producing firms are dealing with a depleting resource base⁸, forcing them to continuously engage in exploration activities in order to stay in business. Again, these activities are aligned with a very high grade of uncertainty. As described in *The Politics of the Global Oil Industry* (2005), "Even after numerous geological tests, only one out of ten wells contains oil and only one out of hundred successful test-wells holds a commercial amount of oil. Once a major field has been discovered, it generally takes several years to develop the first shipment of crude oil".⁹

Third, exploration and oil production is very capital intensive, adding to the overall risk profile of the industry. As an example, for every dollar of value added GDP there was USD8

⁶ Boyer & Filion, 2006, p. 429

⁷ www.di.se, 2009-03-27

⁸ Sadorsky, 2001, p. 18

⁹ Falola & Genova, 2005, p. 8

of capital invested in the Canadian petroleum products¹⁰ industry in 1993. The same figure was USD2.6 for the manufacturing industry.¹¹ Capital intensity indicates sensitivity to interest rate fluctuations.

Finally, there is basically no space for product differentiation in a commodity industry such as the oil industry. This fact increases the comparability between firms within the industry.

1.3 Previous research

Among others, a couple of studies concerning the sensitivity of oil stock returns to commodity prices and macroeconomic price variables will be presented below. These are interesting since the present study also will use stock price as depending variable in a multifactor econometric model. Furthermore, studies on the effect of hedging in the oil and gas industry are also included in this section. The results of these studies are also interesting, if it is assumed that hedging decreases the sensitivity of the firm to macroeconomic risk exposure, and thus stabilising internal cash flows.

Mohn & Misund (2009) test the impact of industry uncertainty and market turbulence on total investment expenditures in the oil and gas industry, covering 170 companies over the period 1992-2005. They calculate two different measures of aggregate uncertainty. The first is the volatility of overall stock market returns, “measured as the annualised standard deviation of daily returns on the S&P500 index”¹² of the US stock market. They refer to this measure as “overall financial market uncertainty – or macroeconomic uncertainty”¹³. In order to capture industry specific uncertainty, they also include a corresponding volatility measure for the crude oil price. Both measures show highly significant and robust effects on investments, where “an increase in financial market volatility of 1 percentage point will reduce the average investment rate by 2.7 percentage points, according to the estimated

¹⁰ *Nota Bene*, this may include refining as well, which is especially capital intensive.

¹¹ Sadorsky, 2001, p. 19

¹² Mohn & Misund, 2009, p. 242

¹³ *Ibid*

model”¹⁴, and “(...) an increase in oil price volatility of 1 percentage point will reduce the average investment rate by 1 percentage point”¹⁵. These are short term effects, but in terms of oil price volatility, the following result was found; “(...) the lagged effect of oil price volatility takes a positive sign, and is higher in magnitude than the contemporary effect. The implication is that a permanent increase in oil price volatility of one percentage point will increase the average investment rate by 4.1 percentage points”¹⁶. Also, they find that a simultaneous, persistent increase of 1 percentage point in both volatility indicators will produce a lasting positive impulse to investment rates of 1.4 percentage points.¹⁷ These findings are related to theories of real options, where the results could be interpreted as oil companies engaging in capital intensive exploration activities, but deferring the extraction process until overall conditions are more favourable.

Another interesting study was conducted by Boyer & Filion (2006), where they use a multifactor model to evaluate and quantify the variations of Canadian oil and gas stocks with regard to common and fundamental factors. Their data consists of 105 Canadian oil and gas companies, of which 99 are plain producers and 6 are integrated firms. The time frame stretches from 1995-2002. The common factors used in their model are interest rates, Canadian exchange rate with the USD, market return, oil prices, and natural gas prices. The fundamental determinants are fluctuation of proven reserves, volumes of production, debt level, operational cash flows, and drilling success.¹⁸ The authors anticipate that all fundamental factors should have a positive impact on oil and gas stock returns. Finally, they also analyze whether the same results holds for pure producer firms and integrated firms respectively.¹⁹

Regarding the common factors, Boyer & Filion find that “the stock price return of oil and gas producers increases when the market return, the oil price return and the natural gas price return increase, and when the interest rate and the exchange rate returns decrease”²⁰.

¹⁴ Mohn & Misund, 2009, p. 245

¹⁵ *Ibid*

¹⁶ *Ibid*

¹⁷ *Ibid*

¹⁸ Boyer & Filion, 2006, p. 429

¹⁹ *Ibid*, p. 434

²⁰ *Ibid*, p. 438

In contrary to producers however, the results imply that integrated firms are significantly positively affected by a depreciation of the Canadian dollar. Moreover, crude oil prices have significantly less impact on integrated companies compared to producers. The latter finding is likely explained by their vertical integration.²¹ This logic is more closely explained by Erik Gustafsson, oil analyst at Carnegie, as he speaks of natural hedges if the company is engaged in both oil production and refinery activities; (freely translated) “If the crude oil price is high, the oil producing part of the company will benefit from it while the profitability of the refinery part will diminish since its main input is crude oil. The other way around holds when the oil price is low”²². Likewise, Boyer & Filion explain how integrated firms may benefit from a depreciating Canadian dollar with the refinery activity; “Indeed, Canadian refinery firms would obtain a cost advantage over American refineries following a weakening of the Canadian dollar. If integrated firms can distribute their products south of the border or prevent American firms from exporting to Canada, Canadian integrated firms that own refineries would benefit from a depreciation of the local currency”²³.

Concerning fundamental factors, the authors find that cash flow is consistent with the perception that “operational cash flows are an important and relatively cheap source of financing. In addition, the use of internal cash flows offers more financial flexibility, lowers financial risk, and allows firms to invest in new developments and to acquire other companies”²⁴. Also, the beta for proven reserves is consistent with expectations as they are likely to reduce operational risk, allowing production increases and appreciation of firm assets. However, the beta for production turns out significantly negative, which is surprising and a bit contradictory.²⁵ Again, a possible explanation could come from the real options theory, where firms hold options on the assets of the firm to expand when the timing is right. Then, it is possible that “an increase in production signifies that the firm has exercised its options so that risk is reduced and return should be reduced as well”²⁶. This assumption is probably aligned with the interesting results made by Mohn & Misund, where they found a

²¹ Boyer & Filion, 2006, p. 439

²² www.di.se, 2009-03-26

²³ Boyer & Filion, 2006, p. 441

²⁴ *Ibid*, p. 446

²⁵ *Ibid*

²⁶ *Ibid*, p. 449

positive relationship between consistent volatility in oil price and investment rates, as described above.

Similar research has been conducted by Sadorsky (2001), using monthly data covering the period 1983:4 – 1999:4 where oil price shares are measured using the Toronto Stock Exchange (TSE) oil and gas index.²⁷ His results also conclude that exchange rates, crude oil prices as well as interest rates, each have large and significant impacts on stock returns in the Canadian oil and gas industry. The coefficient on the exchange rate variable, measured as $\$/\US , is negative,²⁸ and Sadorsky elaborates on this finding as follows “(...) somewhat unexpected given that a lower Canadian dollar helps Canadian energy exports. To obtain a negative sign on the exchange rate variable, a depreciation of the domestic currency must increase firm’s costs by more than it increase revenues”²⁹.

In their study “Firm value and Hedging: evidence from U.S Oil and Gas producers”, Jin & Jorion (2006) confirm that hedging with derivatives against oil and gas prices reduces the stock price sensitivity to these variables.³⁰ They also conclude that the extension of hedging is correlated with company size.³¹ Based on this result, they proceed by testing if the market value is positively affected by the presence of hedging, where market value is measured as different definitions of Tobin’s Q. Hence, they compare different Q values between companies that hedge and do not hedge. Interestingly, they find “no support to the hypothesis that hedgers have higher Q ratios than nonhedgers for oil and gas firms”³². In addition, they add several control variables to their model. Only one of these, “investment growth”, has a strong and consistent effect across all Q-ratio measures. More logically, “investment growth is significantly positively related to Q across all models, indicating that firms with more investment opportunities are valued with higher Q ratios, as expected”³³.

²⁷ Sadorsky, 2001, p. 21

²⁸ As it was for “producers” in the Boyer & Filion (2006) study.

²⁹ Sadorsky, 2001, p. 25

³⁰ Jin & Jorion, 2006, p. 896

³¹ *Ibid*, p. 905

³² *Ibid*, p. 915

³³ *Ibid*

A possible explanation to the lack of correlation between hedging and firm and market value lies in the nature of commodities, such as the price of crude oil. It should be relatively easy for investors both to identify and hedge against the oil price and thus hedging by the firm does not add any value compared to what investors could hedge by their own.³⁴

Haushalter (2000) presents another hedging related study, applied on 100 North American oil and gas companies between 1992 and 1994. Foremost, his tests find that “The fraction of production hedged is positively related to the differences in financial leverage, measured as the ratio of total debt to total assets, and it is greater for oil and gas producers classified as having little financial flexibility (...)”³⁵, which would support theories that corporate risk management contributes to alleviating financial contracting costs. Second, he finds a positive correlation between the decision to hedge and total assets, as did Jin & Jorion previously, which indicates that companies may face economies of scale in hedging.³⁶

Finally, Lin *et al* (2007) examine the interaction between hedging, financing and investment decisions. It is not specifically applied on the oil industry. Nevertheless, their empirical results are interesting; suggesting hedging to be positively related to investment and leverage, while investment is negatively related to leverage.³⁷

To summarize the research outlined above, Mohn & Misund’s study is interesting since it relates to macroeconomic uncertainty and investment decisions in the oil and gas industry. Rather than looking at the financial constraints issue however, they take on an investment appraisal perspective in their research, while the present study aims to capture the importance of internal funds in order to be able to invest and obtain growth. The studies on the Canadian oil and gas industry confirm that stock returns are sensitive to macroeconomic uncertainty and commodity price fluctuation, while the hedging-related articles imply that this sensitivity could be alleviated through the means of hedging. It is also concluded that larger oil and gas firms hedge more, which could imply that lower macroeconomic risk exposure generates growth opportunities in accordance with the hypothesis set initially. Lin

³⁴ Jin & Jorion, 2006, p. 915

³⁵ Haushalter, 2000, p. 107-108

³⁶ *Ibid*, p. 108

³⁷ Lin *et al*, 2007, p. 1581

et al also make the interesting conclusion that hedging is correlated to investment and leverage, while leverage is negatively correlated to investment. This finding underpins the importance of stable cash flows and internal funding, especially in the context of a, to the nature, risky business environment.

Much of the previous research relates to the purpose of the present study, but to the knowledge of the authors, no previous work has explicitly focused on the relationship between macroeconomic risk exposure and growth. Furthermore, little or no attention has been attributed to the European oil industry, which adds to the relevance of the study.

1.4 Disposition

The present study is divided into seven sections. Section 2 provides a general background presentation of the oil industry. In section 3, the theoretical framework will be considered more thoroughly and in section 4, the methodological approach of the study is presented. In section 5, several assumptions are considered as well as the data analysed in the econometric models. Section 6 provides with the empirical findings obtained from the study and finally, section 7 concludes what these findings imply.

1.5 Delimitations

The present study is limited to European based oil producing companies, for which macroeconomic exposure and growth is measured during the period 1999 to 2009. It is predicted that the accounting standards within Europe are more homogenous, motivating the exclusion of non-European oil producers.

Political risk has deliberately been ignored since the present study is restricted to determining the impact of *macroeconomic* risk exposure. Moreover, the relationship between macroeconomic risk exposure, investments and *capital structure* has not been tested since this would require fundamental analysis of the companies with subsequent

market valuation of their respective debt obligations. This is not reckoned as motivated since the procedure is proven to be complicated as well as not being a part of the primary purpose of the present study.

2. Industry background

In this section, a general introduction of the oil industry is presented

2.1 General introduction

The modern oil industry is dated back to 27th of August 1859 when Mr. Edward Drake drilled for oil in Titusville in Pennsylvania, USA. Oil has developed for these last 150 years to become the most important commodity in the world. The world economy is highly affected by the movements on the oil markets. Fossil fuels (coal, oil and gas) accounts for approximately 80 percent of the total world energy supply, with oil as the independently most important source of energy.³⁸ According to IEA the global oil demand is expected to grow by an annual average of 1.6 percent per year until 2030, where the majority of the increase in demand comes from developing countries.³⁹ Many think of oil as the source of transportation fuel, but it is also used for heating, electricity and is in some form included in many everyday products.

The process to get the oil from the field to the customer is said to include four major phases; production, refining, transporting and marketing. The first step, production, also includes exploration and drilling and is referred to as the *upstream* of petroleum. This is the part of the process that the companies in the present study to a large extent is involved in. In opposite, *downstream* means the petrochemical process, refining, and transportation of oil to the end consumer. Oil is classified in terms of viscosity and weight (heavy, medium and light). Another important measure is the amount of sulphur and other impurities that has to be removed from the crude oil. Sour crude oil is the term used for a sulphur content of 0.6 percent or more, and sweet is said to contain 0.5 percent or less. Sour, heavy oil results in a more expensive and time consuming process extracting and refining it.⁴⁰

³⁸ <http://www.spi.se/fprw/files/omolja.pdf>, 2009-05-18

³⁹ <http://www.iea.org/Textbase/nppdf/free/2007/Findings.pdf>, 2009-05-18

⁴⁰ Fattouh, 2007, p. 7-10

2.2 OPEC and world oil supply

OPEC was founded in 1960 by Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. Between 1961 and 1975 Algeria, Ecuador (suspended 1992-2007), Gabon (suspended 1994), Indonesia (suspended 2009), Libya, Nigeria, Qatar and United Arab Emirates joined the organization. Angola was added as a member in 2007. The head quarter is located in Vienna, Austria since 1965.⁴¹

OPEC's missions are summarized in below quote taken from its homepage:

“OPEC's mission is to coordinate and unify the petroleum policies of Member Countries and ensure the stabilization of oil markets in order to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers and a fair return on capital to those investing in the petroleum industry.”⁴²

The largest oil deposits are located in Middle East, around the Caspian Sea, Alaska, southern USA, Mexico, northern South America and North- and West Africa. The majority of the crude oil imported to Sweden comes from deposits in the North Sea, primarily belonging to the United Kingdom and Norway. Almost 40 percent of the world's crude oil production comes from the OPEC countries. Other major oil producing nations are USA, Canada, Russia, Norway and United Kingdom.

OPEC has an objective to limit the oil production to keep the price within a certain range. This is to make sure the OPEC countries and their state owned oil companies receive stable revenues.⁴³ OPEC's ability to affect the world price is questioned. With 72 percent of the worlds proven crude oil reserves, OPEC obviously has the ability to restrict a large part of the total oil output.⁴⁴ IEA and EIA expect an increase in their market share and the dependency on OPEC oil, especially Middle Eastern oil, for the next two decades, which could increase

⁴¹ <http://www.opec.org/aboutus/history/history.htm>, 2009-05-19

⁴² <http://www.opec.org/home/>, 2009-05-19

⁴³ <http://www.spi.se/fprw/files/omolja.pdf>, 2009-05-18, p. 17-18

⁴⁴ Sheik Ahmad Fahad Al-Ahmad Al-Sabah, 2006, p. 1

the market power of OPEC. Despite this, Fattouh (2007) states that OPEC's pricing power varies over time and the changes can occur in both bull and bear market conditions. With a growing importance of the futures market as a price determinant of the oil price, OPEC's output policies has become more complicated since it is hard to influence the expectations in the futures market. Another reason to doubt OPEC's pricing power is its long-term investment capacity.⁴⁵

For oil producing companies and countries, the size and value of oil is in general discussed in terms of reserves. An estimation of the amount of crude oil that could be produced is made, and measured in barrels. Saudi Arabia holds the largest reserve in the world, with an approximate of 260 billion barrels. In order to include a field as a reserve in calculations, capital has to be allocated for the drilling.⁴⁶

2.3 Oil price and pricing system

Petroleum is always priced in USD per barrel. There are two major types of oil used as benchmark prices, namely "Brent Oil" (Brent) and "West Texas Intermediate" (WTI). Brent refers to oil of quality equivalent to the oil produced from an oilfield in the North Sea and is the most common in international trading.⁴⁷ The Brent Blend is sweet and contains 0.37 percent sulfur.⁴⁸ The WTI is the most frequent used in North America. Other examples are the OPEC basket for OPEC oil (mainly in Middle East) and "Nigerian Forcados" for Nigerian oil. The price difference between the different types is marginal, historically usually +/- 3 USD per barrel for Brent compared to WTI or the OPEC basket.⁴⁹

The control of the oil price has changed for the past 150 years. Until the formation of OPEC, the oil price was published by the international major oil companies (including Exxon, Mobil, Texaco, BP, Royal Dutch/Shell et al). Thereafter, the control shifted more and more from the

⁴⁵ Fattouh, 2007, p. 2

⁴⁶ Falola & Genova, 2005, p. 10

⁴⁷ *Ibid*, p. 66

⁴⁸ Fattouh, 2007, p. 8

⁴⁹ <http://www.spi.se/fprw/files/omolja.pdf>, 2009-05-18

companies to the oil-producing countries, represented by OPEC, due to their ability to control a large amount of the amount produced. Since the 1990s the pricing is more or less depending on worldwide supply and demand and is determined on exchanges, i.e. the NYMEX and IPE. Since 2005 it has also been traded electronically on the ICE. There is a traditional contract market, a spot market and the futures contract. On the futures market delivery and payment will take place in the future, usually the following month, which means that it is to a large content based on expectations. Thus, in a short and medium term horizon the oil price reflects the economic and political situation of the world market.⁵⁰ Other factors influencing the oil price includes quality (difficulty to refine), business cycle forecasts, reported reserves, season variations, weather and taxes. Another aspect is the exchange rate, since the oil always is sold in USD there is a risk vis-à-vis any other currency.⁵¹

For the period 1980 to 2000, the Brent price peaked at USD37 per barrel and noted its lowest level at USD13 per barrel, with an average of USD22 per barrel (measured in nominal values). The Brent crude oil futures price the previous 12 months peaked at USD147.27 per barrel in July 2008, and noted USD55.98 on 15th of May 2009.⁵²

The oil price development for the last ten years is displayed below in figure 1.

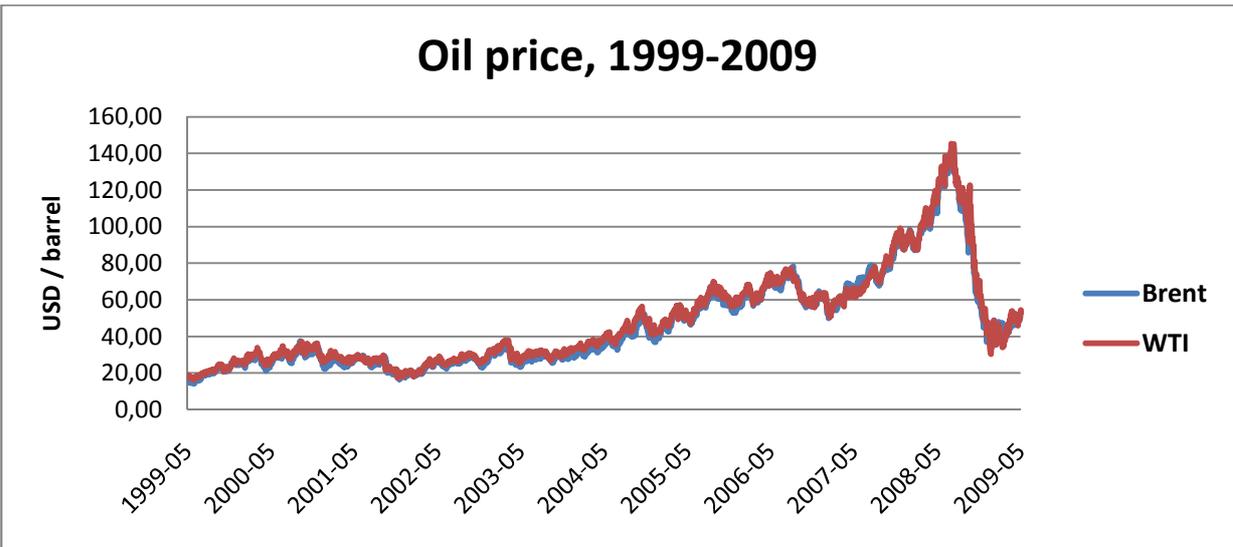


Figure 2.1. Oil price, 1999-2009 Source: <http://tonto.eia.doe.gov/dnav/pet/hist/rbrted.htm>

⁵⁰ Fattouh, Bassam, 2007, p. 15-17

⁵¹ <http://www.spi.se/fprw/files/omolja.pdf>, 2009-05-18

⁵² <http://www.energyeconomist.com/a6257783p/daily/graphs/spicb.gif>, 2009-05-19

2.4 Global oil shocks

The first oil shock that dramatically increased the oil price occurred in 1973. Oil producing countries, mainly OPEC-members, demanded a higher participation in the oil business at the same time as reserves seemed to be decreasing.⁵³ In addition, the political conflict in Middle East led to an oil embargo and consequently a price increase of Saudi Arabian oil, from USD7 per barrel in 1973 to reach USD25 per barrel in 1974.⁵⁴

The second large oil crisis occurred in 1979 due to political instability in Middle East. The consequence of this instability can be exemplified by the decrease in Iranian oil supply from 6 Million bbl per day to less than 500 000 bbl per day, following the Iranian revolution and the Iran-Iraq war. The oil price increased almost 170 percent from USD13 to USD35 per barrel between 1979-1981.⁵⁵

In 1985 the prices started to fall dramatically. OPEC, and in particular the world's largest oil producing country Saudi Arabia, tried to stop this trend in an attempt to keep the price stable at around USD18 per barrel. They failed, and the price kept getting lower with the break-out of the Gulf War in 1990. From 1994, the price turned upwards, explained by a mixture of inflation and coordination of pricing among OPEC and non-OPEC countries.⁵⁶

2.5 Exploration and production

The exploration and production process of oil is in general very unpredictable. The industry is to a large extent built on trial and error. As explained in section 1, even after promising geological tests, only about one out of ten wells contain oil and the odds that the successful test wells contain enough oil to be developed into a commercial oil field is one to hundred. After the discovery of a major field, the first shipment of crude oil in general will not leave for several years. The exploration process requires a great amount of capital and time. The

⁵³ Falola & Genova, 2005, p. 70

⁵⁴ *Ibid*, p. 145

⁵⁵ *Ibid*, p. 146

⁵⁶ *Ibid*, p. 146-147

great value of oil still often makes it worth the uncertainty for the companies, but they take on much risk indeed.

The location where oil is extracted from is referred to as either onshore or offshore. The majority is produced onshore, but with an increasing share from offshore fields.⁵⁷

2.6 Oil as a finite resource

New oil is always naturally created, but the supply will continuously decrease. Eventually the exploration and development costs will exceed the benefit of the oil produced. For the last 150 years it has been said that the oil will last for another 30 years, but new deposits, new technology and better economical conditions means that the conventional oil reserves will last for at least another 75 years, according to *Svenska Petroleum Institutet*. The use of oil is always changing, but there are presently no economical, realistic options to replace the oil as the worldwide dominant source of energy.⁵⁸

⁵⁷ Falola & Genova, 2005, p. 8-10

⁵⁸ <http://www.spi.se/fprw/files/omolja.pdf>, 2009-05-18, p. 21

3. Theory

This section constitutes the theoretical framework of the present study

3.1 Macroeconomic uncertainty

No company in the world is large enough to control the macro economy. The performance of any given company, regardless of business or size, is still highly affected by any macroeconomic development, and it is thereby of great concern to the management or external stakeholders.⁵⁹

Risk is in general referred to as “(...) the magnitude and likelihood of unanticipated changes that have an impact on a firm’s cash flow, value or profitability”⁶⁰, and is associated with a negative outcome. Uncertainty is instead the word used if outcome could mean opportunities or drawbacks. There is commonly a further distinction of risk into systematic and unsystematic risk, with unsystematic defined as the risk that can be diversified away by increasing the number of assets in any portfolio.⁶¹

3.1.1 MUST-analysis

The Macroeconomic Uncertainty Strategy – MUST – developed by Oxelheim & Wihlborg, can be applied from two perspectives, the forward- and backward-looking way. The forward-looking part refers to exposure measuring and risk management, while backward-looking “filters out” macroeconomic developments from profits to analyze the historical core

⁵⁹ Oxelheim & Wihlborg, 2008, p. 3

⁶⁰ *Ibid*, p. 16

⁶¹ *Ibid*, p. 18

company performance.⁶² The filtered result, without impact from macroeconomic generated noise, is the best indicator of the firm's competitiveness.⁶³

The MUST analysis can briefly be summarized in three steps⁶⁴, where the first step involves an assessment of the macroeconomic price variables most likely to be affecting the firm's cash flow. Step two consists of a cash flow sensitivity analysis to each of these variables and step three is formulating a risk management strategy based on the previous steps.⁶⁵

3.1.2 Variables

According to Oxelheim & Wihlborg, relative *exchange rates*, relative *interest rates* and relative *inflation*, in competition with other market price variables, are the major explanatory factors that jointly can explain most macroeconomic shocks.⁶⁶ An important implication of the MUST analysis is that such variables need to be considered simultaneously. In particular, exchange rates, interest rates and inflation rates are not independent since they are influenced by the same macroeconomic conditions and policies.⁶⁷ If exchange rate, interest rate and inflation rate are correlated as expected, they need to be considered in a multiple regression analysis, since this will solve any overlapping problems.⁶⁸

Moreover, there is the misconception that interest rates only influences the financial costs of a firm, not taking into account the effects the variable has on aggregated demand in an economy. This notion is also corrected by the means of the MUST analysis.⁶⁹ In addition,

⁶² Oxelheim & Wihlborg, 2008, p. 12-13

⁶³ Oxelheim, 1999, p. 73

⁶⁴ Please be advised, this is a much simplified review of the elements of the MUST-analysis. For a complete coverage, please be referred to Oxelheim & Wihlborg, 2005, p. 263-265

⁶⁵ Oxelheim & Wihlborg, 2005, p. 263-265

⁶⁶ Oxelheim & Wihlborg, 2008, p. 218

⁶⁷ Oxelheim & Wihlborg, 2005, p. 70

⁶⁸ Oxelheim & Wihlborg, 2008, p. 77

⁶⁹ Oxelheim, 1999, p. 69

there is the uncertainty regarding changes in the “political regime” in the countries where the company is present, referred to as the *political risk*.⁷⁰

Depending on purpose and econometric limitations, different independent variables can be chosen. Using pre-determined variables that is expected to give a high explanatory value is preferred if the purpose is to explain as much total variability as possible.⁷¹ There are two alternative formulations to approach macroeconomic exposure; either via changes in the macro policy, or the market price variables. The latter has the benefit of being easier observable and is applicable if the development is independent of events in the macroeconomic environment.⁷²

Some of the possible measures that can be used as dependent variables in a regression of macroeconomic variables are cash flow, economic value or book value.⁷³ Historical cash flow requires figures on a quarterly frequency for at least five years, preferably divided by product line, geographical market, currency etc.⁷⁴ A more easily observable dependent variable to measure macroeconomic exposure against is the share price of the company. The stock-market value is the market value of a company’s total assets subtracted by the market value of debt. The exposure to the stock-market value is not independent of financial decisions and hedging decisions and consequently should values and returns be adjusted for effects on financial positions in different currencies and effects of interest rate changes with different maturities, in order to use it as a proxy for the company’s cash flow-generating assets. However, for an outsider, proper information to correct the stock market values is generally hard to obtain.⁷⁵

⁷⁰ Oxelheim, 1999, p. 69

⁷¹ Oxelheim & Wihlborg, 2008, p. 93

⁷² *Ibid*, p. 83

⁷³ *Ibid*, p. 90

⁷⁴ *Ibid*, p. 221

⁷⁵ *Ibid*, p. 85-86

3.2 Capital structure

Based on the assumption of perfect markets and perfect competition, Modigliani & Miller (1958)⁷⁶ argues that the capital structure of the company is irrelevant in the perspective of the shareholder. However, this assumption presumes that the expected rate of return equals the required rate of return and a world with no transaction costs or taxes. Under these assumptions an increased level of debt means more capital to invest at the (higher) rate of return. With a higher debt ratio, the expected rate of return on equity will rise, and these increases are assumed to exactly even out. This implies that the capital structure is irrelevant for the value of the company.⁷⁷

This is summarized in three propositions developed by Modigliani & Miller and presented by Arnold (2005):⁷⁸

- The total value of any company is independent of its capital structure
- The expected rate of return on equity increases proportionately with the gearing ratio
- The cut-off rate of return for new projects is equal to the weighted average cost of capital – which is constant regardless of gearing

In contrast to above theory, Ward (2002) points out the relevance of capital structure under more realistic assumptions. Firstly, there is the positive correlation between risk and return, where a higher level of perceived risk (“volatility in future expected returns”) requires for an increased return rate of return. The total risk can be divided into two parts, the *business* (industry) *risk* and the *financial risk*. The total, combined, level of risk perceived by investors is what determines the required rate of return. Depending on the stage in the life-cycle, the company’s financial risk should be adjusted to fit the present level of business risk. A heavy leveraged firm with high business risk will have an impending risk of default. Despite the

⁷⁶ Through Ward, 2002, p. 8

⁷⁷ Ward, 2002, p. 8

⁷⁸ Arnold, 2005, p. 974-977

collapse risk, shareholders might invest in the stock since the potential upside might be very attractive. This implies that it is the lenders, who will gain nothing of the potential excess profits (only interest payments, which are fixed), who should be careful with high combined (business and financial) risk companies. Consequently, high business risk firms should be financed primarily by equity.

On the other hand, at a stage with low business risk and stable cash flows, the company could take up more debt and let the shareholders benefit from higher leverage and a lower cost of capital, in particular since the interest payments is tax deductible. It should be noted that stronger emphasis on debt financing occurs at the *maturity* state of the firm according to the one product business-cycle model provided by Ward. This implies that there are restricted opportunities of reinvesting profits into the current business. If companies cannot reinvest profits at the rate of return demanded by shareholders, these funds should rather be paid out as dividends in order to maximize shareholder value.⁷⁹

3.3 Pecking order or the hierarchy of finance

As a continuation of the theory of capital structure and financial gearing, there is the idea of pecking order (or “the hierarchy of finance”), which is defined by Arnold (2005) as follows:

“Pecking order theory – firm’s exhibit preferences in terms of sources of finance. The most acceptable source of finance is retained earnings, followed by borrowing and then new equity issues”⁸⁰.

With availability of potentially profitable investments, the company will try to finance them by retained earnings (previous year’s profits). If the internal funds are not sufficient, the firm will approach the capital markets, firstly the debt market and as a last option issue new stock. A new issue of shares is supposed to be as a sign of problem within the company. The information asymmetry between managers and external stakeholders implicates that

⁷⁹ Ward, 2002, p. 10

⁸⁰ Arnold, 2005, p. G:22.

managers within the company will only issue new shares when they find the share price overvalued, unless being under financial constraints.

In addition, there is another argument for why internal funds are preferable; managers are said to choose type of financing by following a line of least resistance. Using retained earnings means no contact with outside investors, which is associated with “wasted” time and costs trying to attract external capital. The administrative costs are an important aspect in favor of retained earnings, before debt capital and the most costly option, newly issued shares.⁸¹

Bond & Meghir (1994) support this notion, stating that external finance (debt or new share issues) is a more expensive alternative compared to internal finance from retained profits. This is explained by tax effects (dividends vs. capital gains for the shareholder), transaction costs involved in raising external financing and the information asymmetries between insiders and outsiders.⁸²

3.4 Hedging

In light of the hierarchy of finance, the marginal cost of external financing may be increasing for debt and equity financing respectively due to imperfections in the capital markets. A shortage of internal funds then results in either higher cost of capital or underinvestment problems. However, corporate risk management and hedging can “help coordinate investment and financing policies and thus harmonize the need and availability of funds”⁸³. Hedging reduces the influence that external sources of financing may have on firm investment decisions by reducing the likelihood that the firm faces a shortage in cash flow.⁸⁴

⁸¹ Arnold, 2005, p. 985

⁸² Bond & Meghir, 1994, p. 4

⁸³ Bartram, 2000, p. 313

⁸⁴ Froot *et al*, 1993, p. 1647

Theory says that financial risk connected to changes in foreign exchange, interest rate and commodity price changes exist because international parity conditions such as Purchasing Power Parity and the International Fisher Effect hold, at the best, in the long run.

In practise, shareholders could hedge against these risks themselves, but statistics indicate a significant increase in hedging activities among firms as well as an increased awareness with regard to macroeconomic price variables and their impact on company performance.⁸⁵

As explained above, unsystematic risk can be diversified away according to the portfolio theory. If exchange rates, interest rates and commodity price changes are unsystematic then, they are not compensated with a positive risk premium in CAPM (the capital asset pricing model). In this scenario, the cost of capital can only be decreased from risk management performed by the company if major shareholders are unable to hedge themselves, or only at a higher cost.⁸⁶

Since systematic risk cannot be diversified away, hedging against financial risks that are systematic would entail a movement along the Security Market Line to the left with a reduced beta as a result (reduced risk and reduced expected return). However, the CAPM (together with the Modigliani & Miller propositions) is based on the somewhat unrealistic assumption of perfect capital markets. Therefore, it seems more rationale to measure the impact of corporate risk management in terms of cash flow rather than cost of capital (discount rate), where corporate risk management is expected to reduce the volatility of cash flow and lower variance of firm value.⁸⁷

⁸⁵ Bartram, 2000, p. 313

⁸⁶ *Ibid*, p. 295-296

⁸⁷ *Ibid*

4. Methodology

In this section, the methodical approach of the study is presented

4.1 Statistical method

The macroeconomic exposure is measured through a multiple regression. The regression model used is a classical one, with one dependent variable and several independent variables. The dependent variable's movement over the years is sought to be explained by the independent variables movements. The part of the dependent variable's movement that cannot be explained by the independent variables is explained by an error term, the residual.⁸⁸

$$y_i = \beta_1 + \beta_n x_{ni} + e_i$$

Where:

y_i = the dependent variable

β_1 = the intercept

β_n = the beta of an independent variable

x_n = the value of an independent variable

e_i = the error term

i = a set of observations

An estimator is often characterized by three traits. *Unbiased* means that the estimator is on average correct in its estimation of the dependent variable. It does not mean that $E(\bar{x})$ equals \bar{x} of the population, rather it will come closer on average with an increasing amount of samples. Many estimators are unbiased, so the estimator chosen should be the most efficient (best) one. *Efficiency* means that the estimator has the least variance in its

⁸⁸ Damodar, 2006, p. 138

estimates, compared to other models. *Consistency* means that the probability of an accurate estimation increases with an increased number of observations in the sample.⁸⁹

The fit of the model is calculated using ordinary least squares (OLS). In order for OLS to be the best linear unbiased (BLUE) regression, a number of assumptions must hold for the data used.⁹⁰ This is known as the Gauss-Markov theorem.⁹¹ If these assumptions do not hold, this would not only mean that there are better regression models to explain the behavior of the dependent variable, but also that all inference and conclusions made from the regression would risk having bias or being incorrect.

The assumptions that must hold in order for OLS to be BLUE are the following.⁹²

1. $y_i = \beta_1 x_1 + \beta_n x_{ni} + e_i$
2. $E(e_i) = 0$, the expected value of the error term e_i is 0.
3. $\text{Var}(e_i) = \sigma^2$ for all observations.
4. $\text{Cov}(e_i, e_j) = 0$ unless $i = j$.
5. The independent variables are not random and take at least two values.
- (6.) $e_i \sim N(0, \sigma^2)$ The error term e_i has a normal distribution.

The first assumption is that the dependent variable can be explained by a linear function with an intercept, explaining variables and an error term. Assumption (2) means that on average estimations of y are expected to be correct. Anything else would mean a systematic error in the model. If assumption (3) holds, the variance for e_i is the same for all observation, i . This means that the variance does not depend on an independent variable or similar. This is called homoscedasticity, while the opposite is known as heteroscedasticity. Assumption (4) says that if any error term e_i shows a covariance with another error term e_j , the data suffers from autocorrelation. Assumption (5) aims to ascertain that the sample includes data which makes it possible to separate effects from being random and being a

⁸⁹ Damodar, 2006, p. 110

⁹⁰ *Ibid*, p. 113

⁹¹ *Ibid*, p. 174

⁹² *Ibid*

result of an independent variable. Simply put, an independent variable must take more than one value in the sample to be explanatory, less it be a constant.⁹³

The central limit theorem (CLT) says that regardless of the parent distribution (the distribution of the population), the distribution in the sample will regress towards a normal distribution with the mean of the population and a variance divided by the number of observations N .⁹⁴

$$\bar{x} \sim N(\mu, \sigma^2/N)$$

This is why assumption six is in parenthesis; regardless of the parent distribution, inference can be made by making the sample large enough. How quickly this is achieved depends on the form of the parent distribution.⁹⁵

In the second step company growth is explained by macroeconomic exposure and size of the firm in a similar fashion to the theories listed above. However, as the data is structured as unbalanced panel data the model is expected to suffer both from heteroskedasticity in cross-sections and autocorrelation over time. These “spherical disturbances” causes the OLS to no longer be BLUE.⁹⁶ Heteroskedasticity violates assumption three, while autocorrelation contradicts assumption four. In order for our inference to be correct, the OLS regression model needs to be converted into a generalized regression model (GLS). An example of these procedures is presented in appendix 1 and 2 (this operation is automatically performed by EViews.)

4.2 Practical method

The present study is done in two steps. In step one, adjusted R^2 -values are subsequently calculated for every two year period on a rolling basis, i.e. for the years 1999-2001, 2000-

⁹³ Damodar, 2006, p. 174-175

⁹⁴ Greene, 2000, p. 116

⁹⁵ *Ibid*

⁹⁶ *Ibid*, p. 220

2002 and so on. These two-year-based adjusted R^2 :s determine how big the companies' exposure was over the corresponding years, where high adjusted R^2 -values indicate high exposure. In the second step, the companies' growth during the years is compared to the amount of exposure suffered.

The optimal time period for measuring each company's exposure is set to 1999-2009. As recent figures as possible are preferred, and a time period shorter than 10 years would result in an insufficient number of observations. However, companies that have been listed on their respective exchange later than 1999 have been measured from their introduction date. For the regression during the years 1999-2009, a typical company regression is made up of approximately 2600 observations per variable. Similarly, a two year regression consists of about 520 observations. All calculations are made in EViews 6.0 for both steps respectively.

4.2.1 First step

As explained above, to the extent of availability, daily data for the last ten years has been used for these multiple regressions. All observations have been logarithmized in Excel 2007, using $\ln(x_{t+1}/x_t)$, to avoid problems with non-stationary variables and making the change in stock price comparable between companies.⁹⁷ The only output from regression one used for step two is the adjusted R^2 . Using the adjusted R^2 and not the ordinary R^2 facilitates the comparison of exposure between companies with different variables and takes into account the decreased number of degrees of freedom when having multiple explaining variables in the regression.⁹⁸

⁹⁷ Damodar, 2006, p. 246-254

⁹⁸ *Ibid*, p. 229

This is the regression model used for step one:

$$Stockprice_{company} = \beta_1 + \beta_2 * Oil_{Brent} + \beta_3 * Oil_{WTI} + \beta_4 * IR_{3\ month} + \beta_5 * IR_{1\ year} + \beta_6 * IR_{10\ years} + \beta_7 * Alu_{LME99,7\%} + \beta_8 * ER_{Domestic\ currency/USD} + \beta_9 * Inflation + e_i$$

Where:

IR = Interest Rate

ER = Exchange rate

Alu = Aluminium Price

e_i = Error term

4.2.1.1 Negative values

The fact that some of the values are negative is not of importance as it is the relation between them that that is important. This is, as mentioned above, caused by the compensation for the lost degrees of freedom. Excluding these observations would not only cause a loss of data but also a truncation of the data which would lead to bias.

4.2.1.2 Heteroskedasticity, autocorrelation and multicollinearity

Precautions are taken by examining the residual distribution, checking for heteroskedasticity and autocorrelation. Some of the regressions show signs of autocorrelation in the Breusch-Godfrey Serial Correlation LM test.⁹⁹ However, the coefficients for these auto correlated residuals are very small, and very few of them are significant on a 5% probability-level. For an example, see appendix 3.

Since multicollinearity often is a problem in these types of regressions, it is worth mentioning that this source of error has been ignored. Multicollinearity makes it harder to interpret the *coefficients* of different variables, but as the only value observed is the adjusted R^2 , this is ignored.¹⁰⁰

⁹⁹ EViews 6.0 User's Guide I, p. 27

¹⁰⁰ Damodar, 2006, p. 368

4.2.2 Second step

The final regression aims to explain the companies' growth, which differs both on a year to year basis, as well as between companies. A *panel data* regression is suitable, as observations vary both in the time series dimension as well as in the cross-section dimension.¹⁰¹

This is the regression model used for step two:

$$Growth = \beta_1 + \beta_2 * Adj. R^2 + \beta_3 * Size + e_i$$

4.2.2.1 Definition of growth and errors-in-variables

In the present study, growth is defined as the yearly change in total assets. This measure has been calculated by using $\ln(1 + (x_{t+1}/x_t))$, where x represents total assets. In accordance with “the successful efforts model” (see 5.1.2), it is assumed that only oil wells that are proven successful are noted as assets in the balance sheet, which would give the most correct estimator for growth in this case. Sales, defined as number of barrels sold per year, could have been an option to define growth, but would most likely result in an incorrect estimation since oil companies may choose to defer its sales due to low oil prices. However, these deferred sales (defined as reserves) would still be taken up as assets by the companies, which will be covered by the approach applied in the present study. The adjusted R^2 :s are altered by taking $\ln(1 + Adj. R^2)$, to smoothen out the scale and make the values more evenly distributed. Adjusting the data by adding a constant does not affect our inference.¹⁰² As these adjusted R^2 :s are estimated, this gives rise to problems with errors-in-variables. Errors-in-variables is defined as when the dependent, or as in this case the explanatory variable, is observed with error. This is why the adjusted R^2 :s are based on two-year periods, by including a higher number of observations the risk of errors in estimates is decreased.

¹⁰¹ Damodar, 2006, p. 5

¹⁰² Westerlund, 2005, p. 178

4.2.2.2 Adding the control variable “size”

In addition, a company’s growth is expected to be dependent on its size and hence, “size” has been included as a control variable. This variable is logarithmized and then added as an independent variable in the regression. This means that the variable helps explaining what fluctuation in the dependent variable is caused by the adjusted R^2 variable.¹⁰³

4.2.2.3 Matching exposure and growth

In this regression, yearly data is used for 33 companies, and the total sample amounts to a total of 225 observations. The estimated adjusted R^2 between 1999:5 and 2001:5 is compared to the growth between 31st December 2000 and 31st December 2001, the macroeconomic exposure between 2000:5 and 2002:5 is matched to the growth between 31st December 2001 and 31st December 2002 etc. After trial-and-error, this matching has given the best result, with maximum number of observations included in the panel data regression. It is assumed that there is a certain delay between the macroeconomic exposure and the growth in total assets. The data has been arranged as unstructured panel data in EViews 6.0. Arranging it as balanced panel data would have allowed adding effects for both cross-sections and time. However, with the data available, this would decrease the number of observations from 225 to ~80 as not all companies have data for all time periods.

4.2.2.4 Autocorrelation and heteroskedasticity

With this type of data, symptoms of both autocorrelation and heteroskedasticity are expected. Tests show that both types of disturbances might be present. However, as the data is unstructured, EViews is unable to correct for both errors simultaneously. EViews correct these errors by adding fixed effects, either for cross-section disturbances or period disturbances. The fixed effect is created by EViews by adding a dummy variable which alters the intercept differently for each company. The symptoms for heteroskedasticity are thereby removed.

¹⁰³ Damodar, 2006, p. 347

The model is commonly known as the least squares dummy variable model (LSDV) and is presented below:¹⁰⁴

$$y_i = \mathbf{D} * \beta_1 + \beta_n x_{ni} + e_i$$

Where:

D = a dummy variable which is calculated separately for each company depending on observations.

The symptoms of heteroskedasticity are caused because the independent variables “size” and “R²” are differently distributed depending on which company the observations belong to. This is unavoidable since the companies differ in size and have different exposure depending on their operations.

The likelihood for these effects being added by chance is then tested in EViews and the results are shown in appendix 4 and 5. Both disturbances show a low likelihood of being randomly added; however the test for period effects shows a higher probability of this error, and thus they are more likely to be incorrect. Also, as cross-section observations are 33 in comparison to 10 years in the period equivalent, we can expect the heteroskedasticity effect to be bigger than the effect for autocorrelation. Furthermore, the model with cross-sections fixed effects gives a better result. The regression with fixed time-effects is presented in appendix 6. After adding cross-section fixed effects, the model has yet again been estimated using a number of different specifications, including “Whites cross-section”, “Whites period” and “Period weights” covariance methods without any apparent differences compared to the original result (please refer to appendix 7, 8 and 9).¹⁰⁵ The model is therefore interpreted as fairly robust. In terms of autocorrelation, it is not possible to correct for these errors or comment on them as the same residual tests are not available for panel data. However, the effects of autocorrelation on the estimated coefficients are expected to be modest.¹⁰⁶

¹⁰⁴ Greene, 2000, p. 560

¹⁰⁵ Damodar, 2006, p. 414

¹⁰⁶ Greene, 2000, p. 582

5. Data

In this section, several assumptions are considered as well as a presentation of the data-input processed in the econometric models

5.1 Assumptions

Several assumptions need to be made regarding the choice of data and variables for the econometric models. Also, certain assumptions are required in order to interpret the results.

5.1.1 RONIC and WACC

According to economic theory, abnormal returns for companies will eventually diminish, leading to a RONIC (Return On New Invested Capital) equal to WACC (Weighted Average Cost of Capital). For companies with sustainable competitive advantage however, RONIC is expected to be higher than WACC and thus value creating.¹⁰⁷ It is assumed that the companies included in this research continue to invest until RONIC equals WACC.

5.1.2 The successful efforts method

It is assumed in the present study that “(...) only cost incurred from the exploration of *successful* oil wells are *capitalised* and included on the firms’ balance sheets”¹⁰⁸. This assumption is in accordance with the FASB, 1982 accounting principle.¹⁰⁹ Moreover, companies are not allowed to include reserves for which no money to drill has been allocated¹¹⁰, and it is believed that the sample companies act accordingly.

¹⁰⁷ Koller *et al*, 2005, p. 278-279

¹⁰⁸ Mohn & Misund, 2009, p. 243

¹⁰⁹ Financial Accounting Standards Board, 1982, p.25

¹¹⁰ Falola & Genova, 2005, p. 10

5.1.3 Independent variables

In previous research, indexes have been used as a proxy for macroeconomic variables, which imply that it should be satisfactory to exclude indexes if multiple, individual macroeconomic variables are included instead. In contrast, it is assumed that this approach will give an even more accurate estimation of firm macroeconomic risk exposure.

Furthermore, fundamental analysis has not been conducted on each of the sample companies. It has been argued for above, that the oil industry is relatively homogenous to its commodity based nature, limiting any endogeneity problem. As such it is assumed that the industry- and firm specific variables are equivalent to a large extent. Naturally, firm specific variables do exist, but no deeper analysis of each company is made as this probably would lead to some form of bias, finding an unequal amount of the true exposure each company undoubtedly has. Nevertheless, it is assumed that the common macroeconomic price variables affect all companies and cover the major macroeconomic risk exposure for all companies. Hence the results should be highly comparable.

5.1.4 Dependent variable

Despite apparent flaws discussed above, the daily stock price of each company will be used as a proxy for cash generating assets, due to the lack of the availability of consistent cash-flow data. Also due to lack of information, these values have not been adjusted for effects on financial positions in different currencies and effects of interest rate changes with different maturities.

It is assumed that the company is valued fairly by the market, according to present value of future operations or similar.

5.2 Independent variables

The variables used are interest rates; 3 months, 1 year and 10 years, the USD exchange rate, the inflation rate, oil prices for Brent and WTI standards, and the price of aluminum. As argued before, exchange rates, interest rates and inflation rates all have a significant effect on any business. Contrary to previous studies, these essential variables will be properly considered simultaneously. Oil- and aluminum prices are reckoned as industry specific.

All interest rates are domestic for each company as well as the nominator for the USD exchange rate and inflation rates. Interest rates are sought to be indicators for economic up and downturns as well as increased or decreased cost of debt, aluminum is needed in large amounts for oil production, and the market price of oil and USD price is expected to have a large impact on the companies' revenues.

All below mentioned variables, except inflation rate, are noted on a daily basis. The inflation rate is in general published only on a monthly basis, and is therefore converted into daily observations to match the other variables in the regression. The modification is performed in Microsoft Excel 2007 according to the following formula:

$$\pi_{dt} = \pi_m + \frac{(\pi_{m+1} - \pi_m)}{T * t}$$

Where:

π_{dt} = Estimated inflation at time (day) t

π_m = Actual inflation at time (month) m

π_{m+1} = Actual inflation at time (month) m+1

T = Total number of trading days of month

t = Trading day

5.2.1 Commodities, general for all companies

Europe Brent Spot Price FOB (Dollars per Barrel)

EIA Sourcekey RB RTE, First observation 1999-05-04¹¹¹

OK WTI Spot Price FOB (Dollars per Barrel)

EIA Sourcekey RWTCD, First observation 1999-05-04¹¹²

LME-Aluminium 99.7% Cash U\$/MT

Datastream code LAHCASH~U\$, First observation 1999-05-04¹¹³

5.2.2 Macro variables, EU-zone specific

Exchange rate, EUR/USD

Datastream code ECURR\$, First observation 1999-05-04¹¹⁴

Interest rate, 3 month (Euribor)

Datastream code Y03728, First observation 1999-05-04¹¹⁵

Interest rate, 12 month (Euribor)

Datastream code Y10056, First observation 1999-05-04¹¹⁶

Interest rate, 10 year (Euro Area Govt. Bond)

Datastream code EURGLTB, First observation 1999-05-04¹¹⁷

Inflation rate, (EJ PPI NADJ)

Datastream code EJPROPRCF, First observation 1999-05-04¹¹⁸

¹¹¹ <http://tonto.eia.doe.gov/dnav/pet/hist/rbrted.htm>, 2009-05-11

¹¹² <http://tonto.eia.doe.gov/dnav/pet/hist/rwtcd.htm>, 2009-05-11

¹¹³ Datastream, 2009-05-11

¹¹⁴ *ibid*

¹¹⁵ *ibid*

¹¹⁶ *ibid*

¹¹⁷ *ibid*

¹¹⁸ *ibid*

5.2.3 Macro variables, Norway specific

Exchange rate, NOK/USD

Datastream code MSERNOK, First observation 1999-05-04¹¹⁹

Interest rate, 3 month (Norway Interbank)

Datastream code S97789, First observation 1999-05-04¹²⁰

Interest rate, 12 month (Norway Interbank)

Datastream code S97792, First observation 1999-05-04¹²¹

Interest rate, 10 year (Norway Benchmark Bond)

Datastream code S06770, First observation 1999-05-04¹²²

Inflation rate, (NW PPI NADJ)

Datastream code NWPROPRCF, First observation 2000-01-15¹²³

5.2.4 Macro variables, Russia specific

Exchange rate, RUB/USD

Datastream code CISRUB\$, First observation 1999-05-04¹²⁴

Interest rate, 3 month (Russia Interbank)

Datastream code RSIBK90, First observation 1999-05-04¹²⁵

Interest rate, 12 month

No data available in Datastream. No other sources found. Variable excluded.

Interest rate, 10 year (Russia Govt. Bond Yield)

Datastream code Y74884, First observation 2003-02-11¹²⁶

Inflation rate, (RS PPI NADJ)

Datastream code RSPROPRCF, First observation 2001-01-15¹²⁷

¹¹⁹ Datastream, 2009-05-11

¹²⁰ *Ibid*

¹²¹ *Ibid*

¹²² *Ibid*

¹²³ *Ibid*

¹²⁴ *Ibid*

¹²⁵ *Ibid*

¹²⁶ *Ibid*

¹²⁷ *Ibid*

5.2.5 Macro variables, Sweden specific

Exchange rate, SEK/USD

Datastream code MSERSEK, First observation 1999-05-04¹²⁸

Interest rate, 3 month (Sweden Treasury Bill)

Datastream code S06156, First observation 1999-05-04¹²⁹

Interest rate, 12 month (Sweden Treasury Bill)

Datastream code S06165, First observation 1999-05-04¹³⁰

Interest rate, 10 year (Sweden Govt. Bond Yield)

Datastream code S02088, First observation 1999-05-04¹³¹

Inflation rate, (SD PPI NADJ)

Datastream code SDPROPRCF, First observation 1999-05-04¹³²

5.2.6 Macro variables, UK specific

Exchange rate, GBP/USD

Datastream code UKDOLLR, First observation 1999-05-04¹³³

Interest rate, 3 month (UK Treasury Bill)

Datastream code S02162, First observation 1999-05-04¹³⁴

Interest rate, 12 month (UK Sterling Certs.)

Datastream code S20552, First observation 1999-05-04¹³⁵

Interest rate, 10 year (UK Govt. Yield Bond)

Datastream code S02090, First observation 1999-05-04¹³⁶

Inflation rate, (UK PPI NADJ)

Datastream code UKPROPRCF, First observation 1999-05-04¹³⁷

¹²⁸ Datastream, 2009-05-11

¹²⁹ *Ibid*

¹³⁰ *Ibid*

¹³¹ *Ibid*

¹³² *Ibid*

¹³³ *Ibid*

¹³⁴ *Ibid*

¹³⁵ *Ibid*

¹³⁶ *Ibid*

5.3 Dependent variable

The selection of companies included in the present study is based on the following prerequisites:

- Major part of business engaged in upstream oil (exploration, development and/or production of oil).
- Sales >0 for at least 3 consecutive years.
- European based, publicly listed on a European stock exchange.

SubSea Oil & Gas Directory¹³⁸ lists oil and gas exploration and production companies. In combination with the “sector: Oil & Gas Producers” in the database Thomson Datastream¹³⁹ it has been used as the source for company selection and collection of financial information such as historical, daily stock prices, net sales, total assets etc. Further information on each individual company has been collected from their respective internet homepage. Detailed company information is referred to appendix 10 and 11.

Hundreds of oil companies are being evaluated, and in the final sample 33 European listed companies are included. Most companies that are excluded were recently launched, show zero sales during the period and/or are not directly involved in the core exploration and production of oil. For example, the Danish Atlantic Petroleum had no sales 2006 and 2007, and no figures for 2008 were official at the time of data collection.¹⁴⁰ Russian based Gazprom OAO has some minor oil production, but is more focused towards production and sales of natural gas.¹⁴¹ The A.P. Moller-Maersk Group includes the oil producer “Maersk Oil”, but since the group’s core activity is within various forms of the shipping business, the stock price is not a good proxy for Maersk Oil’s business and is therefore excluded.¹⁴²

¹³⁷ Datastream, 2009-05-11

¹³⁸ <http://www.subsea.org/equipment/exploration+and+production/listcat.asp>, 2009-04-25

¹³⁹ <http://www.datastream.com/>

¹⁴⁰ <http://www.petroleum.fo/APPortal/DesktopDefault.aspx?tabid=109>, 2009-05-14

¹⁴¹ Datastream, 2009-05-04

¹⁴² <http://www.maerskoil.com/en/AboutMaerskOil/Pages/AboutMaerskOil.aspx>, 2009-05-14

In particular, problems finding data for the Russian interest rates for the earlier years have decreased the number of observations for the Russian companies. Similarly, many of the smaller companies have only been operational for a few years. Nonetheless, these observations have helped in making an adequate analysis.

5.4 Data source and collection

All quantitative data has been collected from the database Thomson Datastream Advance on the 4th of May 2009 (except where otherwise stated). Consequently, this data is secondary. Data for the dependent variable (stock price) is noted on a daily basis until 4th of May 2009 (the first observation for each individual company is referred to appendix 10 and 11). The stock price collected from Datastream is adjusted for corporate actions such as dividends, splits etc.

The information used for “Previous research” and “Theory” is derived from published articles and books. The articles are collected from the electronic database ELIN@Lund.

5.5 Criticism of the sources

Thomson Datastream is the world’s largest source of financial information, and performs regular accurate inspections to secure the reliability. Datastream is commonly used as a source of information for financial reports and is used by many major corporations and institutions worldwide, and is thereby considered as a very reliable source.

Articles from ELIN@Lund are published scientific research and as such are assumed to be relevant sources of information and trustworthy in the sense that they have been conducted in an appropriate, scientific way.

5.5.1 Validity

The first step when performing a valid study is to secure that the desired phenomenon actually is measured.¹⁴³ In this case, the question is if the tests actually measure the relationship between macroeconomic exposure and growth. Parallels and comparisons to previous studies will increase the validity. In addition, since no previous research has had the specific approach practiced in the present study, no direct comparison is easily made, which would have confirmed the validity of the present study. In general, a problem when comparing with studies done in other countries is the differences in accounting standards and time period.

5.5.2 Reliability

To guarantee a high reliability, the study should be performed in an accurate and trustworthy way.¹⁴⁴ If the research was done again, the result should be equivalent. The quantitative data is collected from one source, Datastream, which is generally very reliable, but to secure a high accuracy, random figures has been compared with the original source (sales and total assets from companies' annual reports, stock prices from the official exchange where they are noted etc). No discrepancies were found. Figures from annual reports have been reviewed by independent auditors, and should be trustworthy. However, since all data is of secondary nature, there is a risk of inaccuracy which is out of the authors' control. The time period of (up to) ten years and daily observations will give a large number of observations. This will take different business cycles into account and give a high precision. In addition, using an estimated result as the definitive explaining variable could suffer from poor statistical accuracy. This has been discussed more thoroughly in section 4.2.2.1.

The well recognized Microsoft Excel 2007 and EViews 6.0 have been used to process all data and perform all regressions.

¹⁴³ Jacobsen, 2000, p. 259

¹⁴⁴ *Ibid* p. 417

In order for external parties to review the reliability of the present study, all steps and decisions in the process are clearly stated throughout the report. However, the sheer size of the combined data and the multiple procedures in the methodology makes it impossible to include all observations and regressions in appendix. For example, one regression consists of 2600 observations per variable, which makes the total number of observations for one regression 23 400. In total, there are 258 of these regressions.

6. Results / Analysis

In this section, the empirical findings obtained from the study are presented

6.1 First step

Below, figures 6.1-6.3 show the adjusted R^2 :s for the sample companies. The values usually range from about \sim -1% to +25%. The fact that some of the values are negative is not of importance as it is the observed fluctuation that is important. The more negative adjusted R^2 :s, the less they are thought to explain the movements of the dependent variable.

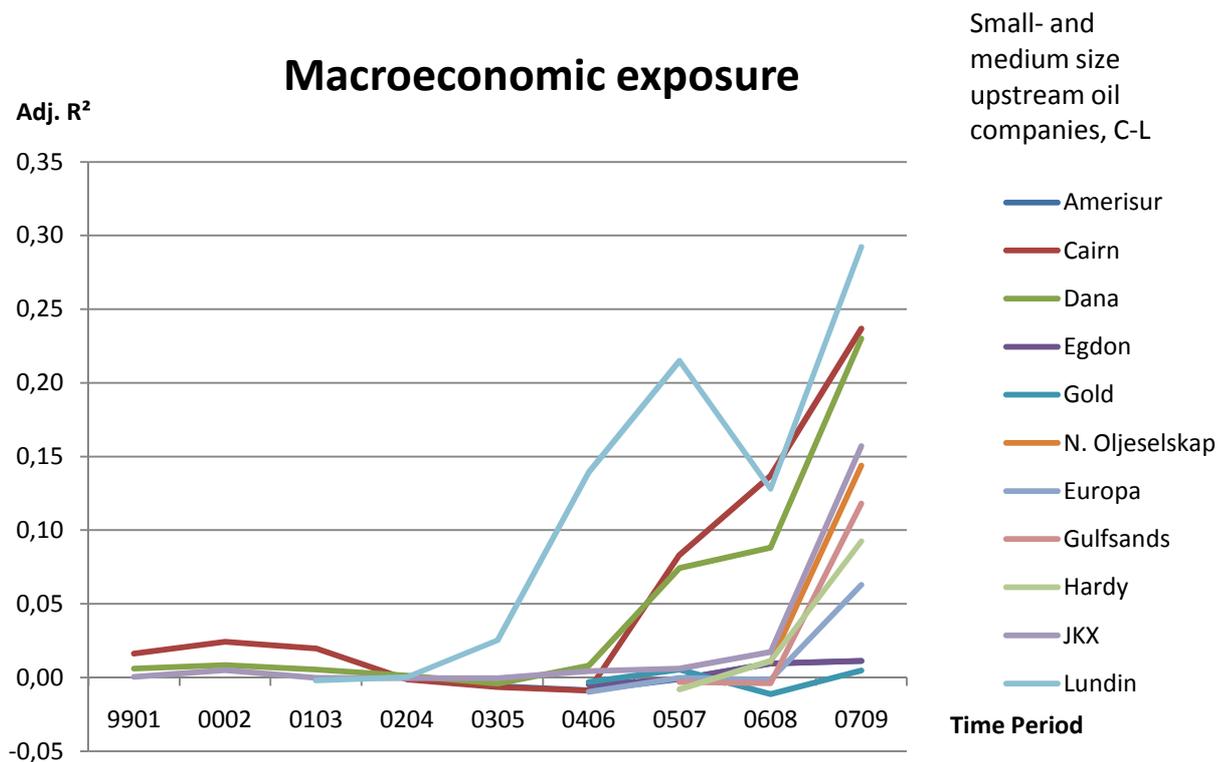


Figure 6.1. Macroeconomic exposure for small- and medium size companies

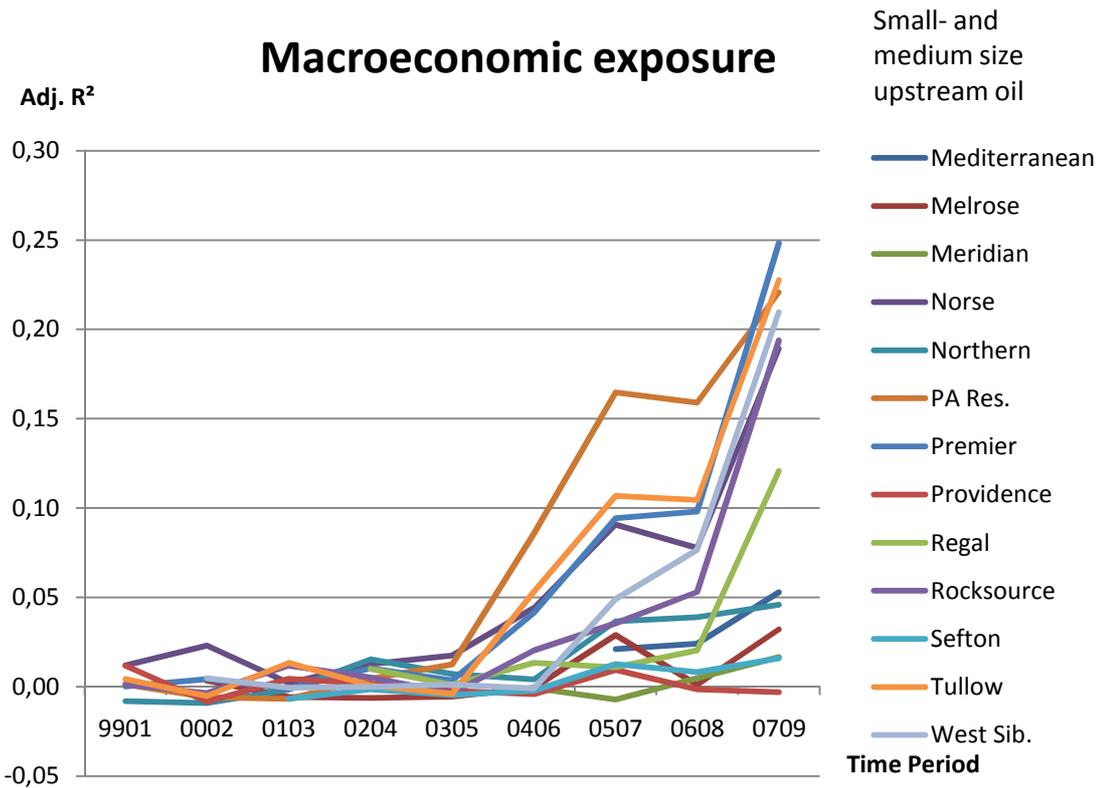


Figure 6.2. Macroeconomic exposure for small- and medium size companies

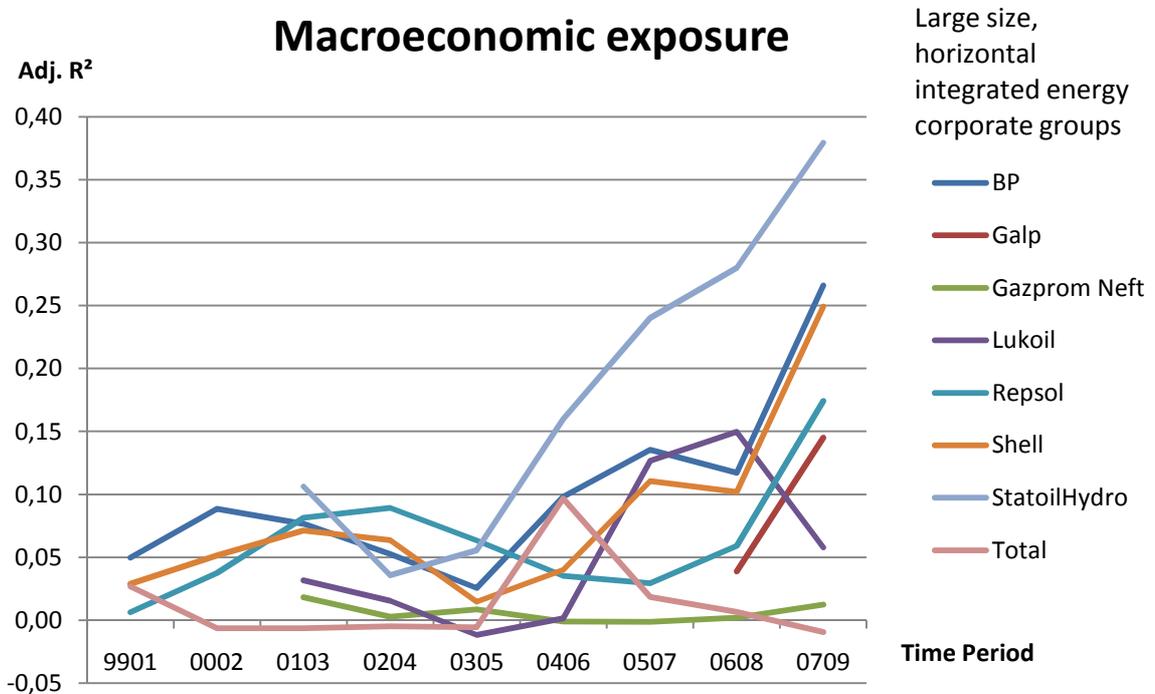


Figure 6.3. Macroeconomic exposure for large size companies

As displayed in the diagrams, the notion of oil companies being very sensitive to global, financial turmoil is supported. Although company specific discrepancies are observed, there is a very strong tendency of increased exposure as of late. This is likely to be caused by increased general uncertainty translated into extensive volatility in the macroeconomic price variables measured. This trend is reckoned to be linked to the subprime crisis and its impact on the global economical environment.

Interestingly, roughly half of the companies show increased exposure from 2003 and onward. Simultaneously, the invasion of Iraq was initialized and the crude oil price began a steady rise until the beginning of 2007. This is assumed to be partly explained by a decrease in total supply due to diminishing outputs from the region affected by the war.

In figure 6.3, results for firms defined as large are displayed. It can be concluded that these firms show less consistent trends vis-à-vis the smaller firms, as well as between themselves. To exemplify, only half of these firms seem to experience increased exposure from the outbreak of previously mentioned subprime crisis. This could be interpreted as these firms having a natural operational hedge due to their integrated firm structure, i.e. engaging in upstream and downstream activity. These multinational firms are also expected to enjoy substantial presence throughout large parts of the world, which also suggests less exposure.

6.2 Second step

In figure 6.4 the results from the final regression is presented.

Dependent Variable:	GROWTH			
Method:	Panel Least Squares			
Date and time:	05/30/09 22:55			
Sample:	1998 2008			
Periods included:	11			
Cross-sections included:	33			
Total panel (unbalanced) observations:	225			
GROWTH=C(1)+C(2)*R2+C(3)*SIZE				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1) - Constant	-2.475007	0.474325	5.217952	0.0000
C(2) - Macroeconomic Exposure (Adj. R ²)	-2.826964	0.774170	3.651605	0.0003
C(3) - Size of Company (Total Assets)	0.233536	0.034661	6.737815	0.0000
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.466614	Mean dependent var	0.704389	
Adjusted R-squared	0.371166	S.D. dependent var	0.479067	
S.E. of regression	0.379896	Akaike info criterion	1.044196	
Sum squared resid	27.42097	Schwarz criterion	1.575589	
Log likelihood	-82.47204	Hannan-Quinn criter.	1.258668	
F-statistic	4.888673	Durbin-Watson stat	1.900701	
Prob(F-statistic)	0.000000			

Figure 6.4 Final regression, results

Despite the discussed shortcomings with the usage of stock price as the dependent variable in step one, as well as the possible presence of errors-in-variables in the two step approach utilized, the results are too significant to be ignored. With a beta coefficient for the Adj. R²-variable equalling -2.83 and an adjusted R² of almost 40 percent, the possibilities of simple coincidence are genuinely slim. The result supports the working hypothesis to an even larger extent than expected and as such it is considered very satisfying.

More explicitly, the result suggests that an increase in macroeconomic uncertainty corresponding to one percent would halter firm growth by almost 2.83 percent.

Furthermore, the positive beta aligned with the control variable "size", is interpreted as

companies growing relatively faster the larger they become. This is also somewhat interesting and will be further discussed below. Nevertheless, the result implicates that the two variables jointly explain approximately 40 % of firm growth in the European oil industry, with the major influence assumed to be derived from macroeconomic risk exposure. Hence, the present study achieves its purpose by finding empirical support to the hypothesis on macroeconomic risk exposure and growth.

The standard error of the independent variables is relatively small (0.774 for macroeconomic risk exposure and 0.035 for size respectively) in comparison to the estimated coefficients. The probability for both independent variables shows an extremely high significance in their explanatory power with values close to zero. The same is true for the complete regression, as the Prob(F-statistic) also show a value tending to zero.

6.2.1 Residual distribution of final regression

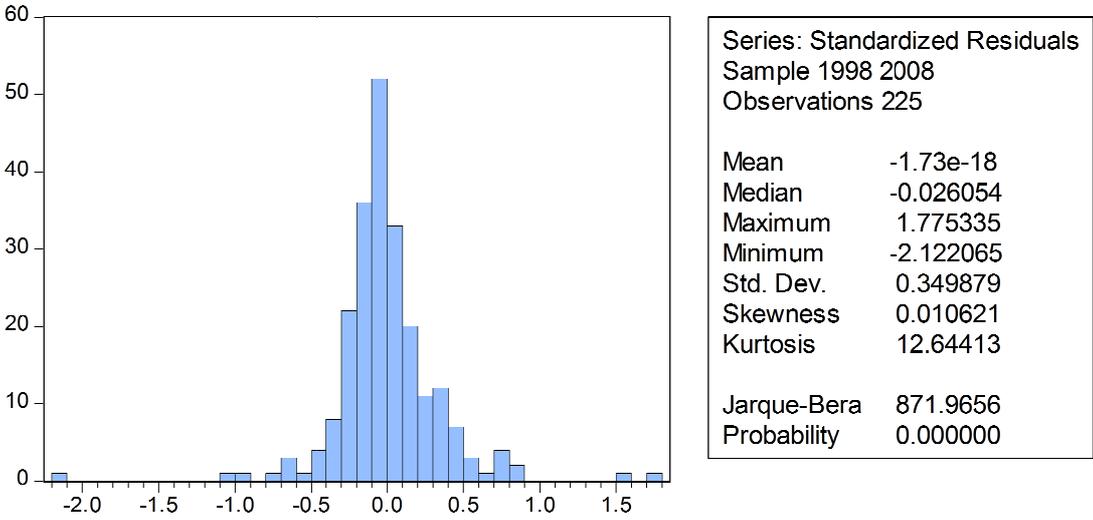


Figure 6.5 Final regression, residual distribution

When looking at the residual distribution in the final regression, we see that they have a skewness of 0.0106 and a kurtosis of 12.6441. This indicates that the mean is close to being normally distributed. However, there is a clustering of observations in the middle meaning that the betas observed in the regression would prove stronger in reality. The probability values for each independent variable also support this. Outliers can be observed, but EViews cannot use weighted estimations when including fixed effects in the regression. These values are however supposed to have a limited impact.

7. Conclusions

This section concludes what the empirical findings imply, as well as suggestions for future research

7.1 Our findings

The first regression performed in this study finds strong support of the sensitiveness of European oil companies to macroeconomic risk exposure. This renders the oil industry very suitable for this research, which is well in line with the assumptions and arguments set in the introduction. The findings are further supported by the research on the Canadian oil & gas industry conducted by Boyer & Filion (2006) and Sadorsky (2001) respectively. The similarities in results also support the theory of the oil industry being homogenous, despite geographical variations.

Moreover, the result from the second step ultimately shows a strong and significant correlation between macroeconomic risk exposure and growth. As argued for above, it is believed that this is achieved through increased cash flow stability when exposed to less macroeconomic risk. From the onset, it has also been assumed that new investments are primarily dependent on internal funds. It is true that lower volatility in cash flows should lower firm beta, and thus lowering the cost of capital and increasing the availability of external funding. However, the hierarchy of finance always favours internal funding before external financing. Furthermore, Lin *et al* (2007) find negative correlation between investment and debt as well as increased leverage symbolizing less investment opportunities according to the theories of Ward (2002). Since capital structure has been beyond the scope of this study, it cannot be concluded that the higher investment rate obtained through lower macroeconomic risk exposure should be directly interlinked with internal financing. Nevertheless, with the support from empirical and theoretical sources, we insist on this standpoint, especially since the exploration business ought to be perceived as very risky from a lender's perspective.

Another interpretation of our findings would be that efficient hedging is highly motivated under the assumption that it results in lower macroeconomic risk exposure. We have already noted from the research of Jin & Jorion (2006) that hedging alleviates stock price sensitivity towards the hedged variables, and our results further confirms the rationale of hedging. Both Jin & Jorion (2006) and Haushalter (2000) also find a correlation between hedging and company size. Notably, we find a positive correlation between growth and size when using size as a control variable. Together with previously mentioned studies, this could indicate that firms experiencing lower macroeconomic risk exposure may benefit from economies of scale, and thus are able to grow at a higher rate. This is interesting since traditional growth theories suggest that it should be easier to achieve relative high growth the smaller the company. Figure 6.3 displayed above may shed light to this phenomenon, as we cannot observe as apparent trends to macroeconomic risk exposure for large size companies compared to smaller firms. According to our theory then, these firms face lower exposure and consequently have greater investment and growth opportunities. Since the majority of the large firms in the data sample are integrated firms, they are more likely to benefit from natural operational hedges as they are engaged in both exploring and refining activities. Also, larger firms are expected to be less affected by financial constraints, in particular within the oil industry where any investment is expected to be very capital intensive. However, we should be aware of the possibility of diminishing returns related to size. In our study, growth is assumed to be value creating, but in reality the case may be different. This should be carefully considered when interpreting the correlation between size and growth.

In conclusion, we are willing to claim that we find strong empirical support to our hypothesis regarding the relationship between macroeconomic risk exposure and firm growth. We can also conclude that the oil industry proved to be a very motivated environment to test it on.

7.2 Future research

In terms of future research in the subject, we auspicate more accurate data, i.e. the utilization of cash flows in favour over stock price as the dependent variable. Most probably, this would entail that companies are required to provide internal information on quarterly cash flows, at least if the very same companies are to be included in the research.

We also encourage the discovery of other methods measuring the correlation between macroeconomic risk exposure and firm growth, preferably excluding the uncertainty related to using an estimated figure as explanatory variable.

It should be noted that Mohn & Misund (2009) find almost identical results concerning the relationship between market volatility and investments as we do with macroeconomic risk exposure and investments. Their beta coefficient for market volatility is -2.7, while our equivalent for macroeconomic risk exposure measures -2.83. As stated before, they have a forward looking investment approach in their study, while ours is backward looking. This implies that it is motivated to conduct an integrated study of these two approaches in order to achieve a *total* picture of the influence macroeconomic risk exposure has on investment and growth, covering all aspects of possible lagging effects.

It would also be interesting to apply our hypothesis in the context of another industry in order to further test its utility and relevance in the academic literature.

Finally, it seems motivated to examine and put greater emphasis on capital structure in future similar studies in order to investigate the accuracy of the argument stressing the importance of internal funding in relation to investments.

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Appendix

Appendix 1. Correction for heteroskedasticity

The conversion effectively transforms the heteroscedastic error terms into homoscedastic error terms, without reducing possible inference. A transformation assuming proportional heteroskedasticity is shown below (Westerlund, 2005, p. 177).

Variance assumed gives

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

Applied by dividing the OLS

$$\frac{1}{\sqrt{x_i}} y_i = \beta_1 \frac{1}{\sqrt{x_i}} + \beta_n \frac{1}{\sqrt{x_i}} + \frac{1}{\sqrt{x_i}} e_i$$

Defining

$$y_i^* = \frac{y_i}{\sqrt{x_i}}, x_{1i}^* = \frac{1}{\sqrt{x_i}}, x_{ni}^* = \frac{x_i}{\sqrt{x_i}}, e_i^* = \frac{e_i}{\sqrt{x_i}}$$

Ultimately gives

$$y_i^* = \beta_1 x_{1i}^* + \beta_n x_{ni}^* + e_i^*$$

This altering of data allows for inference, giving the estimated parameters the same meaning as before (Westerlund, 2005, p. 178). The fact that the error terms now are normally distributed, given that the variance is the one assumed earlier, can be shown by the following equation:

$$\text{Var}(e_i^*) = \text{Var}\left(\frac{1}{\sqrt{x_i}} e_i\right) = \left(\frac{1}{\sqrt{x_i}}\right)^2 \text{Var}(e_i) = \frac{1}{x_i} \text{Var}(e_i) = \frac{1}{x_i} (x_i \sigma^2) = \sigma^2$$

Appendix 2. Correction for autocorrelation

Problems with autocorrelation are solved in a similar fashion. This is shown below with an autoregressive autocorrelation, where ρ denotes an autoregressive variable and represents the correlation between e_{i-1} and e_i . u_i is a random term with no drift, mean of zero and constant variance (Westerlund, 2005, p. 187).

The error term e_i is defined as $\rho e_{i-1} + u_i$, and $-1 < \rho < 1$.

Rearranging the original formula gives $y_i = \beta_1 + \beta_n x_{ni} + \rho e_{i-1} + u_i$

Finding an expression for e_i $e_i = y_i - \beta_1 - \beta_n x_{ni}$

Lagging the expression one period gives $e_{i-1} = y_{i-1} - \beta_1 - \beta_n x_{ni-1}$

Substituting in the rearranged formula $y_i = \beta_1 + \beta_n x_{ni} + \rho(y_{i-1} - \beta_1 - \beta_n x_{ni-1}) + u_i$

Adjusting further makes $y_i = \rho y_{i-1} + \beta_1(1 - \rho) + \beta_n(x_{ni} - \rho x_{i-1}) + u_i$

Adjusting yet again $(y_i - \rho y_{i-1}) = \beta_1(1 - \rho) + \beta_n(x_{ni} - \rho x_{i-1}) + u_i$

Defining $y_i^* = y_i - \rho y_{i-1}$, $x_{1i}^* = 1 - \rho$, $x_{ni}^* = x_i - \rho x_{i-1}$

Yields $y_i^* = \beta_1 x_{1i}^* + \beta_n x_{ni}^* + u_i$

This regression model is BLUE, assuming that the autocorrelation is autoregressive. The fact that the first observation has not yet been transformed can be corrected with a number of adjustments, but given the number of observations this is not necessary.

Appendix 3. Breusch-Godfrey Serial Correlation LM test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.970121	Prob. F(8,506)	0.4585
Obs*R-squared	7.900537	Prob. Chi-Square(8)	0.4432

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Date: 05/30/09 Time: 21:33

Sample: 5/04/2005 5/04/2007

Included observations: 523

Presample missing value lagged residuals set to zero.

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.46E-05	0.000595	-0.024478	0.9805
C(2)	0.014313	0.140867	0.101605	0.9191
C(3)	-0.004967	0.068143	-0.072896	0.9419
C(4)	0.004563	0.064253	0.071011	0.9434
C(5)	0.003957	0.030612	0.129257	0.8972
C(6)	0.002012	0.030182	0.066659	0.9469
C(7)	0.003380	0.032977	0.102487	0.9184
C(8)	-0.012063	0.102351	-0.117859	0.9062
C(9)	-0.087444	3.753973	-0.023294	0.9814
RESID(-1)	-0.061634	0.044658	-1.380126	0.1682
RESID(-2)	-0.093237	0.045175	-2.063914	0.0395
RESID(-3)	-0.004291	0.045150	-0.095032	0.9243
RESID(-4)	0.006373	0.045405	0.140368	0.8884
RESID(-5)	-0.045686	0.045117	-1.012612	0.3117
RESID(-6)	-0.017886	0.045485	-0.393237	0.6943
RESID(-7)	-0.042332	0.044985	-0.941023	0.3471
RESID(-8)	-0.016284	0.045150	-0.360666	0.7185

R-squared	0.015106	Mean dependent var	1.29E-19
Adjusted R-squared	-0.016037	S.D. dependent var	0.011260
S.E. of regression	0.011350	Akaike info criterion	-6.087307
Sum squared resid	0.065179	Schwarz criterion	-5.948850
Log likelihood	1608.831	Hannan-Quinn criter.	-6.033081
F-statistic	0.485061	Durbin-Watson stat	1.998784
Prob(F-statistic)	0.954373		

Appendix 4. Redundant fixed effects tests, time period

Redundant Fixed Effects Tests

Equation: EQ01

Test period fixed effects

Effects Test	Statistic	d.f.	Prob.
Period F	2.121348	(10,212)	0.0241
Period Chi-square	21.457795	10	0.0181

Period fixed effects test equation:

Dependent Variable: GROWTH

Method: Panel Least Squares

Date: 05/30/09 Time: 21:24

Sample: 1998 2008

Periods included: 11

Cross-sections included: 33

Total panel (unbalanced) observations: 225

GROWTH=C(1)+C(2)*R2+C(3)*SIZE

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.342176	0.128394	2.665040	0.0083
C(2)	-0.321787	0.764959	-0.420659	0.6744
C(3)	0.026605	0.009379	2.836664	0.0050
R-squared	0.037244	Mean dependent var		0.704389
Adjusted R-squared	0.028570	S.D. dependent var		0.479067
S.E. of regression	0.472174	Akaike info criterion		1.350306
Sum squared resid	49.49457	Schwarz criterion		1.395854
Log likelihood	-148.9095	Hannan-Quinn criter.		1.368690
F-statistic	4.293994	Durbin-Watson stat		1.330125
Prob(F-statistic)	0.014802			

Appendix 5. Redundant fixed effects tests, cross-section

Redundant Fixed Effects Tests

Equation: EQ01

Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	4.779627	(32,190)	0.0000
Cross-section Chi-square	132.874861	32	0.0000

Cross-section fixed effects test equation:

Dependent Variable: GROWTH

Method: Panel Least Squares

Date: 05/30/09 Time: 21:23

Sample: 1998 2008

Periods included: 11

Cross-sections included: 33

Total panel (unbalanced) observations: 225

GROWTH=C(1)+C(2)*R2+C(3)*SIZE

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.342176	0.128394	2.665040	0.0083
C(2)	-0.321787	0.764959	-0.420659	0.6744
C(3)	0.026605	0.009379	2.836664	0.0050
R-squared	0.037244	Mean dependent var		0.704389
Adjusted R-squared	0.028570	S.D. dependent var		0.479067
S.E. of regression	0.472174	Akaike info criterion		1.350306
Sum squared resid	49.49457	Schwarz criterion		1.395854
Log likelihood	-148.9095	Hannan-Quinn criter.		1.368690
F-statistic	4.293994	Durbin-Watson stat		1.330125
Prob(F-statistic)	0.014802			

Appendix 6. Fixed time effects

Dependent Variable: GROWTH

Method: Panel Least Squares

Date: 05/30/09 Time: 21:25

Sample: 1998 2008

Periods included: 11

Cross-sections included: 33

Total panel (unbalanced) observations: 225

GROWTH=C(1)+C(2)*R2+C(3)*SIZE

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.299214	0.128833	2.322490	0.0212
C(2)	-0.796326	0.850759	-0.936017	0.3503
C(3)	0.030507	0.009550	3.194296	0.0016

Effects Specification

Period fixed (dummy variables)

R-squared	0.124818	Mean dependent var	0.704389
Adjusted R-squared	0.075279	S.D. dependent var	0.479067
S.E. of regression	0.460683	Akaike info criterion	1.343827
Sum squared resid	44.99247	Schwarz criterion	1.541202
Log likelihood	-138.1806	Hannan-Quinn criter.	1.423489
F-statistic	2.519605	Durbin-Watson stat	1.317379
Prob(F-statistic)	0.004049		

Appendix 7. Whites cross-section regression

Dependent Variable: GROWTH

Method: Panel Least Squares

Date: 05/30/09 Time: 21:27

Sample: 1998 2008

Periods included: 11

Cross-sections included: 33

Total panel (unbalanced) observations: 225

White cross-section standard errors & covariance (no d.f. correction)

GROWTH=C(1)+C(2)*R2+C(3)*SIZE

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-2.475007	0.701368	-3.528826	0.0005
C(2)	-2.826964	0.615674	-4.591660	0.0000
C(3)	0.233536	0.051816	4.507052	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.466614	Mean dependent var	0.704389
Adjusted R-squared	0.371166	S.D. dependent var	0.479067
S.E. of regression	0.379896	Akaike info criterion	1.044196
Sum squared resid	27.42097	Schwarz criterion	1.575589
Log likelihood	-82.47204	Hannan-Quinn criter.	1.258668
F-statistic	4.888673	Durbin-Watson stat	1.900701
Prob(F-statistic)	0.000000		

Appendix 8. Whites period regression

Dependent Variable: GROWTH

Method: Panel Least Squares

Date: 05/30/09 Time: 21:26

Sample: 1998 2008

Periods included: 11

Cross-sections included: 33

Total panel (unbalanced) observations: 225

White period standard errors & covariance (no d.f. correction)

GROWTH=C(1)+C(2)*R2+C(3)*SIZE

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-2.475007	0.399649	-6.192955	0.0000
C(2)	-2.826964	0.752744	-3.755542	0.0002
C(3)	0.233536	0.029114	8.021337	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.466614	Mean dependent var	0.704389
Adjusted R-squared	0.371166	S.D. dependent var	0.479067
S.E. of regression	0.379896	Akaike info criterion	1.044196
Sum squared resid	27.42097	Schwarz criterion	1.575589
Log likelihood	-82.47204	Hannan-Quinn criter.	1.258668
F-statistic	4.888673	Durbin-Watson stat	1.900701
Prob(F-statistic)	0.000000		

Appendix 9. Period weights regression

Dependent Variable: GROWTH

Method: Panel Least Squares

Date: 05/30/09 Time: 22:41

Sample: 1998 2008

Periods included: 11

Cross-sections included: 33

Total panel (unbalanced) observations: 225

Period weights (PCSE) standard errors & covariance (no d.f. correction)

GROWTH=C(1)+C(2)*R2+C(3)*SIZE

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-2.475007	0.430933	-5.743366	0.0000
C(2)	-2.826964	0.731612	-3.864021	0.0002
C(3)	0.233536	0.031800	7.343911	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.466614	Mean dependent var	0.704389
Adjusted R-squared	0.371166	S.D. dependent var	0.479067
S.E. of regression	0.379896	Akaike info criterion	1.044196
Sum squared resid	27.42097	Schwarz criterion	1.575589
Log likelihood	-82.47204	Hannan-Quinn criter.	1.258668
F-statistic	4.888673	Durbin-Watson stat	1.900701
Prob(F-statistic)	0.000000		

Appendix 10. Large size, horizontal integrated energy corporate groups

1. BP			
Country	Datastream Code	First Obs.	About
UK	900995(P)~SK	1999-05-04	BP is a 100 year old British based global energy group. One of the major businesses is exploration and production, with operations in 25 countries. BP is also engaged in refining and marketing, gas, power and renewables. http://www.bp.com/subsection.do?categoryId=4&contentId=2006741
2. Galp Energia SGPS			
Portugal, EU-zone	41289P(P)~SK	2006-10-24	Galp is the leading oil and gas group in Portugal, with activities in oil exploration and production, oil refining and marketing, natural gas and power. http://www.galpennergia.com/Galp+Energia/English/The+Company/default.htm
3. JCS Gazprom Neft			
Russia	890341(P)~SK	1999-05-04	Gazprom is one of the largest and fastest growing oil companies in Russia, with main divisions such as exploration, production, refining and marketing of oil and gas. http://www.gazprom-neft.com/company/
4. Oil Company Lukoil JSC			
Russia	872725(P)~SK	1999-05-04	Lukoil is the largest oil business company in Russia and accounts for 2,3% of worldwide oil production. The group is divided into "Exploration and Production", "Crude Oil Development and Production Operations" and "Natural Gas". http://www.lukoil.com/static_6_5id_29_.html
5. Repsol YPF S.A.			
Spain, EU-zone	504421(P)~SK	1999-05-04	With exploration, development and production of crude oil and natural gas in some 30 countries, Repsol is an international integrated energy company. http://www.repsol.com/es_en/todo_sobre_repsol_ypf/conocer_repsol_ypf/presentacion/
6. Royal Dutch Shell PLC			
UK	900998(P)~SK	1999-05-04	Shell is a multinational oil company with headquarters in the Hague and registered office in London. The group is segmented into Exploration and Production, Gas and Power, Oil Sands, Oil Products, Chemicals and Corporate. Shell's main business is in upstream oil. http://www.shell.com/home/content/footer/aboutshell/section_list.html
7. StatoilHydro ASA			
Norway	257544(P)~SK	2001-06-18	The international energy company StatoilHydro was founded in 2007 following a merger between the two companies (previous observations for Statoil ASA). It is one of the largest suppliers of oil and gas in the world and the leading oil product company in Scandinavia. http://www.statoilhydro.com/en/AboutStatoilHydro/StatoilHydroInBrief/Pages/default.aspx
8. Total S.A.			
France, EU-zone	912398(P)~SK	1999-05-04	Total undertakes exploration and production of oil and gas in its "Upstream" segment (the other "Downstream", "Chemicals" and "Holding"). The global energy group is one of the world's largest with presence in more than 130 countries. http://www.total.com/en/group/presentation/

Appendix 11. Small- and medium size upstream oil companies

9. Amerisur Resources PLC			
Country	Datastream Code	First Obs.	About
UK	875851(P)	2003-05-05	The primary business is within exploration, development and production of oil and gas in South America. Formerly known as Chaco Resources. http://www.amerisurresources.com
10. Cairn Energy PLC			
Country	Datastream Code	First Obs.	About
UK	910146(P)~SK	1999-05-04	Cairn is listed on the London Stock Exchange, with exploration, development and production of oil and gas primarily in South Asia. http://www.cairn-energy.plc.uk/about/index.htm
11. Dana Petroleum PLC			
UK	943973(P)~SK	1999-05-04	Dana has 17 wells in the UK, Norway and Egypt and is targeted towards exploration and production of oil, hydrocarbon liquid and gas. http://www.dana-petroleum.com/Company/profile.htm
12. Det Norske Oljeselskap ASA			
Norway	413581(P)~SK,	2006-11-10	Detnor started as Pertra ASA and was converted into a public limited company in 2006. It's a Norwegian exploration and production company with resources in the Norwegian Sea and the North Sea. www.detnor.no/index.php?option=com_content&task=blogcategory&id=5&Itemid=5&lang=en
13. Egdon Resources PLC			
UK	299139(P)	2004-12-20	The group holds 25 licences, and are engaged in exploration, development and production oil oil and gas. http://www.egdon-resources.com
14. Europa Oil & Gas (Holdings) PLC			
UK	29726Q(P)~SK	2004-11-10	Europa produces oil from onshore assets in UK, complemented by exploration and appraisal projects in European and North African countries. http://www.europaoil.com/
15. Fortune Oil PLC			
UK	910419(P)~SK	1999-05-04	Fortune is listed on the London Stock Exchange with operational headquarter in Hong Kong. A pipeline operator and oil producer present in China. http://www.fortune-oil.com
16. Gold Oil PLC			
UK	299139(P)	2004-07-13	Gold is engaged in exploration and production of oil and natural gas, with operations in Brazil, Colombia, Peru and Spain. http://www.goldoilplc.com
17. Gulfsands Petroleum PLC			
UK	30710U(P)~SK	2005-04-07	Gulfsands is an independent oil and gas exploration, development and production company. Syrian Arab Republic, Gulf of Mexico and the Gulf Coast are the main areas of interest, but Gulfsands is also active in projects in Iraq. http://www.gulfsands.com/s/Corporate.asp
18. Hardy Oil and Gas PLC			
UK	31131U(P)~SK	2005-06-06	Hardy holds a portfolio of exploration, development and production assets, with concentration on India and Nigeria. A minor part of the business works with various technical services. http://www.hardyoil.com/main.htm

19. JKX Oil and Gas PLC

UK	139998(P)~SK	1999-05-04	JKX has principal interest in oil exploration and production from reserves in Ukraine and Russia. The company is the leading western operator in the oil business in Ukraine. http://www.jkx.co.uk/overview.asp
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20. Lundin Petroleum AB

Sweden	257636(P)~SK	2001-09-06	Lundin was founded in 2001 as a merger between Lundin Oil and Talisman Energy. Lundin is primarily engaged in exploration, development and production of oil and natural gas. The major assets are located in France, Tunisia, the Netherlands, Norway, Venezuela, Indonesia, Sudan, Nigeria, the UK and Ireland. http://www.lundin-petroleum.com/sve/history.php#Talisman
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21. Mediterranean Oil & Gas PLC

UK	32272U(P)~SK	2005-11-15	MedOil is listed on London Stock Exchange – Alternative Investment Market. London is also where the company is based. The company is focused on production, development and exploration of oil and gas assets, primarily in the central Mediterranean region. http://www.medoilgas.com/
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22. Melrose Resources PLC

Country	Datastream Code	First Obs.	About
UK	282045(P)	1999-12-17	The London Stock Exchange-listed upstream company Melrose produces a significant part of their oil from fields in Egypt, Bulgaria and the United States. There are also development and exploration projects in France and Turkey. http://www.melroseresources.com/

23. Meridian Petroleum PLC

UK	29049N(P)~SK	2004-07-19	Meridian is incorporated and listed in the UK, but the oil and gas production is located primarily in the United States (with some activity in South Australia). The business is all onshore, motivated by the better access to infrastructure. http://www.meridianpetroleum.com/about.asp
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24. Norse Energy Group ASA

Norway	671926(P)	1999-05-04	Norse's two major businesses are within exploration and production of oil and gas, and owning and operating pipeline systems. The company is a result of a merger between NaturGass AS and Northern Oil ASA. http://www.norseenergy.com/index.php?id=117
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25. Northern Petroleum PLC

UK	870445(P)~SK	1999-05-04	The principal activity of Northern is exploring, developing and producing oil and gas assets. The projects are located both onshore and offshore mainly within the European Union. http://www.northpet.com/about/companyinfo.html
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26. PA Resources AB

Sweden	686945(P)~SK	1999-05-04	PA was incorporated in 1994 and is focused on buying, developing, producing and extracting oil and gas in North Africa, West Africa and the North Sea. PA is also working with exploration to find new reserves. http://www.paresources.se/sv/Om_PA_Resources/
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27. Premier Oil PLC

UK	900997(P)~SK	1999-05-04	Premier has production, development and production of oil and gas in UK, Indonesia, Pakistan and Mauretania. It is also exploring in the North Sea, Africa, Middle East and Asia. http://www.premier-oil.com/render.aspx?siteID=1&navIDs=19,20,
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28. Providence Resources PLC

Irland, EU-zone	892788(P)~SK	1999-05-04	With assets in Ireland, UK, West Africa, North America and Asia Providence is an international upstream oil and gas company working with exploration, evaluation and production of oil and gas. http://www.providenceresources.com/overview.aspx
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29. Regal Petroleum PLC

UK	26236W(P)~SK	2002-09-26	Regal is focused on oil and gas production from its fields in Ukraine. They are engaged in a couple of joint ventures to continue exploration and development of new assets in its focus area, North Africa and Former Soviet Union. http://www.regalpetroleum.co.uk/strategy.asp
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30. Rocksource ASA

Country	Datastream Code	First Obs.	About
Norway	882418(P),	1999-05-04	Rocks principal activities are exploration and production of oil as well as petroleum research. The portfolio includes production in Texas and exploration licenses in UK and Norway. http://www.rocksource.com/Default.aspx?tabid=593

31. Sefton Resources Inc.

UK	255646(P)	2000-12-07	Sefton owns two oil fields in California from where it produces oil and natural gas, as well as oil and gas deposits in Kansas. The company trades on the London Stock Exchange AIM Market. http://www.seftonresources.com/about/default.aspx ,
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32. Tullow Oil PLC

UK	506343(P)~SK	1999-05-04	Tullow is diversified with both onshore and offshore oil drilling, production and exploration. The company has one of the largest independent exploration businesses in Europe and is managed from its headquarter in London. http://www.tullowoil.com/tlw/aboutus/
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33. West Siberian Resources Ltd

Sweden	13254J(P)~SK	2000-12-27	West Sib. started out as Vostok Oil Limited in 1998. The company is segmented into "Crude Oil" and "Oil Products" and is focused on producing oil and developing oil fields and oil exploration in Russia. http://www.westsiberian.com/index.php?p=about&s=concept&afw_lang=en
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