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## How strongly did the 2007/08 oil price hike contribute to the subsequent recession?

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# How Strongly Did the 2007/08 Oil Price Hike Contribute to the Subsequent Recession?

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# How Strongly Did the 2007/08 Oil Price Hike Contribute to the Subsequent Recession?

## Abstract

In this paper we challenge the view that the oil price has lost its influence on economic activity after the mid-1980s. While we concede that typical VAR models put forward in the literature fail to identify oil price shocks that significantly affect aggregate production, we obtain clearly negative output and positive producer price effects of oil price hikes in a firm level analysis for which we exploit a unique microeconomic data set for Germany. Inspired by this finding, we aggregate the firm level information into a single indicator that signals in which periods the German economy was in a supply regime, i.e., in a situation when prices and production moved into opposite directions. Concentrating an otherwise standard VAR based search on these periods, we are able to identify an oil price shock that affects the German production even on the aggregate level. In a counterfactual analysis we show that the 2007/08 oil price hike contributed notably to the subsequent recession in Germany even though it was by far not the main driver.

JEL-Code: C300, E300, E320.

Keywords: oil price shock, VAR model, micro data.

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# 1 Introduction

Conventional wisdom says that the worldwide recession of the years 2008/09 was driven by the downturn of the real estate market in the United States and the following crisis of the banking sector, which peaked with the bankruptcy of Lehman Brothers in September 2008. However, some voices argue that other reasons significantly contributed to the recession as well. The preceding oil price hike reaching 159 USD per barrel in June 2008 is a often cited candidate. Hamilton (2009) even argues that in the absence of the high oil price perhaps no recession had occurred.

This statement is controversial. Recent literature suggests that the effects of oil price changes on the economy decreased or even vanished over the last 30 years. Specifically, many authors find that a structural break in the oil price-macroeconomy relationship occurred during the first half of the 1980's. For the time thereafter it seems difficult to identify effects of the oil price on the macroeconomy by using standard VAR approaches (Herrera and Pesavento, 2007, Hooker, 2002). For the G-7 countries Blanchard and Gali (2008) conclude that the oil price has lost its influence on the production level since 1983. They argue that this finding can be explained by more flexible labor markets, more credible monetary policy and a smaller share of oil in the production process.

As a major drawback, many of the results in the literature are based on the assumption that oil price changes are caused by only one single structural shock which is thus very general and difficult to interpret. Kilian (2008) tackles this problem by decomposing oil price changes into demand and supply driven shocks. By comparing seven major industrialized economies he shows that exogenous oil supply shocks can trigger economic downswings, yet the magnitude of the effects differs from country to country. More recently, Kilian (2009) decomposes oil price surprises into three components, namely, world economic demand, world supply of oil and precautionary demand for oil, which captures market concerns about the availability of future oil supply. His central conclusion is that only supply driven oil price shocks and precautionary demand shocks have negative effects on macroeconomic aggregates, while a mainly demand driven shock itself does not affect the economy. Concerning the last recession Kilian (2009) concludes that the oil price increase during 2008 did not contribute to the crisis, since the preceding oil price increase was mainly caused by world demand.

In contrast, Hamilton (2009) argues that the oil price increase in 2008,

although being driven by increasing world demand, affected most countries much like a supply driven shock because the additional world demand mainly was originated by one single country, China, and that this single country took so much of the oil supply that the other countries experienced this as a supply shock.

A further issue pointed out by Hamilton (1996, 2003) is the possible existence of asymmetries in the effects of oil price shocks. He argues that oil price hikes give rise to recessions, whereas oil price decreases do not affect macroeconomic activity to the same magnitude. Moreover, oil price increases may be much less harmful to the macroeconomy if they simply correct preceding decreases.

Against this background, our paper has two aims. First, it contributes to the economic debate whether the oil price has lost its influence on aggregate activity since the mid-1980s as argued by Hooker (2002), Herrera and Pesavento (2007), and Blanchard and Gali (2008). Second, it re-assesses how important the 2007/08 oil price hike was as a cause for the subsequent recession, thereby adding to the discussion between Hamilton (2009) and Kilian (2009). The idea of the paper is to augment an otherwise standard macroeconomic VAR model with information from the firm level and use this to identify an oil price shock that leads to a slump in production and an increase in the general price level, and can thus be termed a “classical” oil supply shock. We concentrate on the German economy as for the German manufacturing sector there exists a unique firm level data set which allows us to implement our combined macro-micro perspective.

We start our analysis by applying various VAR approaches suggested in the literature to identify oil price shocks hitting the German economy. It turns out that it is hardly possible to detect any recessionary tendencies after such a shock. This finding is in line with the results in the literature and seems to confirm that the oil price has lost its influence on the macroeconomy. However, the identification of an oil supply shock is difficult and quite controversial, see Kilian and Murphy (2010). In particular, to convincingly disentangle oil supply from, say, world demand shocks, it is necessary to control for all exogenous demand shifts that affect the oil price. Since the relationship between world demand and oil prices is anything but certain, this amounts to a challenging task.

By exploiting a novel microeconomic panel data set that comprises monthly business survey results for the German manufacturing sector we can alleviate this issue. Controlling for demand developments on the firm level we obtain

significant and intuitive direct effects of oil price changes on production and prices. In addition, we find that demand side effects are strong and may thus obscure the negative effects of oil price hikes in aggregate models.

Inspired by these results, we aggregate the firm level data into an indicator that signals whether the German economy was in what we call a supply regime, i.e., in a situation when prices and production moved into opposite directions. We then take up our VAR analysis but this time concentrate on supply regime periods. It turns out that this is sufficient to identify an oil supply shock with intuitive and statistically significant effects even on the aggregate level. In a counterfactual analysis we show that these effects are also economically significant.

The remainder of the paper is structured as follows. Section 2 provides an analysis on the macro level using different approaches from the literature to examine the effects of oil price changes on German production. In Section 3 we estimate the effect of oil price changes on production and prices at the firm level. In Section 4 we augment an otherwise standard VAR model with the supply regime indicator and find a significantly negative effect of oil price hikes that is robust to a large number of model variations. In Section 5 we ask whether the German economy would have avoided the recent recession if the preceding oil price hikes had not occurred. Section 6 concludes.

## **2 Standard Approaches to Identify the Effects of Oil Price Shocks on the German Economy**

In this section we apply several standard approaches put forward in the literature to identify the effects of oil price shocks on the German economy. In the first step we modify the VAR model for Germany of Peersman and Smets (2003) in a way that allows us to study the effects of unexpected oil price changes. The main drawback of this baseline model is that it only allows for a single, and thus very general, oil price shock. In the second step, we therefore integrate a model of the world oil market in the line of Kilian (2009)—which identifies one supply-specific and two demand-specific oil price shocks—with the German VAR model. To ensure that the results do not depend on a single identification strategy, we use both a Cholesky decomposition as in Kilian (2009) and the sign restriction approach suggested

by Peersman and Van Robays (2009).

## 2.1 The Baseline Model

Our baseline model is a variant of the well-known VAR model for Germany of Peersman and Smets (2003). Unlike them, we specify it with monthly variables and include the nominal oil price instead of a world commodity price index. The model is

$$Y_t = B(L)X_t + A(L)Y_{t-1} + u_t, \quad (1)$$

where  $Y_t$  denotes the vector of endogenous variables and consists of the nominal WTI oil price in euros<sup>1</sup>, German industrial production, the German producer price index, the three-month Euribor<sup>2</sup> and an indicator for German price competitiveness.<sup>3</sup> The vector  $X_t$  defines the exogenous variables, which are included to control for changes in world demand. It contains US industrial production and the effective Fed Funds rate.

We estimate the VAR model in levels using monthly data over the period from January 1980 to February 2009. The sample is chosen to be consistent with our subsequent analysis of a microeconomic data set which is only available for this time period. As proposed by Peersman and Smets (2003) the VAR features a constant and a time trend, and all variables are seasonally adjusted and expressed in natural logarithms, except for the nominal interest rate. The model is estimated as a subset VAR, i.e., we impose the restriction that the oil price only depends on its own lags, a constant, a time trend and the variables summarized in  $X_t$ . The VAR model contains 12 lags.<sup>4</sup>

The oil price shock is identified by applying the Cholesky decomposition, where the oil price is placed first to allow it to influence all German

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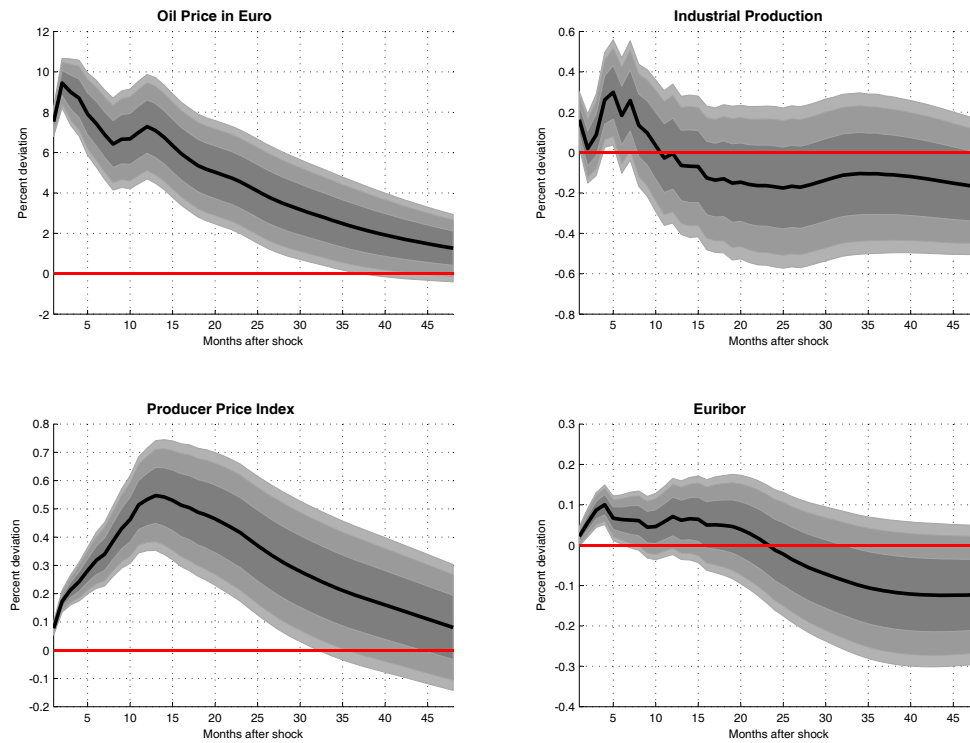
<sup>1</sup> We use the nominal rather than the real oil price for the following reason. Deflating the oil price with a German price index leads to an endogeneity problem, as the price index is affected by domestic variables which violates our assumption of a recursive structure in the following Choleski decomposition, see Fukunaga, Hirakata and Sudo (2010) and the references therein for a discussion.

<sup>2</sup>Before 1999 we use the Fibor as short term interest rate instead of the Euribor.

<sup>3</sup>The indicator for price competitiveness is taken from the Deutsche Bundesbank. It is based on exchange rates and consumer price indices against 23 selected industrial countries and thus can be interpreted as a real effective exchange rate.

<sup>4</sup>The qualitative results do not depend on the choice of the lag order.

Figure 1: Impulse Responses to an Oil Price Shock in the Baseline Model (68-, 90- and 95 Percent Confidence Intervals)



variables contemporaneously. For the remaining variables we choose the following ordering: industrial production, producer price index, Euribor and price competitiveness.<sup>5</sup>

The estimated impulse responses together with 68, 90 and 95 percent confidence bands computed by means of the Hall bootstrap procedure are shown in Figure 1. After an oil price shock, which brings about a price increase for oil of roughly 8 percent on impact, we observe a significant positive reaction of the producer prices. The impulse response function has a hump shape

<sup>5</sup>Changing the ordering of the unrestricted variables in the Cholesky decomposition does not greatly alter our results.



pattern and reaches its peak after 12 months. The nominal interest rate rises as well. However, the response is weak and becomes insignificant after 6 months. Surprisingly, industrial production expands in the first 6 months after the shock even if not highly significantly so. Only after one year the reaction becomes negative but it remains insignificant. Hence, we obtain the counterintuitive result that an unexpected oil price hike has expansionary short-term effects and only mildly contractionary medium-term effects.

## 2.2 The Kilian Type VAR Model with Choleski Decomposition

The main drawback of the baseline model is that it only allows for a single oil price shock which may be a mixture of oil demand and oil supply shocks. Hence, the counterintuitive result obtained before might be the consequence of an incomplete identification scheme.<sup>6</sup> Kilian (2009) addresses this problem by decomposing unexpected oil price changes into three components, namely, shocks to world economic demand, to world oil supply and to oil-specific demand. The latter captures shifts in market concerns about the availability of future oil supply and is therefore also called precautionary demand for oil. To implement this, we add the Kilian (2009) three-equation oil market model to a VAR model of the German economy in a way similar to Fukunaga et al. (2010). Specifically, the resulting VAR model has the form

$$\begin{pmatrix} Y_{1,t} \\ Y_{2,t} \end{pmatrix} = \begin{pmatrix} A_{11}(L) & 0 \\ A_{21}(L) & A_{22}(L) \end{pmatrix} \begin{pmatrix} Y_{1,t} \\ Y_{2,t} \end{pmatrix} + \begin{pmatrix} u_{1,t} \\ u_{2,t} \end{pmatrix}, \quad (2)$$

where  $Y_{1,t}$  defines the vector of global oil market variables and consists of the world oil production, global industrial production and the nominal WTI oil price in US dollars.<sup>7</sup> Here, we denominate the oil price in US dollars rather

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<sup>6</sup>Additionally, the linear relationship between oil price changes and output could be criticized. Hamilton (1996, 2003) proposes nonlinear transformations of oil price increases, called net oil price increases, to better capture asymmetric effects of oil price shocks. However, if one replaces the nominal oil price by net oil price increases, the results of the VAR model do not change considerably. In particular, we still do not obtain recessionary tendencies after an oil price shock.

<sup>7</sup>Global industrial production is proxied by the industrial production of the OECD countries plus the six major non-member economies. The oil price is given in nominal, instead of real, terms for the endogeneity problem discussed in Footnote 1. By using these two variables, we follow Fukunaga, Hirakata and Sudo (2010).

than in euros to be in line with Fukunaga et al. (2010) and Peersman and Van Robays (2009). The vector  $Y_{2,t}$  denotes the domestic macroeconomic block and contains the industrial production, the producer price index, the three-month Euribor and the indicator for price competitiveness as in the baseline model.

We estimate this Kilian-type VAR model using monthly data over the period from January 1980 to February 2009.<sup>8</sup> The VAR features a constant and 12 lags. All variables are seasonally adjusted, expressed in logs and transformed to first differences, except for the nominal interest rate.<sup>9</sup>

For the identification of the structural shocks to the global oil market we follow the recursiveness assumption by Kilian (2009). To identify oil supply shocks as innovations to global oil production, it is assumed that there exist no contemporaneous reactions of global oil production to global demand shocks and oil-specific demand shocks. This assumption is consistent with the consensus view in the literature that the short-run elasticity of oil supply is low. To disentangle the remaining two shocks, it is imposed that the oil-specific demand shock does not affect global industrial production on impact. For the domestic variables we allow that they respond contemporaneously to all oil market shocks. Moreover, we impose a lower triangular structure for the domestic macroeconomic block with the following ordering: industrial production, producer price index, Euribor and price competitiveness.

The cumulative (level) responses of the oil market variables and the German variables are shown in Figures 2 to 4. A negative oil supply shock leads to a permanent decline in oil production but has only a small and transitory effect on the oil price. The German variables are largely unaffected. Hence, we obtain the same counterintuitive result as in the baseline model. This time it is even more surprising, as the Kilian-type model is intended to carefully identify a classical oil supply shock.

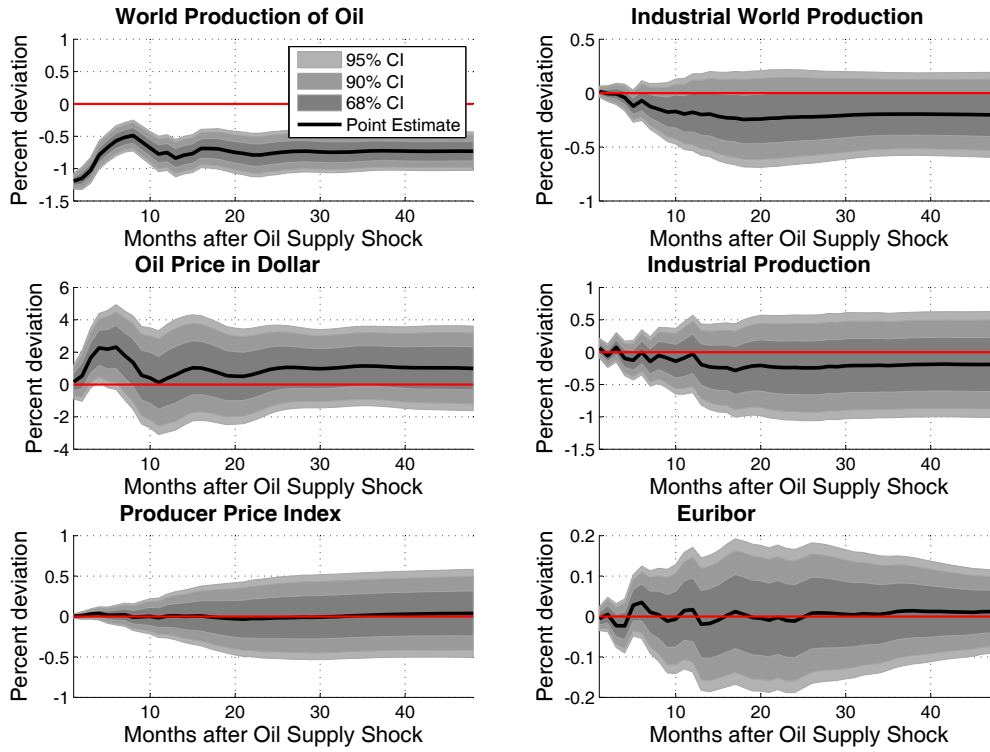
The global demand shock immediately shifts global industrial production upwards by 0.5 percent. The effect peaks after 18 months at 1.5 percent and remains significant for more than four years. As a consequence of this strong and long-lasting increase in world demand, both oil supply and oil prices

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<sup>8</sup>Estimating the oil market block with monthly data from January 1973 to December 2008 replicates the results of Fukunaga, Hirakata and Sudo (2010). However, our estimation sample starts 1980 to be consistent with the micro data approach reported below.

<sup>9</sup>Unlike Peersman and Smets (2003), both Kilian (2009) and Fukunaga et al. (2010) estimate their VAR models in first differences. To facilitate comparison with their results, we follow their specification.

Figure 2: Cumulative Responses to an Oil Supply Shock in the Recursive Kilian Model (68-, 90- and 95 Percent Confidence Intervals)

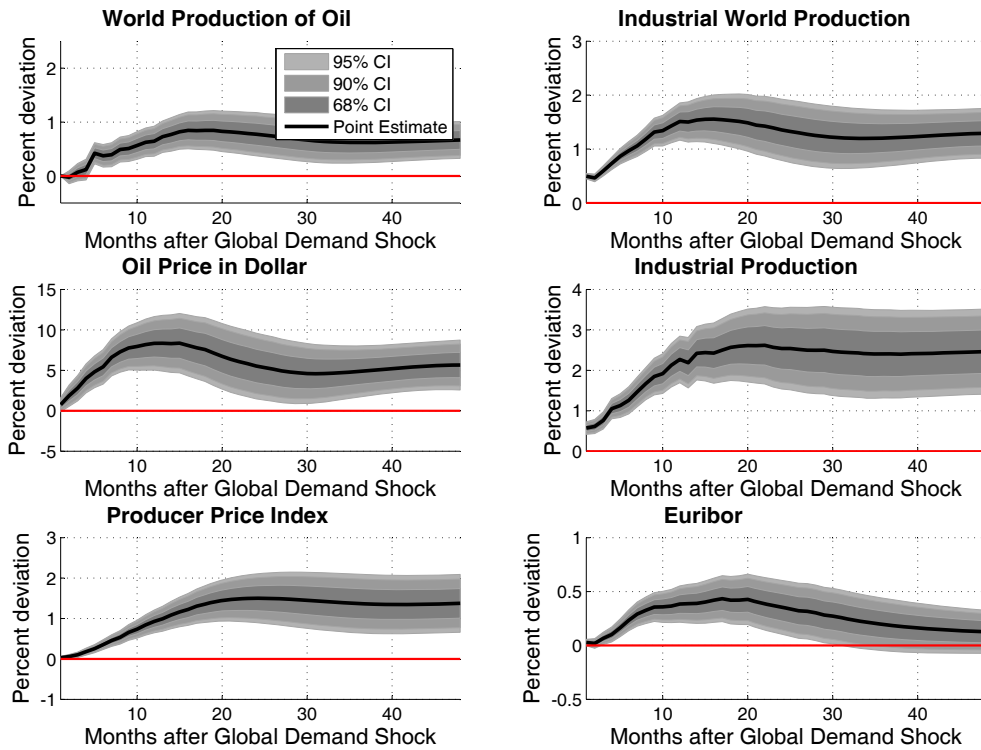


significantly increase for a sustained period of time. Given the export orientation of the German economy, German production reacts more strongly than world production and peaks after 20 months. At the same time, domestic prices increase and the central bank responds with an interest rate hike.

The oil-specific demand shock possesses a large and persistent effect on the oil price but not on oil production or world demand. Therefore, it only transmits to German producer prices which increase significantly. The influence on German industrial production is small and very short-lived.

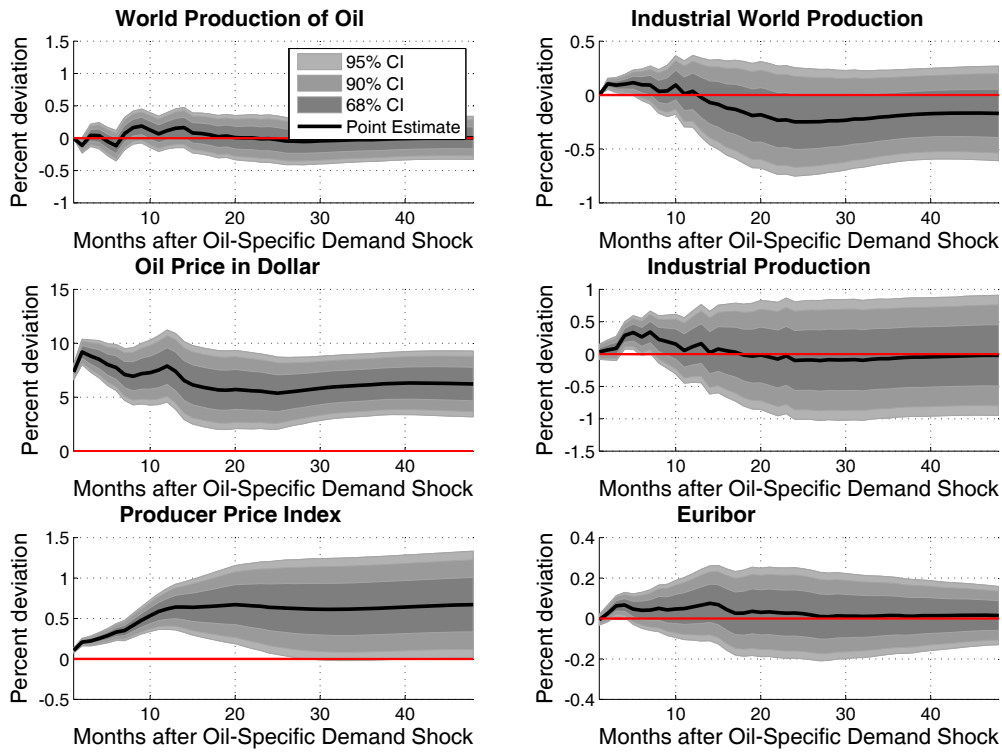
We conclude that identifying oil price shocks by means of the Kilian

Figure 3: Cumulative Responses to a Global Demand Shock in the Recursive Kilian Model (68-, 90- and 95 Percent Confidence Intervals)



approach does not alter the counterintuitive result of the baseline model that supply determined oil price shocks do not affect German economic activity. Instead we find that global demand shocks are of prime importance. That they raise both global oil prices and industrial production might explain the finding of the baseline model that a general, and thus difficult to interpret, oil price hike temporarily increases German production.

Figure 4: Cumulative Responses to an Oil-Specific Demand Shock in the Recursive Kilian Model (68-, 90- and 95 Percent Confidence Intervals)



### 2.3 The Kilian Type VAR Model with Sign Restrictions

In more recent papers, Baumeister, Peersman and Van Robays (2009) and Peersman and Van Robays (2009) try to relax the recursive identification assumptions imposed by Kilian (2009). They use the method of sign restrictions proposed by Peersman (2005) and Uhlig (2005) to disentangle the structural shocks affecting the oil price. More specifically, to identify an oil supply shock, a world demand shock and an oil-specific demand shock they restrict the impulse responses of global industrial production, global oil production and the oil price. In contrast to the Cholesky decomposition, this

identification approach uses soft restrictions in the sense that no zero restrictions are placed on the contemporaneous impact matrix. Our baseline sign restrictions are fully consistent with the restrictions used in the analysis of Peersman and Van Robays (2009) and are summarized in Table 1.

Table 1: Sign Restrictions (Restriction Period of 6 Months)

	Oil Supply Shock	Global Demand Shock	Oil-specific Demand Shock
Oil Production	$\leq 0$	$\geq 0$	$\geq 0$
Global Production	$\leq 0$	$\geq 0$	$\leq 0$
Oil Price	$\geq 0$	$\geq 0$	$\geq 0$

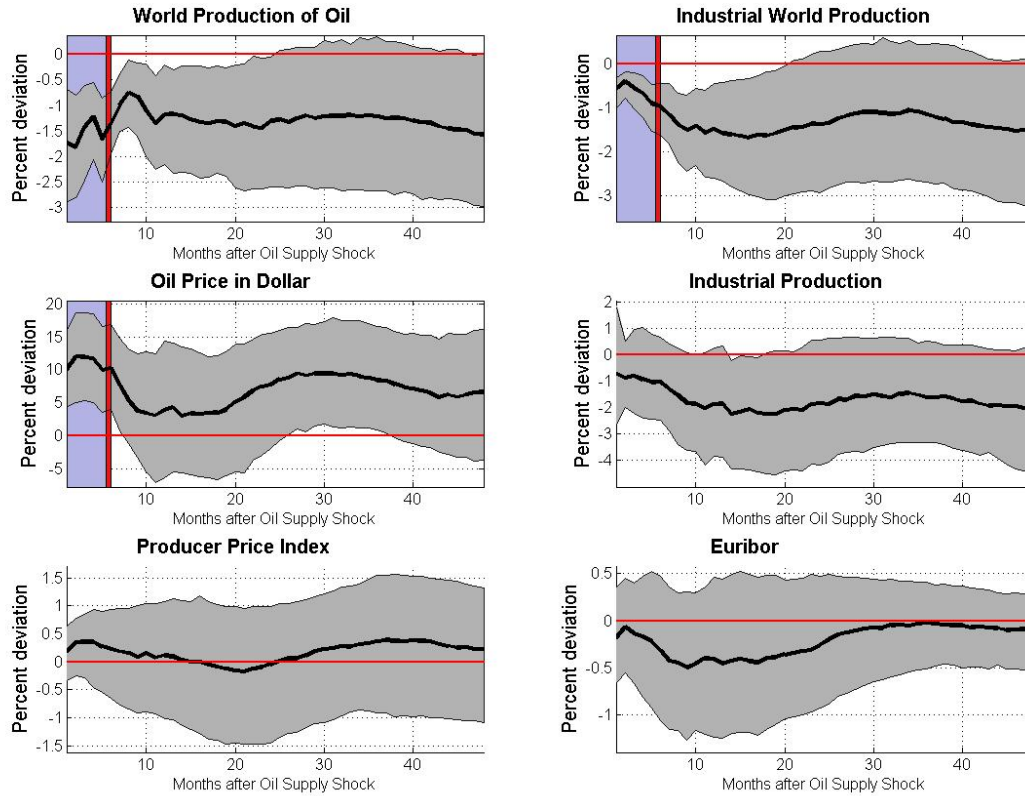
These restrictions imply that a contractionary oil supply shock raises the price of oil and reduces the global production of industrial goods and oil. A positive global demand shock raises oil production, global industrial production and the price of oil. A positive oil-specific demand shock triggers to a contraction of world output while the price and the supply of oil increase. Unlike Peersman and Van Robays (2009) we do not impose restrictions on any of the response functions for a whole year. We prefer a shorter restriction period of 6 months, as the results of the recursive identification scheme above suggests that a restriction period of 12 months might be a too strong assumption.<sup>10</sup>

Figures 5 to 7 depict the cumulated (level) impulse responses of the oil market and domestic variables together with the 16th and 84th percentile error bands.<sup>11</sup> All responses have been normalized to an increase in the price of oil by 10 percent. The effects of a negative oil supply shock identified with sign restrictions are grossly comparable to those identified above with the Choleski decomposition. As the major difference, the shock now leads

<sup>10</sup>This point is supported by the finding that the sign restriction algorithm takes a very long time (several weeks) in order to find the given number of admissible draws for a restriction period of 12 months.

<sup>11</sup>Again, the VAR-system is estimated by using monthly data over the period from January 1980 to February 2009. The VAR features a constant and all variables are seasonally adjusted, expressed in logs and transformed to first differences, except for the nominal interest rate. Note that the error bands are calculated with a Bayesian method of inference and not by the Hall bootstrap procedure. We report 68 percent confidence intervals as usual in the literature on Bayesian VAR models.

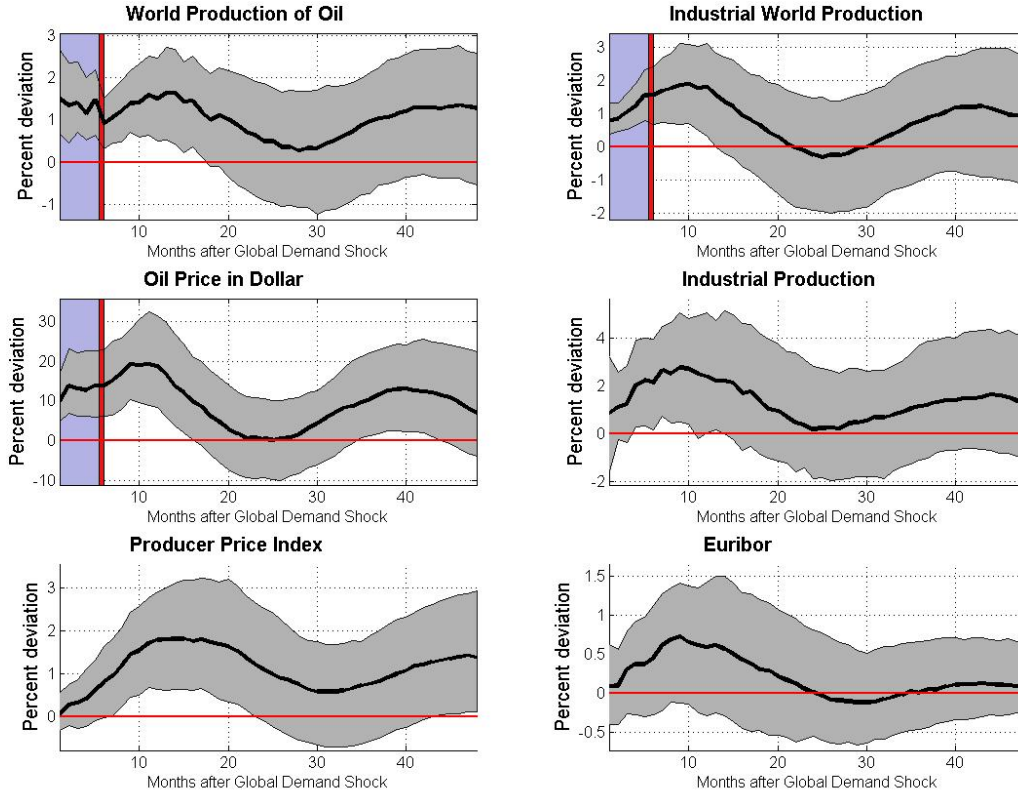
Figure 5: Cumulative Responses to an Oil Supply Shock Using Sign Restrictions (68 Percent Confidence Intervals)



to a significant contraction in world output. This translates into German industrial production, albeit not significantly so. Moreover, as before the German producer price index does not react at all. Hence, it is questionable whether this is really an oil supply shock. Concerning the other two shocks, the qualitative results do not seem to depend strongly on the identification scheme. For example, a global demand shock leads to a gradual increase in German production and prices which is qualitatively and in magnitude similar to the results reported above, while the dynamic patterns change somewhat.

Overall, we find that the sign restriction approach does not allow to con-

Figure 6: Cumulative Responses to a Global Demand Shock Using Sign Restrictions (68 Percent Confidence Intervals)

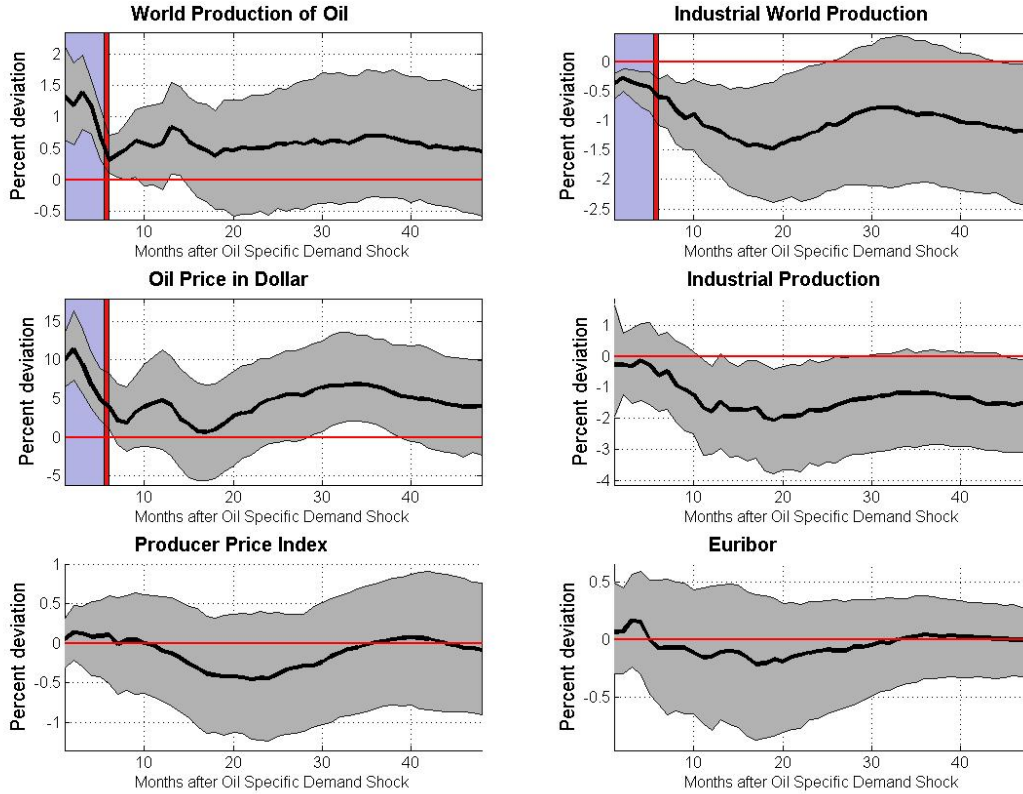


vincingly identify an oil supply shock which simultaneously shifts German production down and producer prices up. Besides this, in a recent paper Kilian and Murphy (2010) cast doubts on the empirical results based only on sign restrictions. In their view the results are biased due to the fact that the eventual impulse response functions are constructed as the medians of all admissible solutions to the sign restriction problem and many of them imply implausible magnitudes for the instantaneous impact on oil market variables, especially the short run elasticity of oil supply. This finally leads to an overestimation of the relevance of oil supply shocks.<sup>12</sup>

<sup>12</sup>We find that this is relevant also for our data set. Once we impose an upper bound



Figure 7: Cumulative Responses to an Oil-specific Demand Shock Using Sign Restrictions (68 Percent Confidence Intervals)



Taking all the previous results together we have to conclude that the VAR models proposed in the literature have difficulties to identify oil price shocks in a satisfactory way. In particular, the German output reactions are small and lack statistical significance. Does this mean that oil price shocks do not matter for economic activity? Given the importance attached to these shocks in the public and professional debate, this interpretation appears premature. It seems much more likely that the VAR models were not

for the absolute short term elasticity of industrial production to an oil supply shocks, the significance of the impulse response is further reduced. Detailed results are available upon request.

successful in disentangling supply and demand side developments. Therefore, in the remainder of the paper we proceed as follows. In the first step, we examine the direct effects of oil price changes on output and price setting at the firm level. This should help us to understand whether there are any noticeable contractionary effects of oil price hikes. The advantage of using firm-level data is that we can control for demand-side developments that otherwise may contaminate the results. However, we cannot derive general equilibrium results from a microeconomic analysis as feedback effects are neglected. Therefore, in the second step, we derive an indicator from the firm-level data that signals whether the firms are, on average, in a “supply regime” (output and prices move in opposite directions) as opposed to a “demand regime” (output and prices move in the same direction). We then use this indicator to identify oil price shocks within a VAR model of the German macroeconomy.

### **3 The Effects of Oil Price Shocks on the Firm Level**

For an average individual firm, a hike in the oil price has *ceteris paribus* a direct cost effect that should unambiguously lead to a reduction in output and an increase of sales prices. On the aggregate level, this effect might be masked if, for example, the oil price hike reflects an increase in world demand. While an appropriate identification scheme should be able to separate out such demand-side shocks, the results of the VAR models analyzed in the previous section indicated that this task is difficult to achieve without recourse to additional information.

Lescaroux (2011) argues that an analysis on the slightly more disaggregate sectoral level yields the expected result that an increase in oil prices depresses production. However, even at the sectoral level, the identification problem is not easily solved unless one is willing to impose an exogeneity restriction on the oil price (as done by Lescaroux, 2011). Therefore, in the following we use firm level survey data which allow us to control for demand developments that are exogenous to the firm. To this end, we estimate a production function and a price setting function for the average German industrial firm and introduce the aggregate oil price as one of the explanatory variables. It turns out that the oil price has a significantly negative effect on production and a

significantly positive effect on prices. After a brief description of the data set we explain our estimation strategy and present our results.

### 3.1 The Survey Data

To measure firm-level production and pricing in the German industry, we use the monthly business tendency survey of the Ifo Institute (for a description of the survey see Appendix A). Specifically, we consider two survey questions. The question “Compared to the previous month, our domestic level of production has decreased/remained unchanged/increased.” characterizes the change in production (*production*). The question “Compared to the previous month, our domestic sales prices have been increased/remained unchanged/decreased.” is used to assess the change in prices (*price*). For these and all comparable questions, the answers are coded as -1 (“decreased”), 0 (“unchanged”), and +1 (“increased”). Note that we analyze qualitative answers, i.e., firms report the direction but not the size of the changes. However, aggregating the firm-level data by subtracting the percentage of price decreases from the percentage of price increases for each month leads to time series that resemble macroeconomic conditions quite well, see Figures 8 and 9. The correlation of the aggregated survey production series and German industrial production is about 0.75, the correlation of the aggregated survey sales price series and the German producer price index is about 0.5.

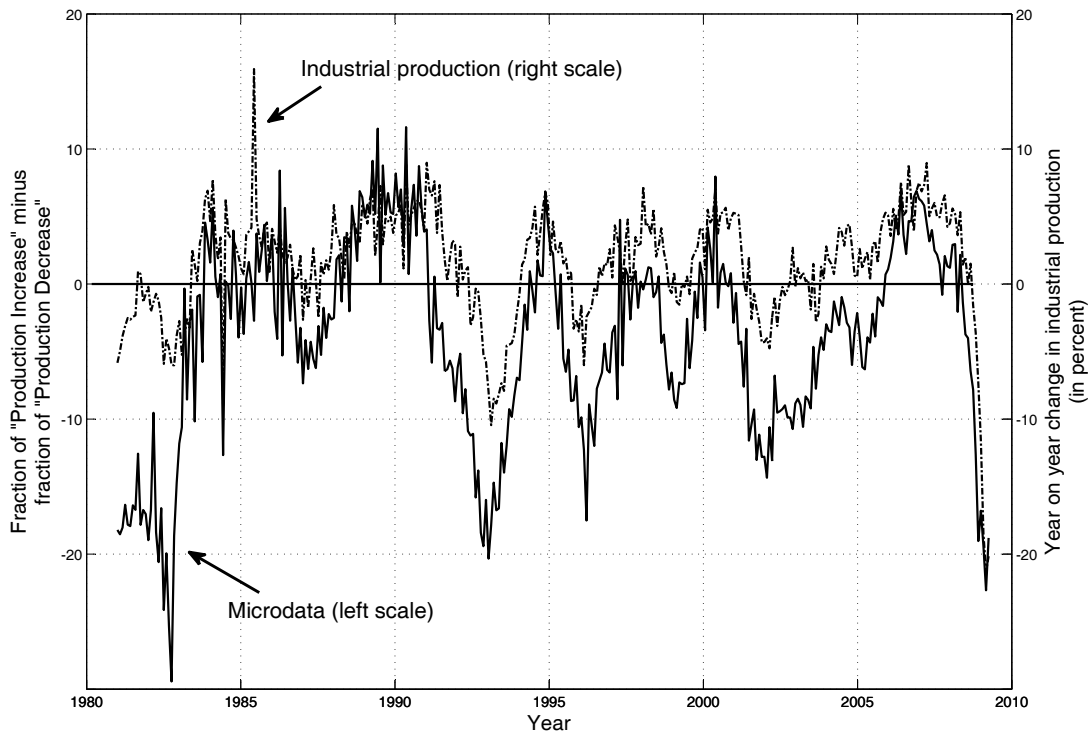
To account for firm-specific demand developments we consider two additional survey questions: the change in demand a firm faces (*demand*) and the change in incoming orders (*orders*). Further firm-specific information is included by using size and sector dummies. Concerning the size of a firm, we know whether the number of employees is below 50, between 50 and 199, between 200 and 499, between 500 and 999, or equal or above 1000. From this, five dummy variables are constructed that can also be interpreted as proxies for labor input in the production function. To control for sectoral differences, we add dummy variables that categorize the firms in one of the 14 industrial sectors listed in Appendix A. To account for geographical effects a dummy variable for Eastern Germany is included.

We use data of the period from January 1980 to February 2009.<sup>13</sup> The data set is organized as an unbalanced panel of around 11,000 firms of the manufacturing industry, which have participated at least 48 times in the

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<sup>13</sup>The firm-level data set is available to researchers with a delay.

Figure 8: Aggregated Micro Production Data and Industrial Production



survey.

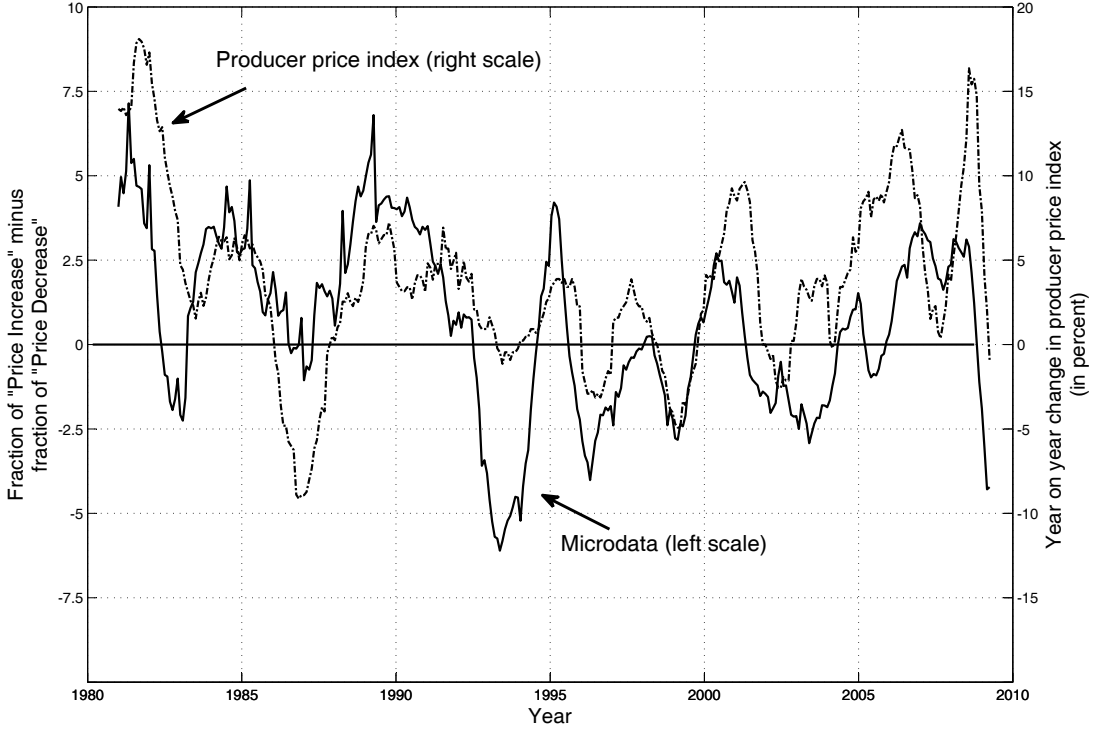
### 3.2 Modeling the Firm Level Effects of Oil Price Shocks

To identify the direct firm-level effects of oil price changes, we specify the following production and price setting functions which can be understood as general reduced form equations. We add various control variables to ensure that the effects are not spurious.

The production function is

$$y_{it} = oil_{it}\beta_1 + MACRO_{it}^{Ger}\beta_2 + MACRO_{it}^{US}\beta_3 + DEMAND_{it}\beta_4 + DFIRM_{it}\beta_5 + DMONTH_{it}\beta_6 + DEVENT_{it}\beta_7 + u_{it}, \quad (3)$$

Figure 9: Aggregated Micro Sales Price Data and Producer Price Level



where the production volume,  $y_{it}$ , is a latent quantitative variable that relates to the qualitative survey variable,  $production_{it}$ , by the observation rule

$$production_{it} = \begin{cases} -1, & \text{if } y_{it} \leq \alpha_1 \\ 0, & \text{if } \alpha_1 < y_{it} \leq \alpha_2 \\ +1, & \text{if } \alpha_2 < y_{it} \end{cases} \quad (4)$$

with threshold values  $\alpha_1$  and  $\alpha_2$ . The variable of main interest,  $oil_{it}$ , is defined as the firm-specific percent change of the WTI oil price in euros between month  $t$  and the last time firm  $i$  changed its production volume. We use this cumulative difference because firms do not report production changes every month. By regressing on this cumulative variable we face the problem of

potential endogeneity due to its state dependency. To alleviate this issue we follow the recommendations of Wooldridge (2005) and add the first individual observation of the dependent variable as an additional regressor to the model.

To be consistent with the baseline VAR model, we also include the remaining German and US macroeconomic variables, denoted as  $MACRO_{it}^{Ger}$  and  $MACRO_{it}^{US}$ , respectively.<sup>14</sup> Like the oil price, all these variables are defined as percent changes since the last revision of the production volume except for the interest rates for which the changes are given in percentage points.

By  $DEMAND_{it}$  we denote a vector of variables that control for the demand situation faced by an individual firm which is assumed to be predetermined in the month of a survey. Specifically, we use the survey variables change in demand (*demand*) and change in orders (*orders*). For both of them, there exist again three answer categories: -1=decrease, 0=unchanged, 1=increase. As these variables have an ordered outcome and the interpretation of coefficients estimated for such variables is not very convenient, we split each of them into two dummy variables. One dummy equals 1 if there is an increase and 0 otherwise and the other equals 1 if there is a decrease and 0 otherwise. We label them with the suffixes *up* and *down*, respectively.

To address the problem of unobserved firm heterogeneity concerning our firm-specific variables we include the vector  $DFIRM_{it}$  of firm-specific control variables. These include averages of each firm-specific variable as proposed by Mundlak (1978) and Chamberlain (1984). By introducing these averages we try to capture unobserved individual effects associated with the firm specific variables and therefore to alleviate the issue of unobserved heterogeneity.<sup>15</sup> In addition, we use a set of dummy variables controlling for the firm size, the sectoral classification as described above, and the geographical allocation (Western versus Eastern Germany).

Finally, we control for specific time patterns. First, seasonal effects are accounted for by including dummies for each month of the year ( $DMONTH_{it}$ ). Second, we also control for important institutional events that could have influenced the behavior of the firms ( $DEVENT_{it}$ ). The events considered are

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<sup>14</sup>The German variables are industrial production, the producer price index, the three month Euribor, and the indicator of price competitiveness. The US variables are industrial production and the federal funds rate.

<sup>15</sup>Furthermore, to tackle the potential problem of endogeneity between our firm-specific variables and our dependent variable we additionally apply a robustness check by including these variables as first lags in an alternative specification.

the physical introduction of the euro in 2002 and the changes in the level of the value added tax in 1983, 1993, 1998 and 2007. These dummies are equal to one for the month the change happened and for the past and following three months, as some firms may have reacted in advance or with a delay.

Because of the latent structure of the left-hand side variable, we estimate the parameters of the production function by means of an ordered probit model. To avoid distortions of the estimated standard errors we cluster the data on the firm level. To control for the decrease of observations in our panel data over time we weight the observations with respect to the number of observations of the corresponding time period.<sup>16</sup> Furthermore, to provide an additional robustness check with respect to the panel structure of our data set we also apply a linear fixed effects panel estimator.

Missing observations are handled as follows. In all estimations reported below, we use a data set from which incomplete spells are dropped because the calculation of cumulative differences requires spells that start and end with a production change. As a robustness check, we repeated all estimations by replacing missing observations with zeros which seems natural because the “no change” answer strongly dominates in the sample. The results remained qualitatively unchanged which suggests that concentrating on complete spells does not create a selection bias.

As a second equation we specify the price setting function of the firms. The dependent variable, *price*, is again qualitative. The right-hand side of the price setting equation is the same as in (3) as it is highly likely that a reduced form equation for the price setting equation contains the same explanatory variables as the reduced form equation for the production function. The macroeconomic variables are defined as the cumulative differences since the last price change. For the price setting decision, this approach reflects a possible menu cost behavior of the firms (see Loupias and Sevestre, 2010). We again create spells of consecutive observations, which start and end with a price change. Finally, to account for the lower trend inflation for the time after 1990, we include a dummy variable for this period.<sup>17</sup>

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<sup>16</sup>The decrease of observations over time reflects the change in the economic structure in Germany (decreasing importance of the industrial sector) rather than problems of the survey to acquire participants. However, we also present an estimation without the time weights as robustness check.

<sup>17</sup>Before 1990 average inflation was more than 1 percentage point higher than thereafter. This can also be seen in the price setting behavior of the firms if one computes the fractions of companies stating that they have raised or lowered their prices.

### 3.3 Results

The estimation results for the production function are shown in the Columns (1) to (5) of Table 2.<sup>18</sup> According to our baseline result in Column (1), an oil price hike significantly decreases the probability that a firm raises its production (and, vice versa, significantly increases the probability that a firm lowers its production), which is the expected result. Columns (2) to (5) display several variations of the model and the estimation method to check for the robustness of this result. First, we use an ordered probit estimator without time-weights, i.e., we neglect that the number of firms in the panel decreases over time (Column 2). Second, we drop the time dummies representing institutional events like value added tax reforms or the introduction of the euro because one could argue that there is some arbitrariness in choosing these events and not others (Column 3). Third, we lag the firm-specific variables by one month to minimize any potential endogeneity problem (Column 4). Finally, we apply a fixed effects panel estimator to take into account the panel structure of our data set (Column 5). In all cases the effect of the oil price is negative, highly significant, and of similar magnitude.

Furthermore, an increase in firm-specific demand, as measured by *demandup* and *ordersup*, leads to an increase in production, while a decrease in demand, as measured by *demanddown* and *ordersdown*, triggers a slightly asymmetric decrease in production. These effects are much stronger than the effects of our macroeconomic variables which suggests that the demand situation plays a central role for the production decision of a firm. Therefore, it is important to control for firm-specific demand if one wants to identify the direct effects of oil price increases. Otherwise, the positive correlation of oil prices and world demand in boom periods may bias the estimated oil price coefficient.

The results for the price setting function of the firms are displayed in the Columns (6) to (10) of Table 2. The baseline result in Column (6) shows that an oil price hike significantly increases the probability that a firm raises its prices. This result is robust to the same variations in the model and the estimation method as described for the production function, see Columns (7) to (10). Moreover, the effects of the firm-specific demand variables are again

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<sup>18</sup>Detailed results are available from the authors upon request. It turns out that the dummies controlling for the sector, the company size, the value added tax reforms, the implementation of the euro, and for seasonality are mostly significant.



Table 2: Results of the firm-level production and price setting equations

	Production equation				Price setting equation					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<i>OIL</i>	-0.011*** (0.001)	-0.013*** (0.001)	-0.012*** (0.001)	-0.009*** (0.002)	-0.031*** (0.003)	0.013*** (0.002)	0.014*** (0.001)	0.012*** (0.002)	0.016*** (0.002)	0.017*** (0.003)
<i>MACRO<sup>Ger</sup></i>	0.168*** (0.011)	0.173*** (0.010)	0.188*** (0.011)	0.346*** (0.014)	0.474*** (0.024)	0.077*** (0.013)	0.083*** (0.011)	0.118*** (0.012)	0.108*** (0.012)	0.258*** (0.022)
<i>ppi</i>	0.036*** (0.009)	0.041*** (0.009)	0.036*** (0.009)	0.002 (0.011)	0.093*** (0.022)	0.154*** (0.010)	0.157*** (0.010)	0.169*** (0.011)	0.127*** (0.010)	0.321*** (0.020)
<i>euribor</i>	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.003*** (0.000)	0.004*** (0.001)	0.004*** (0.000)	0.003*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.009*** (0.001)
<i>compet</i>	-0.007 (0.013)	0.000 (0.013)	-0.019 (0.013)	0.031** (0.015)	0.010 (0.030)	-0.002 (0.013)	-0.022* (0.012)	-0.032** (0.012)	0.053*** (0.013)	-0.044* (0.025)
<i>DEMAND</i>	0.219*** (0.004)	0.224*** (0.004)	0.219*** (0.004)	0.054*** (0.002)	0.409*** (-0.353)	0.021*** (0.002)	0.021*** (0.002)	0.021*** (0.002)	0.002*** (0.002)	0.037*** (0.003)
<i>demanddown</i>	-0.111*** (0.001)	-0.113*** (0.001)	-0.111*** (0.001)	-0.056*** (0.001)	-0.353*** (0.004)	-0.039*** (0.001)	-0.038*** (0.001)	-0.039*** (0.001)	-0.033*** (0.001)	-0.075*** (0.003)
<i>ordersup</i>	0.084*** (0.003)	0.076*** (0.003)	0.084*** (0.003)	0.075*** (0.002)	0.161*** (0.005)	0.036*** (0.002)	0.033*** (0.002)	0.036*** (0.002)	0.028*** (0.002)	0.058*** (0.003)
<i>ordersdown</i>	-0.089*** (0.001)	-0.087*** (0.001)	-0.089*** (0.001)	-0.086*** (0.001)	-0.244*** (0.004)	-0.048*** (0.001)	-0.046*** (0.001)	-0.049*** (0.001)	-0.039*** (0.001)	-0.090*** (0.003)
<i>MACRO<sup>us</sup></i>	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
<i>DFIRM</i>	yes	yes	yes	yes	no	yes	yes	yes	yes	no
<i>DMONTH</i>	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
<i>DEVENT</i>	yes	yes	no	yes	yes	yes	yes	no	yes	yes
Log-Lik.	-639668.29	-646312.67	-640093.28	-754601.83	-	-501228.23	-485935.99	-501586.74	-496610.50	-
Observ.	873657	873657	873657	866387	873657	701961	701961	701961	694956	701961

Columns (1)&(6): ordered probit, time weighted, clustered standard errors. Columns (2)&(7): ordered probit, not time weighted, clustered standard errors. Columns (3)&(8): ordered probit, time weighted, clustered standard errors, without dummies for institutional events. Columns (4)&(9): ordered probit, time weighted, clustered standard errors, firm-specific variables included in lags. Columns (5)&(10): linear fixed effects panel estimator. Columns (1)-(3) and (6)-(8): first observation of depended variable added as explanatory variable (see Wooldridge, 2005). Variable notations: indprod = industrial production; ppi = producer price index; compet = indicator for price competitiveness. All results expressed as marginal effects. Robust standard errors in parentheses. \*\*\*:  $p < 0.01$ ; \*\*:  $p < 0.05$ ; \*:  $p < 0.1$ .

statistically significant, quantitatively important, and of the expected sign.

To sum up, controlling for the firm-specific demand situation we find significant effects of oil price changes on the firm level in the German industrial sector: firms cut their production volume and increase their sales prices. Hence, from this perspective oil price changes can be interpreted as classical supply shocks.

## 4 Using a Supply Regime Indicator to Identify Oil Supply Shocks

The preceding analysis yielded conflicting results regarding the recessionary impact of oil price hikes. On the one hand, using VAR models it turned out to be difficult to convincingly identify negative oil supply shocks that significantly reduce aggregate output. On the other hand, using firm level data there was strong evidence that an average firm reacts to an increase in oil prices by cutting down on production. While it is certainly not possible to derive general equilibrium conclusions from a microeconomic production equation as feedback effects are not modeled, this approach nevertheless seems to deliver information that is not already contained in typical VAR models. Therefore, it could be beneficial to combine the firm level information with an otherwise standard VAR model in order to improve the identification of an oil supply shock to the German economy.

Our approach to use the firm level information is as follows. We calculate the fraction of firms in a given month which report that they move output and prices in opposite directions. If the fraction is large, we conclude that the economy is in a “supply regime”. Assuming that oil supply shocks generate output and price reactions of opposite sign, it seems sensible to concentrate the VAR based search for oil supply shocks on these periods. We implement this by assuming that the effect of an oil price shock depends on how deeply the economy is in a supply regime. It turns out that this is sufficient to generate impulse responses that coincide with both our theoretical expectations and the microeconomic evidence presented above. It should be noted that the definition of what we call a supply regime is not directly related to the development of oil prices because there can be many reasons why prices and output move into opposite directions. Hence, not only oil price shocks can give rise to supply regimes but all sorts of cost push and technology shocks.

This implies that we do not force the VAR to deliver the expected results but simply confine the search to more promising periods. Whether oil price shocks play any role in these periods is left unconstrained.

In the following, the construction of the indicator is described in detail. Subsequently, the indicator is introduced as an interaction variable into an otherwise standard VAR model to analyze how oil price shocks affect the German economy during supply regimes. Finally, some robustness checks are provided.

#### 4.1 Construction of the Supply Regime Indicator

The economy-wide supply regime indicator shall condense the firm level survey information to detect time periods where disproportionately many firms move their production and prices in opposite directions. To this end, for each firm a supply regime indicator,  $S_{it}^{\text{firm}}$  is constructed by subtracting the price response from the production response. Since both production and price responses are coded as  $-1$  (decreased),  $0$  (unchanged) and  $+1$  (increased), the new variable can have 5 different outcomes, see Table 3.

Table 3: Possible outcomes for the firm specific supply regime indicator

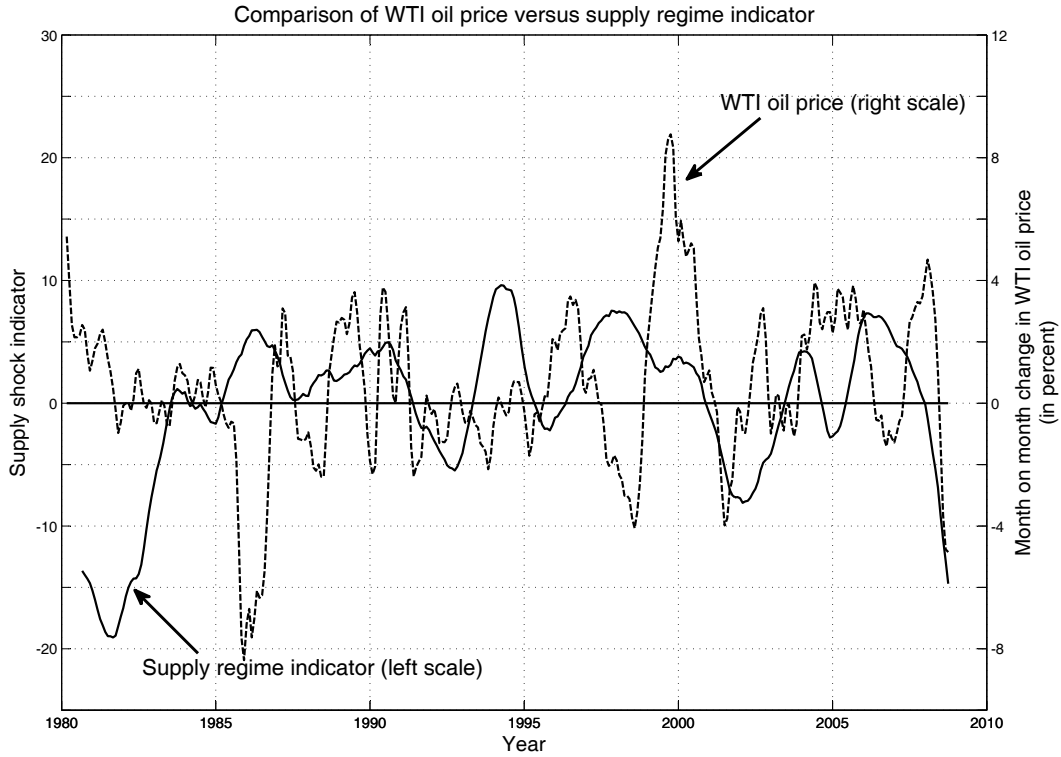
	Price Increased	Price Unchanged	Price Decreased
Production Increased	0	+1	+2
Production Unchanged	-1	0	+1
Production Decreased	-2	-1	0

The outcome  $-2$  indicates that the firm is in a contractionary supply regime as it increases its price and decreases its production level, while a value of  $+2$  indicates an expansionary supply regime where the price is reduced and the production volume is raised. Intermediate cases are coded with  $-1$ ,  $0$ , and  $+1$ . Note that what might be called a demand regime—price and production move in the same direction—is coded as  $0$ .

To calculate an economy-wide supply regime indicator we simply take the cross-sectional average of the firm specific indicator at each month,

$$S_t = \frac{1}{N} \sum_{i=1}^N S_{it}^{\text{firm}} \quad (5)$$

Figure 10: Economy-wide supply regime indicator



and center the resulting time series at zero. The upper panel of Figure 10 depicts the economy-wide indicator together with the month on month growth rate of the WTI oil price in euros. To enhance readability, both series are smoothed by means of a centered 12-month moving average. The supply regime indicator is particularly negative at the beginning of the 1980s after the second oil price shock, in late 2001 following the the 9/11 terrorist attacks, and in the second half of 2008 after the strong oil price increases. However, there is no clear stable relationship between the indicator and the movements of the oil price. This implies that the indicator carries information not already contained in the oil price.

## 4.2 Identification of Oil Price Shocks during Supply Regimes

To concentrate the VAR based search for oil price shocks on supply regimes, we use an interaction variable approach. To this end, we normalize the absolute value of the economy-wide supply regime indicator such that it takes values between 0 and 1. Let us denote this variable by  $I_t$ . It takes on values near 1 if many firms move their output and prices into opposite directions which signals that the economy is in a supply regime. We then multiply  $I_t$  with the WTI oil price in euros,  $oil_t$ , which yields the interaction  $Ioil_t = I_t oil_t$ . This is introduced into our baseline VAR model as follows:

$$Y_t = B(L)X_t + A(L)Y_{t-1} + C(L)Ioil_{t-1} + u_t, \quad (6)$$

where as before  $Y(t)$  denotes the vector of endogenous variables (the WTI oil price in euros, the industrial production, the producer price index, the three-month Euribor and the indicator for price competitiveness) and  $X_t$  comprises the exogenous variables (US industrial production and the effective Fed Funds Rate). The vector of lag polynomials  $C(L)$  corresponds to the interaction and can be interpreted as follows. During deep (positive or negative) supply regimes the indicator is near one. In this case, the total effect of the oil price on the left-hand side variables is the sum of the lag polynomial  $C(L)$  and the respective coefficients related to the oil price in the lag polynomial  $B(L)$ . Put differently, if the oil price is ordered first in vector  $Y_t$ , we add the first column of each matrix in  $A(L)$  to the corresponding vector of  $C(L)$ . In the other extreme, e.g. during strong demand regime periods, the indicator is 0 and  $C(L)$  can thus be neglected. In average times, the indicator is between 0 and 1 and downweights the coefficients in  $C(L)$ .

The interaction setup can be interpreted in two different ways. We prefer to think of it as a tool to disentangle oil supply from other shocks to oil prices, notably demand shocks. This is possible if oil supply shocks dominate other oil shocks during supply regimes. Hence, we do not identify world demand or oil-specific demand shocks. Moreover, we neither argue that oil supply shocks were absent during non-supply regime periods nor that other oil price shocks were absent during supply periods. All we say is that oil supply shocks dominate and are thus easy to identify during supply regime periods, i.e., during periods in which many firms move prices and output in opposite directions. Hence, the respective column in  $A(L)$  characterizes the average impact of a very general oil price shock during non-supply regime

periods while  $C(L)$  contains the additional effect during supply regimes that is presumed to be due to an oil supply shock. Their sum is thus the total effect that can be attributed to oil supply shocks.

Alternatively, the interaction dummy setup can be thought of as a way to detect non-linear relationships in the transmission of oil price shocks to the German economy. In contrast to Hamilton (1996, 2003), who proposes nonlinear transformations of oil price increases, our approach then poses that a general oil price shock may have different effects during supply regime periods and other times, no matter whether it is positive or negative. As a robustness check, we also restrict our indicator variable to contractionary supply regime periods, i.e., to periods when many firms reduce output and raise prices. As described below, this does not change the results markedly.

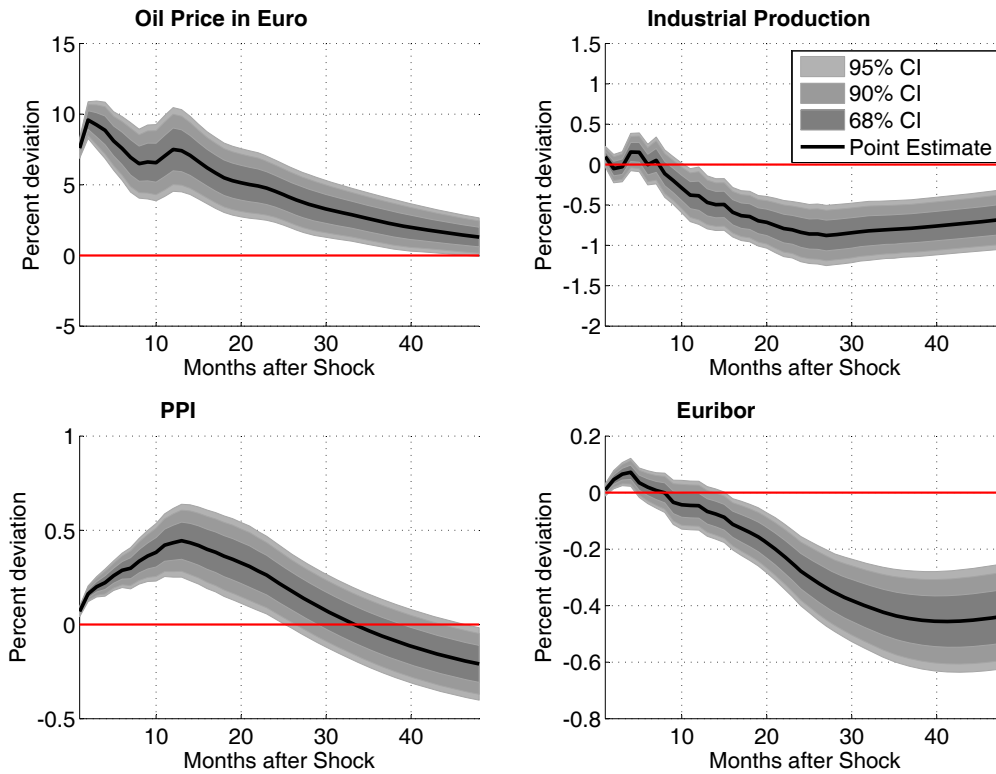
The interaction VAR model is estimated in levels using monthly data over the period from January 1980 to February 2009. It features a constant and a linear trend.<sup>19</sup> All variables are seasonally adjusted and expressed in natural logarithms, except for the nominal interest rate. The model is estimated as a subset VAR where the oil price defines the only subset variable. The covariance matrix is orthogonalized by means of a Cholesky decomposition, where the oil price is placed on the first position. For the remaining variables we choose the same ordering as in Section 2.

Figure 11 displays the impulse responses during a supply regime. The oil price shock triggers a very persistent increase in the oil price which peaks at nearly 10 percent after one month. Producer prices jump upwards on impact and rise further for more than one year. Industrial production does not change significantly during the first few months but it starts falling within the first year and remains below zero for an extended period of time. This is very different to the standard VAR model without interaction term analyzed above. Probably as a reaction to rising prices, the nominal interest rate goes slightly up on impact and is lowered only after industrial production has started to decrease. The results indicate that it is possible to identify oil price shocks which lead to a slump in production and a rise in prices.

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<sup>19</sup>We do not include the supply regime indicator  $I_t$  in levels as its interpretation is not straightforward. However, if we do so as recommended by, e.g., Brambor et al. (2005) for interaction models, the impulse responses remain largely unchanged.

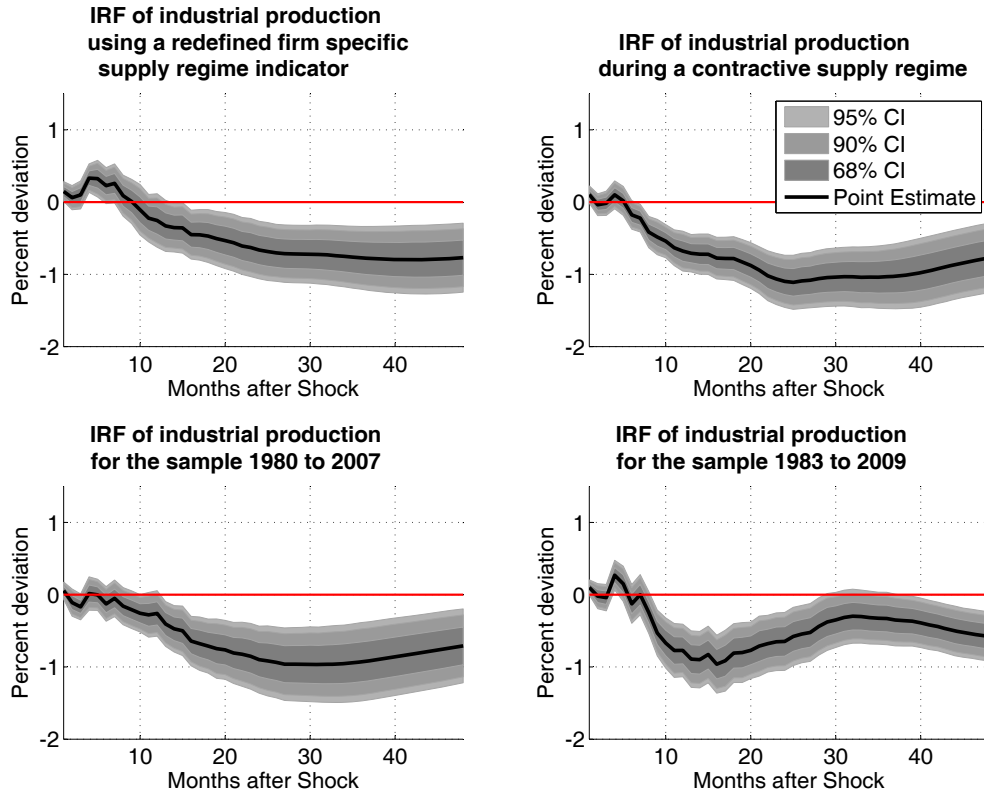
Figure 11: Impulse Response Functions to an Oil Price Shock during a Supply Regime (68-, 90- and 95 Percent Confidence Intervals)



### 4.3 Robustness Checks

In this section we provide a number robustness checks. As the first check, we redefine the firm specific supply regime indicator by assigning to it a  $-2$  if the firm increases its price and decreases its production level, a  $+2$  if the firm decreases its price and increases its production level, and a  $0$  else. This means that, unlike before, all intermediate cases, where one of the two variables changes and the other one is constant, are coded as  $0$ . Thereby, possible misallocations of periods as supply regimes that are in fact demand regimes are circumvented and the indicator becomes more selective. All other steps remain unchanged. The resulting impulse responses are very similar

Figure 12: Robustness Checks 1



to the baseline interaction VAR with the only exception that the short-term response of industrial production becomes significant, see Figure 12 (upper left panel).<sup>20</sup>

Following Hamilton (1996, 2003) who stresses the importance of oil price increases as opposed to decreases, we also consider to select only contractive supply periods, i.e., periods in which unusually many firms reduce output and raise prices. To this end, we set all values of  $I_t$  to zero for which the economy-wide supply regime indicator is positive. This means that we concentrate only on periods where our indicator provides evidence for a negative supply regime. This may have two advantages: First, the motivation for our

<sup>20</sup>Detailed results are available from the authors upon request.

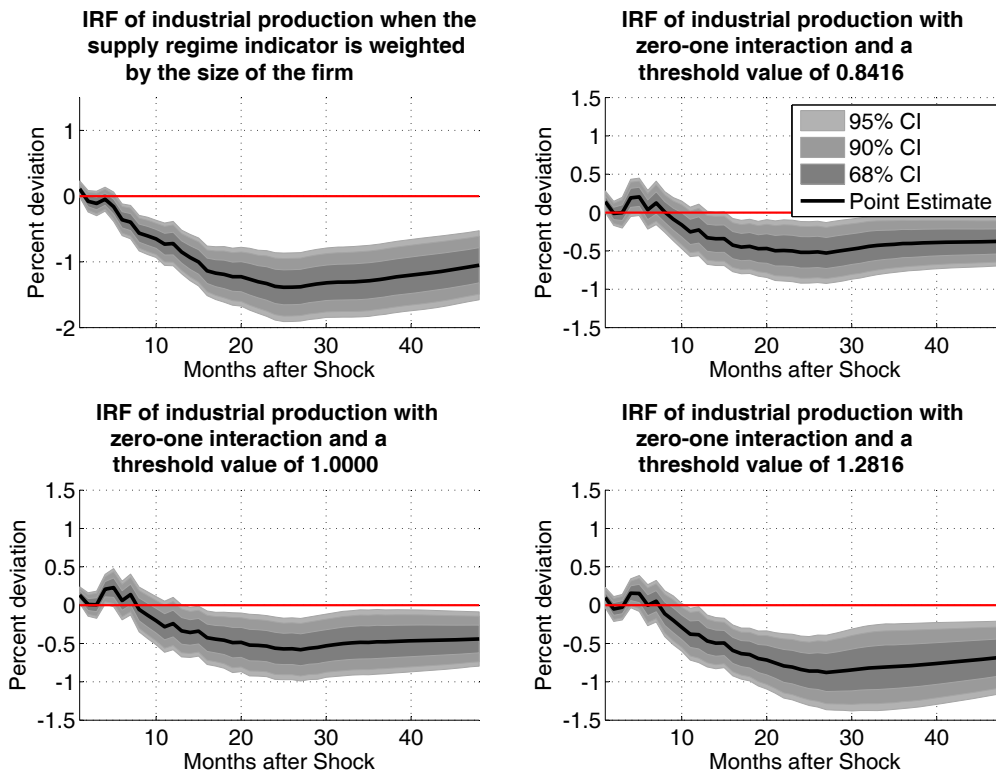


paper was the question whether and how the 2008 oil price contributed to the subsequent recession. Second, by identifying periods where the indicator features very positive values, we encounter the potential problem of not being able to distinguish between a cost shock (such as an oil price shock) and a positive technology shock. Assuming that economic contractions are rather not caused by negative technology shocks, this problem is mitigated during negative supply regimes. The impulse response of industrial production extracted from negative supply periods only is displayed in the upper right panel of Figure 12. It is very similar to the one extracted from both positive and negative supply periods. The same holds for all other impulse responses. Only the confidence bands are now tighter. This could reflect that it is easier to identify contractionary as opposed to expansionary oil supply shocks which is in accordance with the findings of Hamilton (1996, 2003).

To examine whether our results are driven by influential observations at the beginning and the end of the sample, we report estimation results based on either the period from January 1980 to December 2007 or the period from January 1983 to December 2009. The first sample excludes the recent recession and the preceding oil price hike in 2008, the second sample excludes the effects of the second oil price crisis that—according to our indicator—led to a contractive supply regime during 1980-82, see Figure 11. The resulting impulse responses are provided in the lower panels of Figures 12 and show that our previous findings remain largely unaltered. However, excluding the first three years of the sample has the effect that the output response becomes less persistent. Nevertheless, unlike Blanchard and Gali (2008), we still find strongly significant effects for the sample starting in the mid-1980s.

Furthermore, one could argue that neglecting the firm size when calculating our economy-wide supply regime indicator as an unweighted average across all firms could distort the results. This is possible if, e.g., large firms are better hedged against oil price risks and thus react more mildly than smaller firms such that an unweighted average would be too volatile. To the extent that this leads to a wrong identification of the supply regime periods, our baseline results could be biased. Therefore, in a next step we use an indicator that is constructed as a cross-sectional average weighted by firm size. Firm size is measured as the fraction of employees in firm  $i$  in the total number of employees at time  $t$  ( $empfrac_{it}$ ). The weighted economy-wide supply regime indicator is then constructed from the firm-specific supply regime variables  $S_{it}^{\text{firm}}$ —defined as the firm’s production response minus its

Figure 13: Robustness Checks 2



price response—as

$$\tilde{S}_t = \sum_i empfrac_{it} S_{it}^{\text{firm}}. \quad (7)$$

After centering this variable, we proceed in the same way as in the baseline interaction VAR. It turns out that accounting for the firm size does not change our findings to a large extent. In particular the impulse response of production remains largely unchanged, see the upper left panel in Figure 13.

As a final robustness check, we use a zero-one instead of a continuous interaction. To this end, we construct a dummy variable  $D_t$  that is assigned a value of 1 if in a certain month the economy-wide supply regime indicator lies outside the range  $[-v, v]$ . To limit the arbitrariness of a specific threshold

value  $v$  we report the results for three different choices, namely  $v = 0.8416\sigma$ ,  $v = 1.000\sigma$ , and  $v = 1.2816\sigma$ , where  $\sigma$  is the sample standard deviation of the supply regime indicator. Under normality, these thresholds correspond to the 20, 16, and 10 percent quantiles, respectively. We then replace  $I_{oil}_t$  in (6) with  $Doil_t = D_t oil_t$  and leave everything else unchanged. The resulting impulse responses of industrial production after an oil supply shock are displayed in the upper right and the two lower panels in Figure 13. It turns out that the downswing in production is the larger the more observations are placed in the non-supply regime. This is the expected result as on the flip side this means that the reaction becomes (absolutely) stronger the smaller and, thus, the more extreme the sample is from which the oil supply shock is identified. Still, the exercise demonstrates that our identification strategy does not depend very strongly on how the dummy is defined. In addition, the difference to the continuous interaction approach is not substantial.

## 5 How Strongly Did the 2007/08 Oil Price Hike Contribute to the Recession in Germany?

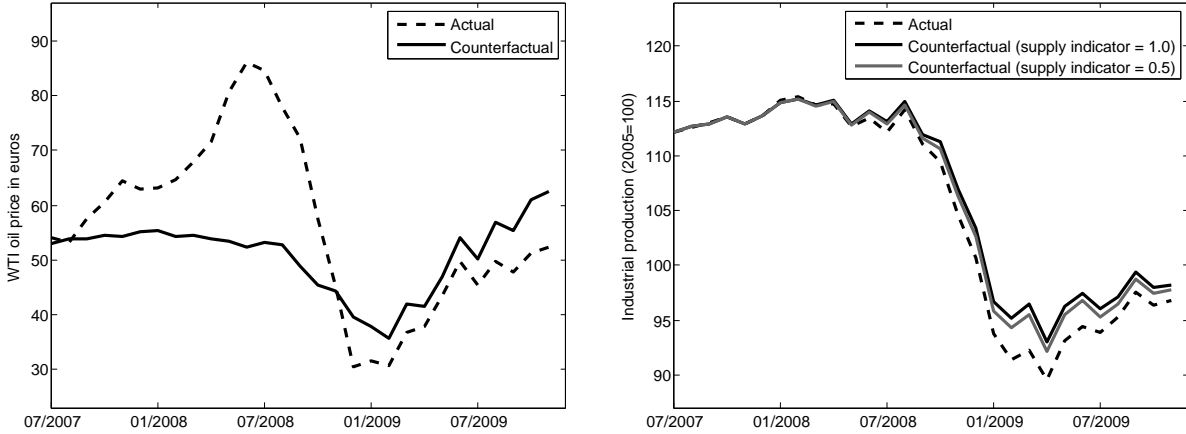
In the preceding section we have shown that there exists a clear relationship between oil price changes and real economic activity. Now we examine how strongly the oil price hike in 2007/08 contributed to the recent recession in Germany. To this end, we set all oil price shocks from July 2007 to February 2009 to zero and calculate the counterfactual development of the variables endogenous to our VAR model. We find that both the initial increase and the subsequent decline in oil prices would not have occurred, see Figure 14 (left panel). Without the shocks, the oil price would have stayed between 50 and 60 euros per barrel until mid-2008 instead of rising up to almost 90 euros. Being partly driven by the US business cycle it would have dropped to 40 euros during the US recession and recovered to 60 euros by December 2009.<sup>21</sup>

The effect on German industrial production can be inferred from the right panel of Figure 14. Even without the oil price shocks, there would have been a huge drop in German production because in the counterfactual

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<sup>21</sup>Note that our estimation sample ends in February 2009, hence this is an out-of-sample forecast and must be taken with great caution.

Figure 14: Counterfactual Analysis for Industrial Production



experiment we leave US industrial production and the Federal funds rate plunge as actually observed, which in turn drives Germany into a recession. Nevertheless, the oil price has a non-negligible effect on German production. The extent of this effect depends on the development of the supply regime indicator which took values between 0.5 and 1.0 since August 2008. As we did not model this variable, we assume that an endogenized counterfactual indicator would have been within this range. Specifically, we perform two counterfactual experiments taking as given over the whole simulation period an indicator value of either 0.5 or 1.0. It turns out that without the oil price shocks, average production in 2009 would have been between 1.9 and 2.7 percent higher for supply regime indicator values of 0.5 and 1.0, respectively.

At first sight, a direct oil price effect on German output in the range of 2.5 percent appears to be small given a total drop in production of more than 15 percent from 2008 to 2009. However, the average annual growth rate of German production between 1991 and 2007 was as small as 1.2 percent and thus only half of the oil price effect. In addition, one has to bear in mind that the experiment leaves US industrial production and the Federal funds rate as actually observed because they are exogenous to our VAR model. To the extent that the oil price hike had a contractive effect on the US business cycle, the transmission to German production would have been stronger. Hence, our results can be interpreted as a lower bound for the unknown total effect.

## 6 Conclusion

In this paper we have shown that the oil price still has an economically and statistically significant effect on aggregate production in Germany. Thereby, we challenged the view put forward in the literature that oil price increases have lost their influence on the macroeconomy since the mid-1980s. We arrived at this conclusion in three steps.

First, when estimating standard VAR models often used to assess the impact of oil price shocks on macro variables, we replicated the neutrality result of the literature. It is however debatable whether this finding really reflects the unimportance of oil products for the economy or whether it must be attributed to the difficulty to identify an oil price shock that is not contaminated by demand developments. This is important because demand shocks move output and oil prices simultaneously in the same direction and may thus obscure the negative effect independent oil price shocks have on output.

Therefore, in a second step, we analyzed the effect of oil price changes on output and prices at the firm level using a unique survey data set for German manufacturing firms. The microeconomic approach has the advantage that problems of endogeneity and reverse causality are circumvented. Moreover, the data allow to control for demand shifts faced by the firms. Estimating reduced form production and pricing functions yielded the plausible result that oil price hikes lower production and increase prices. From this we concluded that oil price shocks should be easier to identify on the macro level if we concentrate on supply regime periods, i.e., on periods in which output and prices move into opposite directions.

In a third step, we implemented this idea by constructing a survey based indicator that signals how deeply the German economy is in a so-defined supply regime. We augmented an otherwise standard VAR model for the aggregate economy with this indicator and obtained the same result as on the micro level, namely, that positive oil price shocks lead to rising prices and declining output. In a counterfactual analysis, we showed that oil price changes are not only statistically significant but also quantitatively relevant: Without the 2007/08 oil price hike, German industrial production in 2009 would have been around 2.5 percent higher than actually observed. Given an average annual growth rate of 1.2 percent this is a notable effect. At the same time, this result is not in conflict with the view that the oil price was not the major driver of the 2009 recession which witness a total drop in production of more than 15 percent.

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# Appendix

## A The Ifo Business Tendency Survey

The micro data stems from the Ifo Business Tendency Survey for the German manufacturing industry. The survey is conducted monthly since 1949 and serves as base for the well-known Ifo Business Climate index. However, due to longitudinal consistency problems and availability of micro data in a processable form we only use the data since 1980. Before 1991, only firms from West Germany participated in the survey. Subsequently, the panel was enlarged to Eastern Germany. Currently, the total number of companies registered for the survey is about 3200. The participation rate is about 92 %, resulting in a coverage ratio of about 35 % of the German manufacturing industry in terms of turnover (Goldrian (2004)). The firms are asked about the development of certain key measures. These measures are classified in groups concerning the current situation (business situation, volume of orders), tendencies in the past month (demand, production level, domestic sales prices, volume of orders), expectations for the next 3 months (production level, domestic sales prices, exports and employment) and expectations for the next 6 months (business situation). The enterprises can give one of three categorical answers (“1” positive, “2” neutral, “3” negative) per standard question.

For our analysis, the information on the production development, the price development, the order development and the demand development is central. In order to better understand the information the data set contains, this section provides some details on the questionnaire design of the central variables. As far as production realizations are concerned, firms are asked to answer the following question: *“Compared to the previous month, our domestic level of production has decreased/remained unchanged/increased”*. Concerning the price realizations the firms are asked to answer the question *“Compared to the previous month, our domestic sales prices have been decreased/remained unchanged/increased”*. Regarding the demand situation, firms are asked to answer the following question: *“Compared to the previous month, our demand situation has improved/remained unchanged/worsened”*. Concerning the order situation the firms are asked to answer the question *“Compared to the previous month, our overall level of orders has decreased/remained unchanged/increased”*.

Furthermore, each firm is allocated to one of the following 14 manufactur-

ing subsectors: Food, Beverages and Tobacco; Textiles and Textile Products; Tanning and Dressing of Leather; Cork and Wood Products except Furniture; Pulp, Paper, Publishing and Printing; Refined Petroleum Products; Chemicals and Chemical Products; Rubber and Plastic Products; Other Non-metallic Mineral Products; Basic and Fabricated Metal Products; Machinery and Equipment; Electrical and Optical Equipment; Transport Equipment; Furniture, Manufacture. Finally, the data set provides a size classification of the firms, categorizing the firms to 5 different size classes. The exact classification is as follows: “1” firm with less than 50 employees, “2” firm with 50-199 employees, “3” firm with 200-499 employees, “4” firm with 500-999 employees, “5” 1000 or more employees.

A more detailed overview about the questionnaire can be found in Becker and Wohlrabe (2008).