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How Do Oil Price Changes Affect German Stock Returns?

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ABSTRACT: In this article, the effects of oil price changes on the stock return of 17 German DAX companies are studied from February 1982 to July 2007. By applying panel estimations, we initially identify a nonlinear and asymmetric relationship between oil prices (quoted in US dollar) and the German stock market,which is consistent with a signalling (transmission) channel. Additionally, further evidence is provided for the signalling channel on a disaggregated and daily data base. The results reveal, however, that only certain specific industries are affected by oil price shocks, whereas others remain unaffected. These varying effects of oil price shocks mainly result from the cost- and demand-side dependence on oil that different companies are exposed to.

Keywords: Oil prices; German stock returns; firm level analysis
JEL Classifications: G12; Q43

1. Introduction

Oil and its derivatives play a significant role in German production; as a nation it is one of the largest oil consuming countries in the world with a consumption of 2,357,500 barrels per day of which 98% are imported. Germany therefore ranks among the top oil importing countries in the European Union in contrast to oil exporting countries like Norway or the U.K. When an economy is highly dependent on oil imports – such as Germany – it is expected that oil price changes will have an influence on the economy, its producers and, therefore, also on the stock returns. In fact there seems to be a "general market perception that stock markets react to oil price shocks" (Nandha and Faff, 2008:986). Numerous studies have revealed a general relationship between oil prices and macroeconomic variables of an economy such as real economic activity, GDP growth or productivity. Others witnessed that stock returns are significantly affected by these macroeconomic variables (Hooker, 2004; Chiarella and Gao, 2004). Consequently, a growing body of literature analysing the direct relationship between oil prices and stock returns has emerged. While most of these studies investigate this relationship for the United States, little research has been done on this subject with regard to Germany.

This study aims, however, not only to conduct a primary investigation of the relationship between oil prices and German stock returns on a disaggregated, company specific basis, but also to identify channels of transmission. Thus, it contributes to the existing literature in both these respects. For the second issue we distinguish between a signalling and a profit channel, which are explained later in more detail. The main characteristic of the signalling channel is, however, that market participants form their expectations on (future) profits based on oil prices quoted in US dollar because they are readily available. Since our empirical analysis focuses on this transmission channel we start by applying a panel analysis to answer the question of whether or not oil price changes quoted in US dollar (representing the signalling channel) affect German stock market returns in a linear or non-linear fashion. This analysis reveals that it is only oil price *shocks* that have a significant and asymmetric impact, causing "extraordinary" oil price increases to reduce German stock returns. Given these results, we proceed by analysing the short term impact on a disaggregated and daily data basis. Again, we are able to confirm the working of a signalling channel following asymmetric oil price shocks, although this is not true for all companies involved in the analysis. Those companies exhibiting significant results could, in turn, be largely accounted for by their cost- or demand-side dependence on oil.

The remainder of this paper is organised as follows: Section 2 presents a short review of the literature. Next, Section 3 describes the general relationship between oil prices and stock returns, while Section 4 discusses alternative definitions of oil price shocks and the model applied. Section 5 outlines the structure of our panel analysis and presents the corresponding results. Based on these results, Section 6 introduces a disaggregated, company-specific analysis based on Granger (non-)causality tests. Section 7 provides an explanation of why specific firms found in Section 6 are hit by oil price shocks while others are not. Finally, Section 8 concludes.

2. Literature Review

There currently exists a wide range of literature concerning the relationship between oil prices and macroeconomic variables (e.g. GDP growth, exchange rate, employment and international debt). An early study was presented by Hamilton (1983) who examined the relationship between the price of oil and real GDP, finding that increasing oil prices lead to a declining real GDP. Based on this strand of literature, a variety of studies about the connection between oil prices and the stock market subsequently emerged. One of the first was the seminal paper by Jones and Kaul (1996) who established that, at the very least, the reaction of the US and the Canadian stock market to oil price shocks is caused completely by changes in cash flows and expected returns. Later on, Sadorsky (1999) discovered – by estimating a VAR model – that both oil price shocks as well as its volatility cause stock return changes. Similar to Basher and Sadorsky (2006), as well as Chiou and Lee (2009), he reports that oil price shocks have negative and asymmetrical effects. In other words that is to say, positive[1] oil price shocks have a significant negative effect on stock returns whereas negative oil price shocks do not have a positive effect.[2]

Although most research still focuses on US data, other countries have lately attracted increasing attention. In a more recent study, Park and Ratti (2008) show that oil price shocks have a significant negative influence on real stock returns in the US and 12 European countries including Germany. It is only Park and Ratti (2008) as well as Apergis and Miller (2009) who examined, among other countries, the reaction of the German stock market to oil price shocks. Concerning Germany, the first study found a nonlinear relationship between oil prices and the DAX as a whole, but no asymmetric effects. In a similar way, Apergis and Miller (2009) analysed the reaction of eight aggregated stock market indexes to oil price shocks which again detected a significant reaction of the German aggregated stock returns represented by the DAX to three different structural oil shocks (namely oil supply shocks, global demand shocks, and idiosyncratic demand shocks).

Moreover, in accordance with the majority of the existing literature, their findings are generally based on the returns of aggregated stock indexes. Little research has been done, however, on the relationship between oil price shocks and stock returns on a disaggregated industry or even on a company level. Lee and Ni (2002) Mohamed El Hedi and Fredj (2009), Goginieni (2010) as well as Scholtens and Yurtsever (2012) pertain to the few who did; they all pointed to the importance of using disaggregated data in order to reveal varying effects of oil price shocks among different industries or even companies. Although using industry specific indexes Scholtens and Yurtsever (2012) were unable to derive country specific results because their analysis is based on 38 industry equity indexes being, however, aggregated over 15 European countries. As a further result, their industry index include both the development in oil importing, as well as in oil exporting countries (e.g. Norway and UK) what may be a reason for their unusual outcome that positive oil price shocks show only a few significantly negative reactions, while negative oil price shocks exhibit a significantly positive reaction in many

[1] In this connection, "positive" points to a rise in oil prices and vice versa.

[2] Research concerning oil exporting countries such as by Hammoudeh and Aleisa (2004) who include Bahrain, Kuwait, Oman, Saudi Arabia and the UAE mostly arrive at the opposite result reporting a positive relationship between oil prices and stock market activity, which is logical on account of these countries' (additional) profits from rising oil prices, as petroleum and petroleum products are often their major source of income.

industries. Since they focus on highly aggregated European industries and their stock market developments no assertions can be made concerning German industries or even companies.

3. Theoretical Background

If oil plays an important role in an economy it follows logic to expect oil prices to be correlated with stock returns (Huang et al., 1996). The stock price reflects the economic conditions, and is regarded as the "market's best estimate of the future profitability of firms" (Jones et al., 2004:13) because it is normally calculated as the present discounted value of their future profits. Most of the models designed to calculate the value of a stock have their origin in the theory of the valuation of firms. This is due to the fact that, in principle, the theory-based value of a stock can be derived from the firm's market value divided by the number of shares. The firm's value corresponds to the present value of the expected future free-cash-flows, less the value of all liabilities. Related to the stock valuation are the cash flows to the investors, the dividends, and not the free-cash-flows of the firm. A basic model to describe these relations is the dividend discount model which is a classic discounted cash flow model. It can be written formally as:

$$PV_0 = \sum_{t=0}^{\infty} \frac{D_t}{(1+i)^t} \tag{1}$$

where PV_0 is the present value of the stock at the beginning of time period t, defined as the sum of the expected future dividends D_t divided by the discount rate $(1+i)$. For the sake of simplicity, the discount rate is assumed to be constant over time and can be expressed as a function of a given interest rate i, which represents the opportunity costs of the stock investment. Standard textbook formulations of stock valuation models generally consist of some variation of the discounted dividend approach shown above.[3] Assuming that the dividend pay-out ratio is 1, the total dividends amount to the firm's total profits. Therefore, the stock value could be described as the present value of expected future profits. In general, a firm's profit can be defined as the difference between its revenues (R) and total costs (TC):

$$Profit = R - TC = D \tag{2}$$

The revenue of a firm, in turn, is equal to the (average) market price per unit ($P_M^€$) multiplied by the number of products sold (x). TC, is again composed of costs concerning oil imports (C_{Oil}) in addition to all remaining costs (C). Since oil is typically invoiced in US dollar, C_{Oil} depends on the price for oil imports in foreign currency ($P_{Oil}^\$$) as well as on the corresponding exchange rate (e).

$$Profit = \left[P_M^€ \cdot x\left(P_{Oil}^\$ \cdot e\right)\right] - [C + \underbrace{(\underbrace{P_{Oil}^\$ \cdot e}_{P_{Oil}^€} \cdot x_{Oil}\ )}_{C_{Oil}}] \tag{3}$$

with $CD \equiv \frac{C_{Oil}}{TC}$ as the cost-side dependence

and $DD \equiv \frac{\partial x}{\partial P_{Oil}}$ as the demand-side dependence

If market participants form rational expectations concerning a firm's future profits then they should subsequently be expected to conduct a fundamental analysis based on equation (3). There are two channels through which a change in oil prices can influence profits: Firstly, they can operate via cost effects (C_{Oil}) which gain in importance the higher the "cost-side dependence" (CD). Secondly, they can influence revenues via its impact on the number of products sold, which is called "demand-side dependence" (DD). Both these effects point in the same direction. Following an increase in oil prices, rising costs and/or falling revenues are to be expected, resulting in sum to reduced (future) profits, and vice versa. Thus, of importance for an increase or decrease in profits due to oil price changes is the corresponding price in Euro. A given change in oil prices quoted in US dollar may, therefore, result in a smoothed or even in an exacerbated development of Euro prices due to simultaneous changes in the exchange rate. It is only if economic agents look at this joint effect that we should expect an influence of oil price shocks quoted in Euro (home currency) on equity returns. A procedure of even greater

[3] These variations contain different extensional parts, such as factors representing constant or variable growth.

sophistication takes into account additional revenue effects due to the price at which the corresponding product – having oil as an input factor – can be sold. In this case the real price of oil quoted in Euro $\frac{P_{Oil}^{€}}{P_{M}^{€}}$ affects market participants' activities and, therefore, expected equity returns. In many cases some index for the cost of living (e.g. HCPI) is taken as a proxy for $P_{M}^{€}$. This implies, however, that single prices such as $P_{M}^{€}$ develop closely in line with the price index.

Conversely, the signalling channel is based on the assumption that economic agents react primarily to readily available information on oil prices, which are in most cases quoted in US dollar. This holds true e.g. for news on the TV as well as for newspaper articles. According to this transmission channel, even an oil price change quoted in US dollar should have a significant influence on equity returns for firms with a high dependence on oil. Furthermore, this effect should come into play immediately after a price change, since all necessary information is instantly available. This transmission channel incorporates to some extent the assumption of a specific form of money illusion.

The difference between both these channels may diminish, however, if the exchange rate changes by only a slight amount and the oil price in Euro is dominated by the oil price in US dollar. Moreover, economic agents may expect firms to have hedged the risk of exchange rate changes in order to reduce uncertainty only to the price in US dollar. Last but not least, if purchasing power parity holds even in the short run, then $P_{M}^{€}$ and e would net out from the real price of oil quoted in Euro with $P_{Oil}^{\$}$ as the only remaining factor influencing equity returns. Nevertheless, if there is a significant correlation between oil prices quoted in US dollar and stock returns then this points to the existence of a signalling channel. A distinction between both these transmission channels has not yet appeared in the existing literature. One reason for this omission may be that for the US – where most studies concerning the effects of oil price changes focus upon – both these channels coincide because the US dollar is at the same time the domestic currency. Thus, oil price changes in US dollar immediately reflect the cost effect without the necessity to additionally consider the exchange rate.

The present analysis is concentrated on firms that typically import oil from abroad and do not produce oil themselves.[4] This situation applies to almost all German firms, especially for those contained in the DAX[5]. An increase in oil prices (positive oil price change) is, therefore, expected to reduce stock returns of the involved companies while the effects of a decrease are – according to existing research – much more ambiguous. Against this background, we not only analyse the general impact of all oil price changes, but control as well for any possible (asymmetric) effects following oil price *shocks* being basically defined as an extraordinary change.

4. Modelling Oil Price Shocks

The specific definition of an oil price *shock* varies considerably across authors. Some regard every change of the oil price as a "shock", assuming a linear relationship between oil prices and stock market returns. Other researchers define an oil price shock as an extraordinary increase in oil prices. Davis and Haltiwanger (2001), for example, used a 5-year average of the oil price to capture this effect. One outcome of this specification is that changes in oil prices have no immediate influence unless it materialises as a long-run effect. It was also Hamilton who provides several different specifications of an oil price shock. While starting from the basic definition (Hamilton, 1983) that oil price shocks coincide with any oil price change – implying symmetric effects – later refinements also include nonlinear as well as asymmetric effects. While nonlinear effects reflect the assumption that small fluctuations in oil prices may not affect economic agents' behaviour, asymmetric reactions imply that oil price increases hit the economy more severely than decreases. In Hamilton (1996) the use of a "net oil price increase", defined as the amount by which the current oil price rises above the maximum over the last four quarters, was suggested. Hamilton (2003) later consideres to define an oil price shock as a substantial rise in oil prices, which occurs if the current oil price is higher than the maximum over the last three years. This approach has, in turn, been extended by Engemann et al. (2014) who allow not only for positive oil price shocks but also for negative ones. In the following, we employ this specification in

[4] A more detailed analysis of the differing effects of oil price shocks on countries importing and exporting oil can be found in Wang et al. (2013).

[5] The only company within this index which produces oil is BASF with its division Oil & Gas performed by the Wintershall Company which, in turn, is responsible for around 15% of the company's total revenues.

order to control for nonlinear as well as for asymmetric effects. Consequently, a positive oil price shock is defined as

$$op_t^+ = \max \begin{cases} 100 \cdot ln \dfrac{op_t}{max\{op_{t-1}, \dots, op_{t-n}\}} & if\ op_t > max\{op_{t-1}, \dots, op_{t-n}\}, \\ 0 & if\ op_t \leq max\{op_{t-1}, \dots, op_{t-n}\}. \end{cases} \tag{4}$$

and a negative oil price shock as

$$op_t^- = \min \begin{cases} 100 \cdot ln \dfrac{op_t}{min\{op_{t-1}, \dots, op_{t-n}\}} & if\ op_t < min\{op_{t-1}, \dots, op_{t-n}\}, \\ 0 & if\ op_t \geq min\{op_{t-1}, \dots, op_{t-n}\}. \end{cases} \tag{5}$$

According to this definition, a positive (negative) oil price shock occurs if the actual oil price is higher (lower) than the maximum (minimum) over the last *n* observations.

5. Panel Analysis

5.1 Data

In order to investigate the general relationship between oil price changes and the German stock market we employ a data sample based on monthly observations from January 1980 to June 2008. This period was chosen in order to exclude the two major oil crises in 1973 and 1979 on the one hand as well as the extraordinary effects of the subprime crisis,[6] which reached its peak in September 2008 with the demise of Lehman Brothers and the subsequent global downturn, on the other hand. The data set for the panel analysis of the German DAX companies includes monthly data of corresponding German stock prices and oil prices as well as German industrial production. The data set is a balanced panel which contains 5372 observations with 17 individuals (firms) and 316 time periods.

Table 1. Descriptive statistics

Variable	No. of Obs.	Mean	St. Dev.	Min	Max
Ind. Production	316	87.36	11.41	63.7	115.4
Oil Price $	316	28.49	18.56	9.3	128.3
Positive Oil price shocks	78	1.64	4.20	0	38.6
Negative Oil price shocks	62	-1.20	4.01	-36.4	0

Table 1 reports descriptive statistics for the group invariant variables industrial production, oil prices, and the oil price shocks. The oil price applied in this study is the nominal price of Brent crude oil which is the leading benchmark for Atlantic crude oils quoted in US dollar. As a control variable for business cycle effects industrial production is included in the analysis. The index used is the German index of industrial production including construction based on the year 2005. All data are provided by Thomson Reuter's *Datastream*. As a benchmark for the German equity market the companies included in the ***D**eutscher **A**ktien Inde**X** (DAX)* are analysed. Over time the composition of the DAX, introduced in 1987, changed on numerous occasions so that some stocks have been replaced by others. Therefore, we only include those companies where data are available over the entire sample period. Consequently, 17 companies[7] and their monthly stock prices form our individuals.

5.2 Model structure

To test our hypothesis that oil price changes affect stock market returns of German DAX companies, estimations are based on a company-specific fixed-effects model with time dummies. We start by estimating the log of the stock return of firm i at time t (y_{it}) as follows:

$$\Delta y_{it} = \alpha_{it} + \beta_1 \Delta ip_t + \beta_2 op_t^{\$} + \epsilon_{it} \tag{6}$$

[6] The influence of the financial crisis on oil prices was studied in more detail by Salisu and Fassanya (2012).

[7] These companies are: BMW AG, Volkswagen AG, Deutsche Bank AG, Commerzbank AG, BASF SE, Bayer AG, Linde AG, Siemens AG, Allianz SE, Munich RE, Deutsche Lufthansa AG, TUI AG, E.ON AG, RWE AG, Continental AG, MAN SE and ThyssenKrupp AG

where ip_t represents the log of industrial production and $op_t^{\$}$ the log of the oil price of Brent crude oil measured in US dollar. $\epsilon_{it}$is a well behaved error term and α and β are the parameters to be estimated.

To analyse the effects of oil price shocks on stock returns instead of any change of the oil price we modify equation (6) as follows to obtain our second estimation equation:

$$\Delta y_{it} = \alpha_{it} + \beta_1 \Delta ip_t + \beta_2 op_t^+ + \beta_3 op_t^- + \epsilon_{it} \tag{7}$$

now including op_t^+ and op_t^- which represent positive and negative oil price shocks as defined above. Similar to e.g. Jones and Kaul (1996) and Sadorsky (1999) we additionally involve industrial production in equations (6) and (7) as a control variable for cyclical variations in economic activity. In accordance with Park and (2008) we select $n = 6$ to calculate oil price shocks for the monthly data base.

We start our empirical analysis by conducting panel unit root tests for all variables except the oil price shocks[8]. As all tested series proved to be integrated of order one, the entire panel analysis is based on first differences of stock returns and industrial production. Moreover, all model specifications were tested for remaining autocorrelation and heteroscedasticity. While there was no sign of autocorrelation independent of the model specification, we found some evidence of heteroscedasticity. We, therefore, calculated heteroscedasticity robust standard errors which are indicated in Table 2 and 3.

5.3 Results

Firstly, test results based on equation (6) wich are compiled in Table 2 show unambiguously that oil price changes in general have no effect on the stock returns of German DAX companies.

Table 2. Estimation results equation (6)

Variables	Coefficients	t-Value
Ind. Production	0.0050***	0.0011
	(4.31)	
Oil Price ($)	-0.0363	0.0406
	(-0.90)	
Time fixed effects	yes	
No. of obs.	5372	
No. of groups	17	
F−test	19.00	
$adj.R^2$	0.54	
*, **, *** indicate statistical significance on the 90%-, 95%-, and 99%-level. Heteroscedasticity robust standard errors in parentheses.		

It is only industrial production which has a significant influence, reflecting the varying development of a firm's profit over the business cycle. Thus, we are unable to detect any linear relationship between oil price changes and the German stock market. This is consistent with the majority of findings in the literature concerning other countries. To control for non linearities and asymmetric effects we estimated equation (7). Our findings are presented in Table 3.

The results indicate that the coefficient for positive oil price shocks is highly significant with the expected negative sign, whereas negative oil price shocks lack any significant influence. With this considered, our estimation suggests an asymmetric effect of oil price shocks, meaning that rising oil prices lead to declining stock returns but that declining oil prices do not affect stock returns at all. In summarising our results so far we can conclude that oil price changes affect German stock market returns not only in a nonlinear way but also in an asymmetric one. For the control variable we identify significant effects at the 1% level, comparable to the results of equation (6).

In this first step of our analysis we detect a significant relationship between positive oil price *shocks* and the German stock market. Former investigations for other countries (Lee and Ni, 2002) showed that

[8] Results are available from the authors on request.

it is of great importance to analyse the effect of oil price shocks on a disaggregated level due to the differing effect of oil price shocks on various industries. Therefore the causal link between an oil price shock and the return of single DAX companies is analysed in the following section.

Table 3. Estimation results equation (7)

Variables	Coefficients	t-Value
Ind. Production	0.0051***	0.0012
	(4.26)	
Positive Shock ($)	-0.0037***	0.0003
	(-9.76)	
Negative Shock ($)	0.0003	0.0006
	(0.46)	
Time fixed effects	yes	
No. of obs.	5372	
No. of groups	17	
F−test	19.00	
$adj.R^2$	0.54	
*, **,*** indicate statistical significance on the 90%-, 95%, and 99%-level. Heteroscedasticity robust standard errors in parentheses.		

6. Disaggregated Analysis

In order to investigate the relationship between oil price shocks and stock returns in Germany in more detail, we conduct Granger (non-)causality tests for the individual return series. Data description corresponds to the information given in Section 5.1. The only difference is that individual stock returns are now analysed on a daily data base. Accordingly, oil price shocks are calculated corresponding to equations (4) and (5) over a time horizon of one month (20 data points). To test for Granger (non-)causality we estimate a vector autoregressive (VAR) model which is based on equation (8) for each equity involved in our analysis.

$$y_t = \alpha + \sum_{i=1}^{k+m} \beta_i \cdot y_{t-i} + \sum_{i=1}^{k+m} \gamma_i \cdot op_{t-i}^{+} + \sum_{i=1}^{k+m} \delta_i \cdot op_{t-i}^{-} + u_t \tag{8}$$

Oil price shocks are said to Granger cause y (stock returns) if the sum of the coefficients γ or δ diverge significantly from zero. In the following, the usual zero restrictions on the above mentioned parameters are tested by applying the procedure suggested by Toda and Yamamoto (1995). Therefore, the VAR is set up in (log) levels using a Wald test to assess the restrictions. Since this Wald test does not follow its usual asymptotic chi-square distribution in the instance of (some) non-stationary data, it is necessary to adopt a special procedure. While the VAR is estimated with k+m lags, the Wald test is applied only to the first k lags, where k is the optimal lag length and m the highest order of integration of all time series involved in the equation.

Pre-tests (Akaike information criterion) have revealed that the optimal lag length k varies considerably across equations, with the highest optimal lag being 15. However, when examining the residuals for autocorrelation we find that problems arise, particularly with short lags. To avoid these problems we decided to apply a unique lag-length k=15 for all equations. Additional pre-tests concerning the order of integration (ADF) further show that none of our time series are integrated higher than of order one [I(1)]. As consequence, m is equal to 1. Formal cointegration tests are not conducted because their results do not affect the procedure. It is against this background that we estimated our (partial) VAR in form of equation (8) with k+m lags which are equal to 16.

The results of the corresponding tests are compiled in Table 4. The first obvious outcome is that shocks caused by oil price increases (positive shocks) affect German equities negatively in all cases. These results are only significant, however, in the cases of VW, BMW, BASF, Bayer, Lufthansa, Thyssen, Deutsche Bank and Allianz. Conversely, negative shocks caused by decreasing oil prices do not reveal any significant result, while the sign varies depending on the firm concerned.

To summarise these results, our empirical evidence from \$-quoted oil prices points unambiguously to the working of a signalling channel which transmits oil price changes in an asymmetric way onto stock returns. It is oil price increases alone that can be interpreted as bad news, thus causing a decrease in stock returns of (some) German equities.

Table 4. Granger causality test results

	Oil price (\$)			
	Positive shocks		Negative shocks	
Share	Sign	Chi^2	Sign	Chi^2
Volkswagen	-	33.5*	+	20.9
BMW	-	36.7*	-	10.8
MAN	-	23.6	+	7.3
BASF	-	27.4*	-	12.0
Bayer	-	32.7*	-	21.4
Beiersdorf	-	17.9	+	13.7
K. u. S.	-	16.0	+	18.2
Linde	-	22.9	+	10.8
EON	-	19.1	+	17.6
RWE	-	22.4	+	15.6
Lufthansa	-	32.0*	-	20.0
Siemens	-	20.5	-	9.9
Thyssen Krupp	-	36.9*	+	11.9
Deutsche Bank	-	38.7*	+	10.8
Commerzbank	-	22.9	+	7.2
Allianz	-	31.7*	+	10.1
Muenchener Rueck	-	17.3	-	10.5
* Significant at the 95% level at least.				

7. Dependence on Oil

Our disaggregated analysis observed that for some companies of the German DAX an oil price shock affects their stock returns, while other companies remain unaffected. Therefore, this final section is devoted to explaining these differences, in particular by drawing on a firm's cost- and demand-side dependence on oil which were previously outlined in Section 3.

7.1 Cost-side dependence

The higher the proportion of oil in the production costs of an industry, the higher the expected influence of oil price changes on the stock returns. Oil intensive industries should be more sensitive to oil price changes because a higher oil price results in rising costs and therefore declining profits. Gogineni (2010) calls this the cost-side dependence of an industry. A similar approach was suggested by Hamilton (2011) on the basis of a production function which depends on capital, labour and energy as input factors, and assumes that the capital stock and the supply of labour is fixed, thereby identifying the energy expenditure share as the firm's spending on energy in relation to the total output. According to equation (3) cost side dependence of different industries can be calculated as the value of oil as an input factor in relation to total costs. Using the data of the annual input/output statistic provided by the *German Federal Statistical Office* (2007; 2010) the average cost-side dependence η over the last *T* years is calculated for industry *i* as follows:

$$\eta_i = \frac{1}{T}\sum_{t=1}^{T}\frac{OILin_{it}}{INDout_{it}} \quad (9)$$

where *OILin* corresponds to C_{Oil} in equation (3) while *INDout* is the industry's production value which represents a proxy for total costs in (3). As the input/output tables are only available from 1995 to 2007, *T* equals 13. η-values calculated according to equation (9) serve as an indicator to categorise industries with a high η as oil-intensive. Since the data are only available at the industry level and not for individual companies, the analysed DAX companies are matched to the industries according to the official classification of industry branches issued by the *German Federal Statistical Office* (2003) as seen in Table 5 column 2. Column 3 shows the average η over the complete sample period. According to the results of Table A.1 in the Appendix – where all available industries of the input/output statistic are listed in descending order sorted by their η – a high η and therefore a high oil sensitivity is defined as η≥1.5 representing the upper decile. Corresponding industries are marked in Table 5 with an asterisk.

Oil intensive or sensitive industries identified by calculating the η are air transportation, chemical products, and iron and steel manufacturing, all of which use oil or oil derivatives as a major input. For all companies involved in our study which belong to these particular industries, namely Deutsche Lufthansa, BASF, Bayer and Thyssen Krupp a positive oil price shock had a significant impact on stock returns according to the results of the Granger causality tests. Therefore, we conclude that a high oil intensity in production leads oil price shocks to affect stock returns due to the cost-side dependence of these companies. On the other hand, there are companies such as BMW and Volkswagen which, according to their η, do not depend heavily on oil in the production process. Nevertheless their results are significant. In the next section we will discuss possible explanations for this outcome.

Table 5. Company classification and oil intensity

DAX company	Industry/Classification	η
Lufthansa†	Air transportation (62)	13.19*
BASF†	Chemical Products (24)	2.95*
Bayer†		
Thyssen Krupp†	Iron and Steel Manufacturing (27.1-27.3)	2.44*
K. u. S.	Quarrying and mining products (14)	0.94
E.ON	Electricity and gas production (40.1-40.3)	0.76
RWE		
Linde	Machinery (29)	0.11
Siemens		
MAN		
BMW†	Motor vehicles and parts (34)	0.12
Volkswagen†		
Allianz†	Insurance carriers and related activities (66)	0.03
Muenchener Rueck		
Commerzbank	Credit institution services (65)	0.02
Deutsche Bank†		

† indicates significant effects of oil price shocks according to Granger causality tests in chapter 6
* indicates oil sensitive industries according to η.

7.2 Demand-side dependence

If an industry is not heavily dependent on oil by means of their cost-side dependence there may yet exist a derived dependence on oil, e.g. when the main consumers of a company are oil dependent or modify their consumption decision according to oil price changes. In this case, a positive oil price shock would lead to a declining demand and therefore to a smaller number of products sold (x) as can be seen from equation (3). Given this reaction, DD would be less than zero. This relationship is often considered to apply to the automotive industry. For example Kilian and Park (2009) argue that stocks of the automotive sector depreciate persistently after positive oil price shocks. Lee and Ni (2002) state that the automotive industry, being seriously affected by rises in oil prices, is a supposed result of a declining demand for automobiles. They estimate a VAR model with standard macroeconomic variables including oil price shocks in accordance with our definition[9] and industry specific variables including production and prices. Based on this they compute impulse responses to determine the effects of an oil price shock on an industry's supply and demand. A positive effect on output combined with a negative effect on prices means that the oil price shock leads to a reduction in supply, and consequently causes a

[9] In contrast to our analysis they control, however, only for the effects of positive oil price shocks.

supply shock which is the case for oil intensive industries such as chemicals.[10] A negative effect on output and prices is caused by a reduction in demand for the regarded industry. This is the case for nonferrous metals, lumber products, apparel, household furniture/appliance, and the automotive industry. However, the magnitude of these effects for the automotive industry is nearly twice the size of the effects in other industries. A negative oil price shock affects the automotive industry particularly strongly because consumers willing to purchase a new car may instead decide against it or at least delay their consumption decision.[11] This argument was confirmed and further elaborated upon by Hamilton (2011), who states that the demand for cars is not only dependent on the current oil price but also on the expectations of future oil prices over the whole lifetime of a car. In conjunction with this, Cameron and Schnusenberg (2009), showed that by adding an oil price factor to the Fama-French three-factor model, rising oil prices lead to declining stock returns for American automobile manufacturers – especially those mainly producing SUVs[12]. Moreover, Ramey and Vine (2010) show that changes of labour and capital increased the negative demand effects of oil price shocks in the automotive industry.
Based on these results, one can conclude that a positive oil price shock distinctly affects the automotive industry because it weakens the demand for cars and vehicles. This may lead to declining stock returns which explains the significant reaction of the stock returns of BMW and Volkswagen as both companies belong to the "Motor vehicles and components" industry.

An alternative hypothesis could be based on the assumption that demand does not (immediately) depend on oil prices but instead on (expected) GDP which, in turn, is influenced by todays oil price changes:

$$Revenue = P_M^{€} \cdot x\left[GDP\left(P_{Oil}^{\$} \cdot e\right)\right] \tag{10}$$

If this hypothesis holds, however, then oil price changes should rather affect all share prices under consideration since demand of all industries should react to a considerable extent to changes in GDP. As our disaggregated analysis revealed significant results primarily for those companies exhibiting a considerable cost- or demand-side dependence, such an indirect effect through (expected) GDP changes can be rejected.

7.3 Other forms of dependence

Cost-side as well as demand-side dependencies by and large explain the negative reaction to positive oil price shocks shown by the Granger (non-)causality tests. What is not yet explained, however, is the reaction of financial institutions, like companies belonging to the insurance and banking sector, which were at least in part significantly affected by oil price shocks. These results are in line with the findings of other studies such as e.g. Nandha and Faff (2008). While there is neither a direct connection to oil or oil derivatives as an input factor nor as a factor driving the demand for insurance or bank products, there may well be a derived dependency. Elyasiani et al. (2011) argue that banks may even profit from an increase in oil prices if they are engaged in either financial speculation regarding financial instruments based on crude oil or have a closer relationship lending with oil producing firms. This argument implies, however, a positive relationship between oil prices and stock returns which could not be detected in our analysis (see Table 5). Regarding insurance companies, it is suggested that they may suffer due to a positive oil price shock if they are involved in activities with oil demanding industries, which corresponds to their empirical results. Nevertheless, from a theoretical point of view, distinguishing between banks and insurance companies with regard to more efficient speculative behaviour and customer structure seems less appropriate. Therefore, the effects of an oil price shock on financial institutions in general – including banks and insurance companies – is ambiguous depending on the asset structure of the companies. This may provide reasoning for the differing effect of oil price shocks on financial institutions as found in our analysis. While *Allianz* and *Deutsche Bank* were negatively affected by positive shocks, *Muenchener Rueck* as well as *Commerzbank* remained unaffected.

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[10] Their classification of industries as oil intensive corresponds to our classification based on η.

[11] In addition to their econometric analysis they also conduct an evaluation of business media which provides an indication for demand-side dependence on oil in the automotive industry.

[12] The effect of rising oil prices on the demand for different types of automobiles in the US is analysed by Belenkiy and Osborne (2012). They show that the demand reaction is mainly determined by the fuel efficency of the different types of automobiles.

8. Conclusion and Policy Implications

The main results of our empirical analysis can be summarised as follows: Firstly, based on disaggregated, company specific data it could be shown by panel estimations that general oil price changes had no significant impact on the stock return of German DAX companies during our sample period. Instead, it was only oil price *shocks* that affected stock returns in an asymmetric way. While positive oil price shocks resulted in decreasing stock returns, negative shocks did not reveal any significant results at all. Secondly, this outcome could be further confirmed by applying Granger (non-)-causality tests to each individual DAX company involved in our analysis. Besides the asymmetric operation of oil price shocks it also became obvious that only specific companies within our sample were hit by oil price shocks. These companies are best identified by accounting to their cost- and demand-side dependence on oil. It was only a few financial institutions for which significant results could not be explained in this way – a phenomenon that is well known to the existing literature. Our results concerning the principal operation of oil price changes on German stock returns are, therefore, closely in line with the few existing studies concerning Germany as well as those referring to other industrial (oil importing) countries. Thirdly, by examining oil price changes and oil price shocks as being uniformly quoted in US dollar rather than the local currency, there is a strong indication that oil prices affect German stock returns (at least in the short-term) via a signalling channel. Since such a distinction is meaningless for the United States with the US dollar as the home currency, existing studies may yet have ignored these different channels of transmission because they are typically focused on that country.

These results have various (policy) implications: During times of particularly increasing oil prices (positive oil price shocks), stock returns of demand- or supply-dependent German enterprises belonging to the DAX 30 – as identified before – will significantly decrease compared to the composite index. Therefore, their returns are highly correlated and corresponding stocks are not qualified for portfolio diversification during such times. Moreover, because of the high correlation between certain sectoral stock returns and the oil price, the optimal portfolio weight of oil-dependent sectors (firms) should be lower than that of the other sectors. Since stock returns of certain German enterprises react asymmetrically to positive oil price shocks quoted in US-dollar, this points to the working of a signaling effect as transmission mechanism which makes it comparatively easy to assess the (immediate) effect on the stock returns concerned. Opposed to the implications so far, effects on economic activity – quantified as GDP or industrial production – are more likely to depend on oil price changes quoted in national currency, i. e. euro in the case of Germany, because they reflect more precisely the influence on costs to be carried by firms.

References

Apergis, N., Miller, S.M., (2009), *Do structural oil-market shocks affect stock prices?* Energy Economics 31(4), 569–575.

Basher, S. A., Sadorsky, P., (2006), *Oil price risk and emerging stock markets.* Global Finance Journal 17, 224–251.

Belenkiy, M., Osborne, S., (2012), *The Effect of Changes in World Crude Oil Prices on U.S. Automobile Exports.* International Journal of Energy Economics and Policy 2(3), 147-158.

Cameron, K., Schnusenberg, O., (2009), *Oil prices, SUVs, and Iraq: An investigation of automobile manufacturer oil price sensitivity.* Energy Economics 31(3), 375–381.

Chiarella, C., Gao, S., (2004), *The value of the S&P 500 – A macro view of the stock market adjustment process.* Global Finance Journal 15(2), 171–196.

Chiou, J.-S., Lee, Y.-H., (2009), *Jump dynamics and volatility: Oil and the stock markets.* Energy Economics 34(6), 788–796.

Davis, S.J., Haltiwanger, J., (2001), *Sectoral job creation and destruction responses to oil price changes.* Journal of Monetary Economics 48(3), 465–512.

Elyasiani, E., Mansur, I., Odusami, B., (2011), *Oil price shocks and industry stock returns.* Energy Economics 33(5), 966–974.

Engemann, K.M., Owyang, M.T., Wall, H.J., (2014), *Where is an oil shock?* Journal of Regional Science 54(2), 169-185.

German Federal Statistical Office, (2003), Klassifikation der Wirtschaftszweige mit Erläuterungen: Ausgabe 2003, https://www.destatis.de/DE/Methoden/Klassifikationen/Gueter Wirtschafts klassifikationen/Content75/KlassifikationWZ2003.html

German Federal Statistical Office, (2007), Volkswirtschaftliche Gesamtrechnungen: Input-Output-Rechnung 1995-2006, https://www.destatis.de/DE/Publikationen/Thematisch/Volkswirt schaftlicheGesamtrechnungen/AlteAusgaben/InputOutputRechnungAlt.html, 18. September 2007.

German Federal Statistical Office, (2010), Volkswirtschaftliche Gesamtrechnungen: Input-Output-Rechnung 2007, https://www.destatis.de/DE/Publikationen/Thematisch/Volkswirtschaft liche Gesamtrechnungen/AlteAusgaben/InputOutputRechnungAlt.html, 30. August 2010.

Gogineni, S., (2010), *Oil and the stock market: An industry level analysis.* Financial Review 45(4), 995–1010.

Hamilton, J.D., (1983), *Oil and the macroeconomy since World War II.* The Journal of Political Economy 91(2), 228–248.

Hamilton, J.D., (1996), *This is what happened to the oil price-macroeconomy relationship.* Journal of Monetary Economics 38, 215–220.

Hamilton, J.D., (2003), *What is an oil shock?* Journal of Econometrics 113(2), 363–398.

Hamilton, J.D., (2011), *Nonlinearities and the macroeconomic effects of oil prices.* Macroeconomic Dynamics 15(S3), 364–378.

Hammoudeh, S., Aleisa, E., (2004), *Dynamic relationship among GCC stock markets and NYMEX oil futures.* Contemporary Economic Policy 22, 250– 269.

Hooker, M. A., (2004), *Macroeconomic factors and emerging market equity returns: A Bayesian model selection approach.* Emerging Markets Review 5(4), 379–387.

Huang, R.D., Masulis, R.W., Stoll, H.R., (1996), *Energy shocks and financial markets.* Journal of Future Markets 16(1), 1–27.

Jones, C.M., Kaul, G., (1996), *Oil and the stock markets.* The Journal of Finance 51(2), 463–491.

Jones, D., Leiby, P., Paik, I., (2004), *Oil price shocks and the macroeconomy: What has been learned since 1996.* The Energy Journal 25, 1–32.

Kilian, L., Park, C., (2009), *The impact of oil price shocks on the U.S. stock market.* International Economic Review 50(4), 1267–1287.

Lee, K., Ni, S., (2002), *On the dynamic effects of oil price shocks: A study using industry level data.* Journal of Monetary Economics 49(4), 823–852.

Mohamed El Hedi, A., Fredj, J., (2009), *Short and long-term links between oil prices and stock markets in Europe.* Economic Bulletin 30(1), 817–828.

Nandha, M., Faff, R., (2008), *Does oil move equity prices? A global view.* Energy Economics 30(3), 986–997.

Park, J., Ratti, R.A., (2008)*, Oil price shocks and stock markets in the U.S. and 13 European Countries.* Energy Economics (30), 2587–2608.

Ramey, V.A., Vine, D.J., (2010), *Oil, automobiles, and the US economy: How much have things really changed?* NBER Working Paper No. 16067, June 2010, 333–367.

Sadorsky, P., (1999), *Oil price shocks and stock market activity.* Energy Economics (21), 449–469.

Salisu, A.A., Fassanya, I.O., (2012), *Comparative Performance of Volatility Models for Oil Price.* International Journal of Energy Economics and Policy 2(3), 167-183

Scholtens, B., Yurtsever, C., (2012), *Oil price shocks and European industries.* Energy Economics 34(4), 1187–1195.

Toda, H.Y., Yamamoto, T., (1995), *Statistical inference in vector autoregressions with possibly integrated processes.* Journal of Econometrics 66(1-2), 225–250.

Wang, Y., Wu, C., Yang, L., (2013), *Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries.* Journal of Comparative Economics 41(4), 1220-1239.

Appendix: Calculations of the cost-side dependence η

The η for all industries in Germany is calculated according to equation (9) based on the input-output-tables of the German Federal Staistical Office (2007; 2010). The industry classification follows the German Federal Statistic Office (2003). If possible, comparable classifications according to the NAICS code are statet in parentheses.

Table A.1. Cost-side dependence η for all industries

Class.	Idustry	η
23	Petroleum and Coal Products (324)	13.741*
62	Air transportation (481)	13.194*
61	Water transportation (483)	3.733*
37	Waste products	3.384*
60.2, 60.3	Transit and ground passenger transportation (485)	3.257*
24 (excl.24.4)	Chemical products (325)	2.946*
27.1-27.3	Iron and steel manufacturing	2.435*
1	Farms (111CA)	1.493
25.2	Plastics (326)	1.251
5	Fishing (113FF)	1.228
26.1	Glass and glassware	1.085
60.1	Rail transportation (482)	1.027
14	Quarrying and mining products	0.944
2	Forestry (113FF)	0.940
63	Other transportation and support activities (487OS)	0.856
45.1-45.2	Structural and civil engineering	0.826
40.1-40.3	Electricity and gas production	0.762
26.2-26.8	Ceramic	0.598
27.5	Metals and semifinished products	0.522
15.9	Beverage (311FT)	0.454
51	Whole sale services	0.452
20	Wood products (321)	0.411
10	Coal and peat extraction	0.381
75.1-75.2	State and local general government	0.363
50	Car dealership, repairs and fuel services	0.360
80	Educational services (61)	0.294
52	Retail trade (44RT)	0.274
15.1-15.8	Food (311FT)	0.272
90	Waste management and remediation services (562)	0.259
36	Furniture and related products (337)	0.254
92	Performing Arts, spectator sports, museums, and related activities (711AS)	0.239
22.1	Publishing industries (includes software)	0.237
64	Telecommunications services (513)	0.229
19	Leather and leather products (315AL)	0.229
21.1	Wood products (321)	0.227
73	Research and development services	0.219
27.4	Foundry products	0.218
93	Other services	0.206
17	Textiles (313TT)	0.198
41	Water and water supply services	0.193
85	Health care services (621 and 622HO)	0.191
24.4	Pharmaceutical products	0.180
28	Fabricated metal products (332)	0.176
16	tobacco products (311FT)	0.159
21.2	Paper products (322)	0.155
74	company related services	0.153
18	Apparel (315AL)	0.148
31	Electricity generation equipment	0.137

30	Office machines and data processing equipment	0.136
55	Accommodation (721)	0.133
91	Church and special interest group services	0.133
35	Other vehicles	0.132
25.1	Rubber products (326)	0.124
34	Motor vehicles and parts (3361MV)	0.116
72	Information and data processing services (515)	0.114
29	Machinery (333)	0.110
22.2-22.3	Printing and related support activities (323)	0.109
32	Broadcasting products	0.104
33	Medicine, measurement and control technologies	0.097
75.3	Social insurance services	0.074
71	Rental and leasing services (532RL)	0.066
67	Credit and insurance related services	0.046
66	Insurance carriers and related activities (524)	0.034
65	Credit institution services	0.018
70	Real estate services (531)	0.007
95	Services of private households	0.000
11	Oil and gas extraction (211)	0.000
13	Ore extraction	0.000
12	Uran and thorium extraction	0.000