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How do consumers interpret the macroeconomic effects of oil price fluctuations? Evidence from U.S. survey data

Martin Geiger* Johann Scharler†

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Abstract

We use survey data to study how consumers assess the macroeconomic effects of structural oil market shocks on the U.S. economy using vector autoregressive models. To structurally decompose oil price changes, we impose sign restrictions on impulse responses. We find that the survey respondents' expectations are qualitatively in line with the actual developments in most cases. Nevertheless, survey respondents underestimate the adverse effects of oil market shocks in some cases. We also find that respondents expect the central bank to stabilize inflation as well as output and that expectations are consistent with a standard Taylor rule.

Keywords: Macroeconomic Expectations, Michigan Survey, Structural Vector Autoregression, Zero and Sign Restrictions

JEL codes: E00, E32, D84

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1 Introduction

As monetary policy increasingly relies on the management of private sector expectations (Blinder, 1998; Hoeberichts et al., 2009; Carvalho and Nechio, 2014), central bank communication constitutes an ever more important element of the monetary transmission mechanism. While it is generally acknowledged that monetary policy is more effective when the public is informed about the goals and strategies of the central bank, successful communication also depends on how people interpret the macroeconomic environment in which monetary policy operates. To explore this issue in the context of oil price developments, we use survey data to study how consumers assess the effects of structural oil market shocks on the U.S. economy as well as their expectations of the monetary policy response.

While our analysis is related to a number of contributions that analyze how oil price fluctuations influence inflation expectations (see e.g. Harris et al., 2009; Coibion and Gorodnichenko, 2015b; Wong, 2015; Binder, 2017), we go a step further and study how expectations about macroeconomic developments in a broader sense are revised to infer how survey respondents interpret the effects of oil market shocks in a macroeconomic sense. If, for instance, respondents primarily interpret oil market shocks as cost push shocks, which is also how introductory textbooks treat oil market shocks, then they should expect macroeconomic activity and inflation to move in opposite directions, i.e. a shift of the Phillips curve. In this case survey respondents should be aware of the trade-off between output and inflation stabilization that the central faces. Alternatively, oil market shocks may be transmitted through aggregate demand (Lee and Ni, 2002; Hamilton, 2009; Baumeister and Killian, 2016). If this corresponds to how survey respondents interpret the effects of oil market shocks, then they should expect macroeconomic activity and inflation to move in the same direction. In other words, survey respondents should expect a movement along the Phillips curve.

As survey respondents' interpretations may differ depending on the source of fluctuations in the oil market,[1] we structurally decompose oil price fluctuations into exogenous oil supply shocks, oil-specific demand shocks, and movements in oil prices that are driven by fluctuations in global economic activity using structural vector autoregressive (SVAR) models (see Kilian, 2009; Kilian and Murphy, 2012; Baumeister and Peersman, 2013a). Oil supply shocks are associated with unanticipated changes in the availability of crude oil triggered by e.g. the outbreak of a war or cartel-like arrangements like the OPEC. Oil-specific demand shocks arise due to changes

[1] Güntner and Linsbauer (2018) find that consumer sentiment and other survey measures react differently depending on the source of the oil price disruption.

in the precautionary demand for crude oil. And finally, rather than originating in the market for oil itself, oil price fluctuations may also arise in the wake of global business cycle fluctuations. To identify the structural oil market shocks, we impose sign restrictions on the impulse responses of the global oil market variables (Faust, 1998; Uhlig, 2005), and elasticity bounds on the impact multiplier matrix (Kilian and Murphy, 2012).[2]

We obtain measures of consumer expectations about key macroeconomic variables, such as the unemployment rate, the inflation rate and interest rates from the University of Michigan's Surveys of Consumers, which we refer to as Michigan Survey. To assess the effects of the oil market shocks on expectations, we estimate VAR models with suitably aggregated survey data and global oil market data. While we restrict the signs of the impulse responses of the global oil market variables for identification purposes, we leave the signs of the survey measures unrestricted to study their responses. In addition, we estimate VAR models with realized macroeconomic data instead of the survey data to compare the responses of the expectation measures to the responses of the corresponding macroeconomic variables.

We find that an increase in the price of oil leads to higher expected inflation, regardless of the type of shock, which is in line with the existing empirical evidence (Coibion and Gorodnichenko, 2015b; Wong, 2015; Binder, 2017; Güntner and Linsbauer, 2018). Nevertheless, unemployment and interest rate expectations respond differently depending on the type of shock. Exogenous oil supply shocks give rise to the expectation of higher unemployment together with higher expected inflation, which is consistent with the actual inflation and unemployment responses and also with the characterization of exogenous oil supply shocks in standard macroeconomic models. Given that survey respondents interpret the dynamics induced by this shock as a shift of the Phillips curve, we conclude that they are aware of the trade-off between output and inflation stabilization faced by the central bank. We also find that interest rate expectations remain rather unaffected in the immediate aftermath of an exogenous oil supply shock, but decline over the medium run. Thus, survey respondents do not share the popular view that the Federal Reserve reacts strongly to oil price increases (see e.g. Bernanke et al., 1997). While the response of the expected interest rate is at odds with the transmission mechanism incorporated in standard models, which relies heavily on a contractionary shift in monetary policy, it is broadly in line with the actual response of the policy rate.

Following oil-specific demand shocks that raise the price of oil, unemployment expectations

[2] To explore the robustness of our results we also use a recursive identification scheme in the spirit of Kilian (2009).

tend to decline slightly, whereas expected inflation increases. Since we also find that oil-specific demand shocks affect the U.S. economy adversely over the medium run in the sense of a higher unemployment rate, we conclude that survey respondents underestimate these adverse effects. Nevertheless, survey respondents expect temporarily higher interest rates, which is consistent with a standard Taylor rule. Finally, unemployment expectations are largely unresponsive if higher oil prices are associated with fluctuations in global economic activity, whereas the actual unemployment rate declines slightly in the short-run. In addition, survey respondents expect a monetary tightening, which is also in line with how the policy rate responds to the shock.

Our analysis is related to Edelstein and Kilian (2009) and Güntner and Linsbauer (2018), who also use survey data to analyze the effects of oil market shocks. While these studies focus on consumer sentiment, we are primarily interested in the survey respondents' interpretation of the macroeconomic effects associated with oil market shocks. In this sense, our analysis is also related to the recent strand of literature that studies to what extent survey respondents understand key macroeconomic concepts (Carvalho and Nechio, 2014; Dräger et al., 2016).

The paper is structured as follows: We first present the survey data we use in this paper in Section 2 and discuss the identification strategy and the algorithm we implement in Section 3. In Section 4 we present our results from estimations with U.S. macroeconomic as well as survey data and Section 5 concludes.

2 Survey Data

For our analysis we consider survey data from the Michigan Survey. These data are increasingly used to study expectations of the general public in a macroeconomic context (see e.g. Carvalho and Nechio, 2014; Coibion and Gorodnichenko, 2015b; Wong, 2015; Bachmann et al., 2015; Dräger et al., 2016). The survey respondents are households and the data is available at a monthly frequency. This high frequency is suitable for our approach to identify structural oil market shocks as the restrictions we impose are economically plausible only at the monthly frequency (Kilian, 2009; Kilian and Murphy, 2012). We focus on survey questions that allow us to infer how consumers expect economic activity, interest rates, and inflation to develop over a 12 month horizon.

For expected inflation we use average point estimates provided by respondents, which are elicited through the following questions:

(A12) *'During the next 12 months, do you think that prices in general will go up, or* *go down, or stay where they are now?*

(A12b) *By about what percent do you expect prices to go (up/down) on the average, during the next 12 months?'*

To measure expectations about interest rate developments, we use the following question:

(A11) *'No one can say for sure, but what do you think will happen to interest rates for borrowing money during the next 12 months – will they go up, stay the same, or go down?'*

Note that survey respondents provide only qualitative answers to this question, rather than quantitative answers as in the case of the inflation questions.[3]

The survey center aggregates the individual, qualitative answers using balance scores. In case of expectations about future interest rates, the share of respondents expecting higher interest rates is subtracted from the share of respondents indicating an expected decrease of interest rates and 100 is added to the difference to have the score fluctuating around a level of 100. Hence, when survey respondents expect interest rate to increase, the score declines. To allow for a more intuitive interpretation of the balance score, we therefore redefine the index such that it increases when more respondents believe that interest rates increase.[4]

To proxy expectations about real economic developments in a broad sense, we consider unemployment expectations. The question capturing unemployment expectations reads:

(A10) *'How about people out of work during the coming 12 months – do you think that there will be more unemployment than now, about the same, or less?'*

The balance score associated with unemployment expectations provided by the survey center also increases when relatively few respondents worry about higher future unemployment. Therefore, we also reverse this balance score for our analysis.

[3]It also has to be noted that although we will interpret the answers to this question as reflecting expectations about the future course of monetary policy, respondents may not specifically have the monetary policy rate in mind. However, given that the transmission mechanism of monetary policy performs sufficiently well, changes in borrowing rates should be mainly due to changes in the policy rate. Hence, views about future monetary policy should be reflected in answers to this question. See also Carvalho and Nechio (2014).

[4]We subtract 100, multiply the difference between the two fractions by minus one, and add a level of 100 again.

3 Estimation and Identification

We estimate reduced-form VAR models of the type

$$x_t = c + \sum_{l=1}^{L} B_l x_{t-l} + e_t,$$

where x_t is a vector of endogenous variables, c is the constant, B_l is the matrix of reduced-form coefficients at lag l, and e_t is a vector of residuals with covariance matrix $\Sigma_e = E(e_t e_t')$. In our baseline analysis, we estimate the VAR with $L = 24$ lags as suggested by e.g. Kilian (2009) and Kilian and Murphy (2012). The vector of endogenous variables contains global oil market variables that allow us to identify shocks to the price of oil. Following Kilian and Murphy (2012) we use the month-on-month percent change in the global crude oil production, an index of real global economic activity capturing the global business cycle (see Kilian, 2009), and the logarithm of the real price of oil for the identification of shocks to the price of oil.[5] We use data from January 1985 until December 2016. Even though the survey data is available from January 1978 onwards, we only consider the so-called Great Moderation period to avoid picking up structural breaks in the late 1970s and early 1980s.

While we are primarily interested in how survey expectations respond to oil market shocks, we also study how actual macroeconomic variables are influenced by these shocks, as these results can serve as a benchmark against which we can compare the estimated responses of the expectation measures. For this analysis, the vector of endogenous variables is augmented with the inflation rate, calculated as the annual growth rate of the seasonally adjusted monthly consumer price index (CPI) for urban consumers, the seasonally adjusted civilian unemployment rate, and the Federal Funds rate (FFR). These variables correspond closely to the survey questions in the Michigan Survey that will be used for the analysis of expectations in the second step of our analysis. The series are obtained from the Federal Reserve Economic Data (FRED) database of the Federal Reserve Bank of St. Louis.[6] To avoid potential problems associated with the binding zero lower bound on the nominal interest rates in the VAR model, we splice

[5]As a measure for the world price of crude oil, we use the monthly refiner acquisition cost of imported crude oil in U.S. Dollars per barrel. Data for the oil price and the oil production is from the Energy Information Administration (EIA).

[6]The corresponding *FRED Economic Data* identifiers of the macroeconomic time series are UNRATE, CPI-AUCSL, and FEDFUNDS.

the effective FFR with the shadow short rate (SSR) suggested by Krippner (2015).[7]

The identification scheme is shown in Table 1. We identify the structural oil market shocks using sign restrictions on impulse responses. The sign restrictions imposed on the oil market variables are based on Kilian and Murphy (2012) and are also consistent with e.g. Baumeister and Peersman (2013b). In the case of a shock to the global business cycle, an increase of global economic activity coincides with higher oil production and an increase in the real oil prices. A positive oil-specific demand shock raises the real price of oil and stimulates oil production, but, in contrast to the global business cycle shock, lowers global economic activity. An unanticipated oil supply shocks lowers oil production and global economic activity, while it raises the real price of oil. In line with Kilian and Murphy (2012), we impose sign restrictions only on impact.

In addition, we impose zero restrictions on the residual shocks to separate exogenous domestic macroeconomic developments that affect the macroeconomic variables, such as aggregate demand, aggregate supply, or monetary policy shocks, from endogenous responses of these variables to oil market shocks. In the literature it is well established that energy prices, and thus, the global oil market, are predetermined with respect to domestic macroeconomic developments (e.g. Kilian and Vega, 2011). By imposing the exclusion restrictions we make sure that the structural oil market shocks are orthogonal to domestic developments that, by construction, cannot affect the global oil market contemporaneously. The combination of zero and sign restrictions therefore allows us to study the effects of sign-identified models on U.S. variables within one unified framework.[8]

For the model estimated with survey data instead of the macroeconomic data, the sign restrictions on the global oil market variables are identical to those imposed in case of the macroeconomic variables and hence, the oil market shocks have the same interpretation. We also impose exclusion restrictions on the oil market variables based on the same arguments as in the case of the macroeconomic data. Essentially, the exclusion restrictions guarantee that the residual shocks capture domestic developments that do not affect the global oil market within the month. Table 2 shows the identification assumptions for the model estimated with survey data.

[7]The FFR is spliced with the shadow short rate in 2008m11. The time series of the SSR is publicly available through Krippner's homepage (`http://www.rbnz.govt.nz/research-and-publications/research-programme/research-staff-profiles/leo-krippner`). The SSR is the shortest maturity rate estimated from a term-structure model that suitably takes account of the discontinuity in nominal interest rates at the zero lower bound. It is essentially equal to the FFR in conventional monetary policy environments. However, it can turn negative when the short term nominal interest is bounded by zero because it captures the effects of unconventional monetary policy (e.g. quantitative easing) on longer-maturity interest rates.

[8]Please note that as we do not focus on domestic shocks, we refrain from disentangling domestic shocks from each other. Therefore, the residual shocks do not have a structural interpretation.

We estimate the reduced-form VAR models using Bayesian methods with the Normal-Wishart distribution as an uninformative prior density for the reduced form coefficients. The posterior density of the reduced form coefficients is therefore Normal-Wishart with the location parameters $B = [B_1, \ldots, B_L]'$ and the covariance matrix Σ_e (Uhlig, 1994). To identify structural shocks we apply a zero-and-sign-restrictions algorithm based on Rubio-Ramirez et al. (2010) and Arias et al. (2018), which works as follows: For each draw from the distribution of the reduced form parameters, we take the Choleski factor of $\Sigma_e = PP'$ and use random orthogonal matrices Q to obtain alternative decompositions $\Sigma_e = PQQ'P'$, and orthogonal shocks $u_t = (PQ)^{-1}e_t$. The matrix Q is constructed such that the zero restrictions are fulfilled. To obtain the distribution of permissible SVAR models we iterate the algorithm: We draw one set of parameters from the posterior distribution of the reduced form VAR. For this set of parameters we check whether we can find a transformation that is admissible in terms of the sign restrictions. Specifically, we keep drawing Q matrices until either a permissible transformation is found (then we retain the candidate model and proceed with the next iteration of the algorithm) or a maximum number of 1,000 draws of the matrix Q is reached (then we proceed without retaining any model). In most cases we find a permissible model for each draw from the posterior distribution of the reduced form models, which is reassuring in terms of the empirical plausibility of the imposed sign restrictions (Giacomini and Kitagawa, 2015).

Since the system is set-identified, the prior is only flat over the reduced form coefficients but not necessarily over the structural coefficients as the decomposition of the variance-covariance matrix Σ using random orthogonal matrices Q (where $Q'Q = I$) incorporates an implicit prior distribution (Baumeister and Hamilton, 2015, 2017). However, as shown in Giacomini and Kitagawa (2015), inference is less sensitive to the distribution of Q if zero restrictions are imposed.

Following Kilian and Murphy (2012) we further restrict the set of permissible models by restricting the short-run price elasticity of oil supply to only consider the subset of identified models, which are economically plausible. The intuition is that the short run elasticity of the oil supply is close to zero since to adjust oil supply significantly takes several years in practice. We impose these restrictions on the impact multiplier matrix $PQ = A$. Consider the decomposition of forecast errors into structural shocks

$$e_t \equiv \begin{pmatrix} e_t^{\Delta oil\ prod.} \\ e_t^{real\ activity} \\ e_t^{real\ oil\ price} \\ e_t^{inflation\ exp.} \\ e_t^{unempl.\ exp.} \\ e_t^{interest\ rates\ exp.} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & 0 & 0 & 0 \\ a_{21} & a_{22} & a_{23} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{pmatrix} \begin{pmatrix} \epsilon_t^{oil\ supply\ shock} \\ \epsilon_t^{aggr.\ demand\ shock} \\ \epsilon_t^{oil\ demand\ shock} \\ \epsilon_t^{resid.\ shock\ 1} \\ \epsilon_t^{resid.\ shock\ 2} \\ \epsilon_t^{resid.\ shock\ 3} \end{pmatrix}.$$

Note that a_{13} is the impact response of global oil production to an oil-specific demand shock and a_{33} is the impact response of the real price of oil to an oil-specific-demand shock. Similarly, a_{12} is the impact response of oil production to an aggregate global demand shock and a_{32} is the impact response of the real price of oil to fluctuations in global economic activity. We restrict the impact elasticities of the oil production vis-á-vis the real price of oil. Following Kilian and Murphy (2012), we only consider candidate models where a_{13}/a_{33} and a_{12}/a_{32} do not exceed a value of 0.0258. This upper bound of the elasticity is the empirical elasticity of oil production vis-á-vis the real price of oil associated with the Persian Gulf War in August 1990, which was arguably comparatively large and should therefore be a plausible limit.

We retain 30,000 candidate models that fulfill the zero and sign-restrictions. From these models, in the baseline estimation with the macroeconomic variables, 573 models additionally fulfill the elasticity constraints and allow for a structural interpretation. We consider the distribution of these models in the discussion of the results.

4 Results

4.1 Responses of the macroeconomic variables

Figure 1 shows the distribution of the set-identified models in the impulse response function representation to an oil supply shock in the first column, to an oil-specific demand shock in the second column, and to a global economic activity shock in the third column. The responses of the log of the real oil price are shown in Panel A and Panel B displays the responses of the macroeconomic variables. The solid lines in the graphs represent the pointwise-median responses of the distribution of set-identified models, whereas the dashed lines represent the closest-to-median responses selected as proposed in Fry and Pagan (2011).[9] The bands indicate the 5th and the 16th percentiles as well as the 84th and the 95th percentiles of the distribution of set-identified models. To facilitate comparisons across shocks, we scale the shocks such that the median response of the real oil price reaches a maximum of 10 percent within 12 periods.

We see from Panel A of Figure 2 that although each shock is associated with an increase in the oil price, the dynamics differ. While the effect of an exogenous oil supply shocks and global economic activity shocks build up over time, oil-specific demand shocks give rise to strong response on impact.

Turning to Panel B, we see from the first column that oil supply shocks that raise the real price of oil, lead to higher inflation and unemployment rates, whereas the interest rate declines. We also see that the unemployment rate and the interest rate respond stronger over the medium run, whereas the inflation response is less persistent. Although the unemployment and inflation responses are in line with the effects of a cost-push shock in standard macroeconomic models, the transmission mechanism differs, since standard models rely heavily on contractionary monetary policy to generate a slowdown in economic activity (e.g. Montoro, 2012).[10] In this sense, our results are more in line with the view that households and firms respond to adverse oil supply shocks by cutting back on consumption and investment expenditures due to changes in the purchasing power induced by changes in energy prices (Edelstein and Kilian, 2009). The decline in the interest rate suggests that the Fed expects these adverse demand effects to be large enough to even warrant a monetary easing despite the inflationary pressure induced by the cost-push nature of the shock.

The impulse responses reported in the second column show that the oil-specific demand shock raises the inflation rate as well as the unemployment rate, although the unemployment rate responds only with a delay of 12 months. The interest rate also increases and returns to its pre-shock level after 6 months. Thus, the effect is rather transitory. Finally, the responses in the last column show that an oil market disturbance that occurs together with a global economic upturn increases inflation and the interest rate in the U.S. and reduces the unemployment rate for roughly one year, before it rebounds.

To summarize, oil market disturbances that are associated with oil price hikes lead to higher inflation rates and also higher unemployment rates over the medium run, regardless of the

[9]The closest-to-median responses are the responses from a single model which is selected such that the responses of this single model exhibit the minimum squared deviations from the pointwise-median responses among all permissible models.

[10]Kilian and Lewis (2011) find a similar interest rate response to oil supply shocks.

specific type of oil market disturbance. The unemployment rate starts to increase immediately after the shock in case of an exogenous oil supply shock, remains unresponsive for roughly one year following an oil-specific demand shock, and initially declines if the oil market disturbance is associated with a global business cycle shock. The joint responses of the inflation rate and the unemployment rate suggest that exogenous oil supply shocks give rise to shifts of the Phillips curve, whereas the short-run dynamics induced by global business cycle shocks that raise the price of oil correspond to movements along the Phillips curve. In case of the oil-specific demand shock, the implications of the joint responses are less clear since the inflation response is temporary and unemployment responds with a substantial delay. Across shocks, the responses of the FFR suggests that the Fed aims to stabilize both, output and inflation, in the aftermath of oil market shocks. Interest rates initially increase vis-à-vis oil-specific demand and global economic activity shocks, where the inflation rate goes up and the unemployment rate does either not react systematically or declines. In contrast, oil supply shocks, which are associated with a persistently higher unemployment rate and only small and short-lived increases in the inflation rate, give rise to a lower policy rate.[11]

Although our approach differs from the existing literature in terms of the identification scheme and also in the sense that we study the responses to different shocks simultaneously, the macroeconomic effects of the oil market shocks are largely in line with the existing literature (see also Kilian, 2009; Baumeister and Peersman, 2013b).

4.2 Responses of consumer expectations

Having explored how macroeconomic variables respond to oil market shocks, we now turn to the question of how survey respondents interpret the macroeconomic implications of these shocks. Figure 2 shows the responses of the real oil price together with the responses of the survey expectations.[12] IRFs are again scaled so that the point-wise median responses of the real price of oil goes up by a maximum of 10 percent during the first twelve months after the shock. While we show IRFs for $h = 24$ in case of the oil price and the macroeconomic variables, IRFs are only shown for 12 months in case of the expectation measures due to the forecasting lead.

[11] To explore the sensitivity of our results with respect to the use of the SSR, we also estimate the VAR with the FFR throughout, despite the discontinuity due to the zero lower bound. Figure A.1 in the Appendix presents the IRFs. The IRFs of the real oil price, the inflation rate and the unemployment rate look almost identical compared to the IRFs shown in Figure 1, which is not surprising given these variables remain unchanged. However, also responses of the FFR appear remarkably similar than the responses of the spliced FFR.

[12] Even though the responses of the real oil price are now retrieved from models including the expectation measures instead of the macroeconomic variables, they are very similar to those shown in the previous figure, which supports the comparability of the oil market shocks across the two models.

The responses of survey expectations to oil supply shocks are shown in the first column of Panel B. We see that survey respondents expect inflation as well as unemployment to increase in response to such a shock. After approximately six months, expected inflation returns to the steady state, while unemployment expectations remain in the positive territory. These findings suggest that survey respondents interpret the consequences of oil supply shocks as shifts of the Phillips curve, which is in line with the dynamics of the macroeconomic variables discussed above. The interest rate is expected to essentially remain constant until roughly 4 months after the shock, when survey participant start to expect lower interest rates. While interest rate expectations are adjusted with a delay, as compared to the dynamics of the actual interest rate, the general pattern is broadly in line with what we observe in Figure 1. Overall, survey respondents interpret the effects of oil supply shocks broadly in line with how these shocks affect U.S. macroeconomic variables.

The second column shows the responses to oil-specific demand shocks. We see that survey respondents expect inflation to increase and unemployment to decline slightly. Although the response of unemployment expectations increases in magnitude over time, it remains small. Comparing these results to the dynamics of the corresponding macroeconomic variables in Figure 1, we see that survey respondents underestimate the adverse effects that such a shock exerts on the unemployment rate over the medium run. Interest rates are expected to increase temporarily before survey respondents expect a decline. This pattern is in line with the actual response of the interest rate and also with a standard Taylor rule, given the initially higher expected inflation rate together with the marginally lower expected unemployment rate.

Finally, the last column presents the responses of the expectation measures to oil price hikes that are associated with positive global economic developments. The expected inflation rate increases on impact and remains persistently above its pre-shock level. Expected unemployment, in contrast, remains unresponsive on impact. Over time, survey respondents increasingly expect higher unemployment, but the effect remains small. While the response of expected inflation resembles the dynamics of the actual inflation rate, survey respondents do not appear to expect the short-run decline in the unemployment rate that we observe in the actual data. Nevertheless, given the temporary nature of the decline in the unemployment rate, and taking into account that the forecasting lead in the Michigan Survey is 12 months, this result is not surprising. In any case, survey respondents correctly expect higher interest rates along with the inflationary pressure.

Summarizing the IRFs, across shocks we find that higher oil prices lead to an increase in inflation expectations, which confirms earlier findings reported in the literature (see e.g. Wong, 2015; Coibion and Gorodnichenko, 2015b; Güntner and Linsbauer, 2018). Revisions in expected unemployment are generally less pronounced, except for the oil supply shock. The way how expected interest rates are adjusted indicates that consumers expect the Fed to stabilize inflation as well as output.[13]

4.3 Variance decompositions

To evaluate the quantitative importance of oil market shocks in shaping expectations and interpretations of the survey respondents, we now present forecast error variance decompositions (FEVDs).

The FEVDs of the macroeconomic variables are shown in Panel A of Table 3 and the FEVDs of the expectation variables are displayed in Panel B. The shares of the forecast error variance associated with the oil supply shock in percent are shown in the first column, the second column refers to oil-specific demand shock and the third column to fluctuations in global economic activity. We indicate the median of the distribution of the contributions of the oil market shocks in the FEVDs computed for each set-identified model for the respective horizon h, together with the 16th and the 84th percentile of the contributions. In line with the maximum horizon we show the IRFs above, we present the contributions of the macroeconomic shocks for the expectation measures up to 12 months, while we show contributions for the macroeconomic variables up to 24 months.

We see from Panel A that oil supply shocks contribute approximately 5 percent, oil-specific demand shocks approximately 15 percent, and shocks to global economic activity approximately 44 percent to the forecast error variance of the inflation rate at longer horizons. The dynamics of the unemployment rate and the FFR are less affected by the oil market shocks, with contributions ranging from an almost negligible share in case of the oil-specific demand shock to approximately 10 percent in case of global business cycle shocks. For the FFR, contributions range from 2 percent to 5 percent of the forecast error variance, depending on the shock.

Turning to the FEVD of the expectation variables reported in Panel B, we see that at longer horizons, the oil supply shock explains approximately 6 percent of the forecast error variance of inflation expectations, the oil-specific demand shock up to about 10 percent, and global business

[13]Following Kilian (2009) and Kilian and Murphy (2012) we re-estimate the baseline model using 12 instead of 24 lags. Figure A.2 in the Appendix presents the results for the estimation with fewer lags. The responses of the real oil price shown in Panel A as well as the responses of the expectation measures shown in Panel B resemble the baseline estimation. Thus, our results do not depend on the particular lag structure and indicate that the large number of estimated parameters in the baseline specification is not problematic.

cycle shocks 30 percent. For the remaining expectation variables the contributions are smaller, ranging from roughly 3 to 5 percent in case of unemployment expectations and from 3 to 7 percent for interest rate expectations.

Overall, the FEVDs of the macroeconomic variables and the expectation measures show similar patterns. The dynamics of inflation expectations are shaped more strongly by the oil market shocks than the dynamics of unemployment and interest rate expectations. In addition, the shares of the forecast error variance accounted for by the oil market shocks are of similar orders of magnitude for the macroeconomic variables and the expectation measures, albeit the contributions are slightly smaller in case of the expectation measures.[14]

Since oil market shocks influence macroeconomic variables and the corresponding expectation measures to similar degrees, we conclude that consumers are largely attentive to oil price developments. This finding is somewhat in contrast to results reported in the literature suggesting that consumers typically use available information only to a limited extent to make forecasts about future macroeconomic developments (Coibion and Gorodnichenko, 2012, 2015a). Nevertheless, since gas is purchased frequently it appears plausible that oil prices are more salient compared to other macroeconomic news.

4.4 Alternative Identification Scheme

To explore the robustness of our results with respect to the identification of the oil market shocks, we use an alternative approach to disentangle oil supply, oil-specific demand shocks and fluctuations in global economic activity. Kilian (2009) suggests a recursive identification scheme that can be imposed on the same set of oil market variables. Table 4 shows the exclusion restrictions on the impact multiplier matrix. The restrictions hinge on the following timing assumptions: Oil production is assumed to be the most exogenous variable in the sense that oil supply does not respond to innovations to the demand for oil within the same month. Real economic activity is ordered second and disruptions in global real economic activity that are not due to oil supply are assumed to be associated with the global business cycle. Intuitively, real economic activity may not react to oil-specific demand shocks within the same month because of sluggish behavior of the global real economic activity. Thus, the real oil price is ordered last and innovations that are not associated with oil supply and global business cycle shocks, are

[14] It has to be noted, however, that FEVDs of the macroeconomic variables and of the expectation variables are not directly comparable as they are retrieved from two separate estimations and, in addition, unemployment and interest rate expectations are measured in a different metric as the macroeconomic data due to the qualitative nature of the corresponding survey questions.

therefore due to oil-specific demand shocks.

Expectation variables are ordered below the global oil market variables since, following the intuition from our baseline identification scheme, we assume that innovations to expectations about domestic macroeconomic variables do not impact the global oil market contemporaneously. Note that the reduced form estimation of the VAR is identical to the estimation above.

The distribution of the IRFs are shown in Figure 3.[15] Shocks are normalized as in the baseline. Panel A shows the responses of the real price of price that exhibit similar dynamics than the respective baseline responses. The expectation measures are presented in Panel B. Overall, the responses are remarkably robust across the two identification schemes. The distribution of models is slightly narrower in case of the oil-specific demand shock, whereas responses to fluctuation in global economic activity are slightly more disperse. Qualitatively, however, the picture that emerges from this robustness analysis corroborates the baseline results.[16]

5 Concluding remarks

How do consumers interpret the macroeconomic consequences of oil market developments? In this paper, we use survey data to study this issue. We find that survey respondents interpret the dynamics induced by oil supply shocks as a shift of the Phillips curve. In addition we find that interest rate expectations tend to be unaffected in the immediate aftermath of oil supply shocks and decline over the medium run indicating that respondents do not expect the Fed to react to this shock by raising interest rates. In contrast, respondents expect higher interest rates after oil-specific demand shocks and shocks to global economic activity where inflation expectations increase while unemployment expectations remain largely unaffected. In addition, we find that in most cases the survey respondents' expectations are qualitatively in line with the actual effects of oil market shocks on the U.S. economy.

Our results have several implications for the conduct of monetary policy as central banks increasingly seek to manage private sector expectations (Blinder, 1998; Hoeberichts et al., 2009; Carvalho and Nechio, 2014). When explaining policy responses to oil market shocks, central bank communication can take into account that people are aware that oil market shocks give rise to different macroeconomic dynamics depending on the source of the shock. Another

[15]As in the baseline we assume a flat prior. To generate the posterior distribution we draw 1,000 models.

[16]In addition we evaluate whether the robustness of our results vis-á-vis the identification approach in respect to the FEVD. Table A.1 in the Appendix shows FEVDs from the expectations measures as well as their macroeconomic counterparts. Even though the contributions of the shocks to the forecast error variance of the expectations measures tends to be somewhat smaller compared to the macroeconomic variables, patterns are similar supporting the robustness of our results.

implication of our results is that central bank communication may help to further improve the public's understanding. Although we find that consumers have a relatively good understanding of how oil market shocks influence the economy and the corresponding response of monetary policy, some aspects are less well understood. For instance, people tend to underestimate the adverse effects of oil-specific demand shocks.

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Table 1: Identification scheme for the model with macroeconomic data

	Oil supply shock	Global BC shock	Oil-specific demand shock	Residual shock 1	Residual shock 2	Residual shock 3
Oil production	↓	↑	↑	0	0	0
Real activity	↓	↑	↓	0	0	0
Real price of oil	↑	↑	↑	0	0	0
Inflation rate						
Unemployment rate						
Spliced FFR						

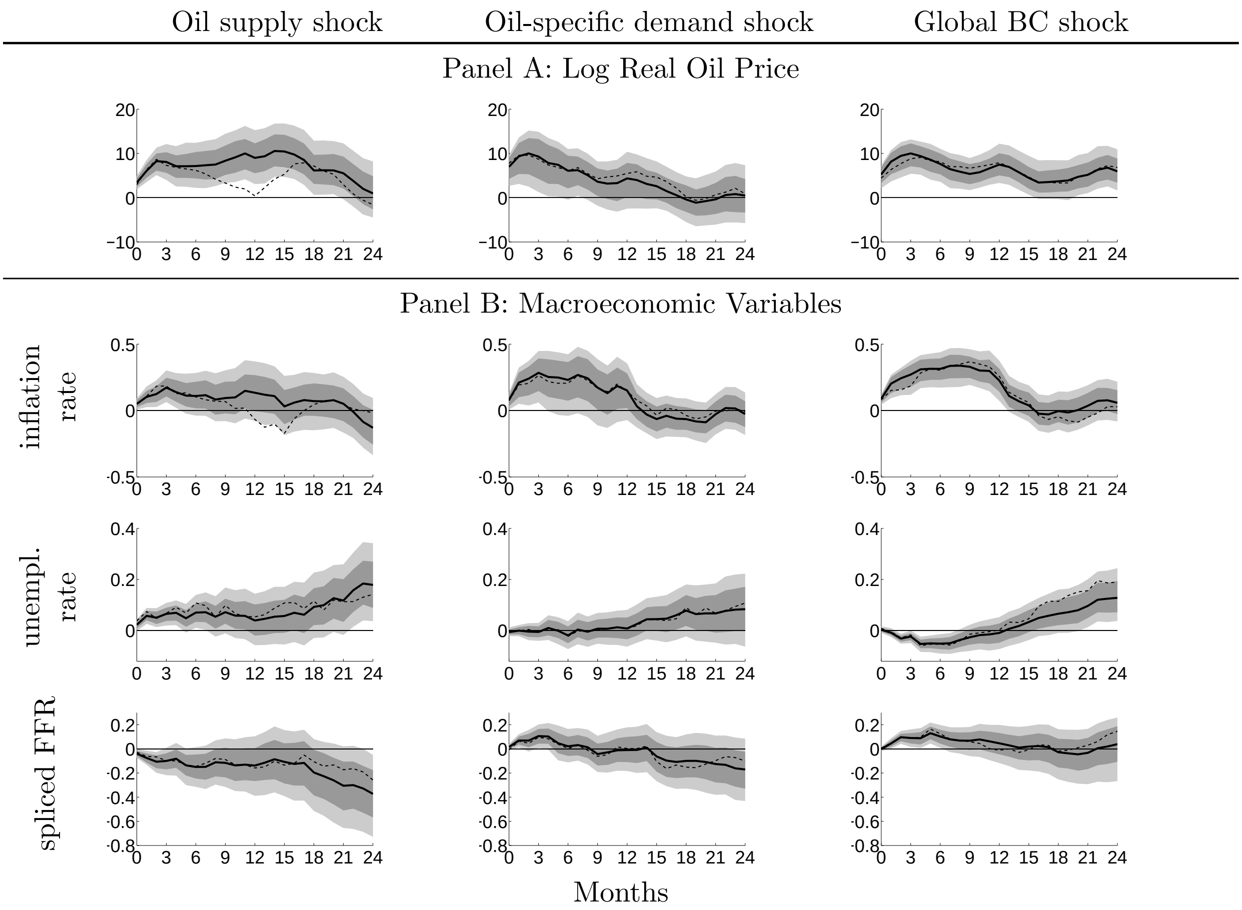
Notes: Sign restrictions are imposed on impact.

Table 2: Identification scheme for the model with survey expectations

	Oil supply shock	Global BC shock	Oil-specific demand shock	Residual shock 1	Residual shock 2	Residual shock 3
Oil production	↓	↑	↑	0	0	0
Real activity	↓	↑	↓	0	0	0
Real price of oil	↑	↑	↑	0	0	0
Inflation expect.						
Unempl. expect.						
Interest rate expect.						

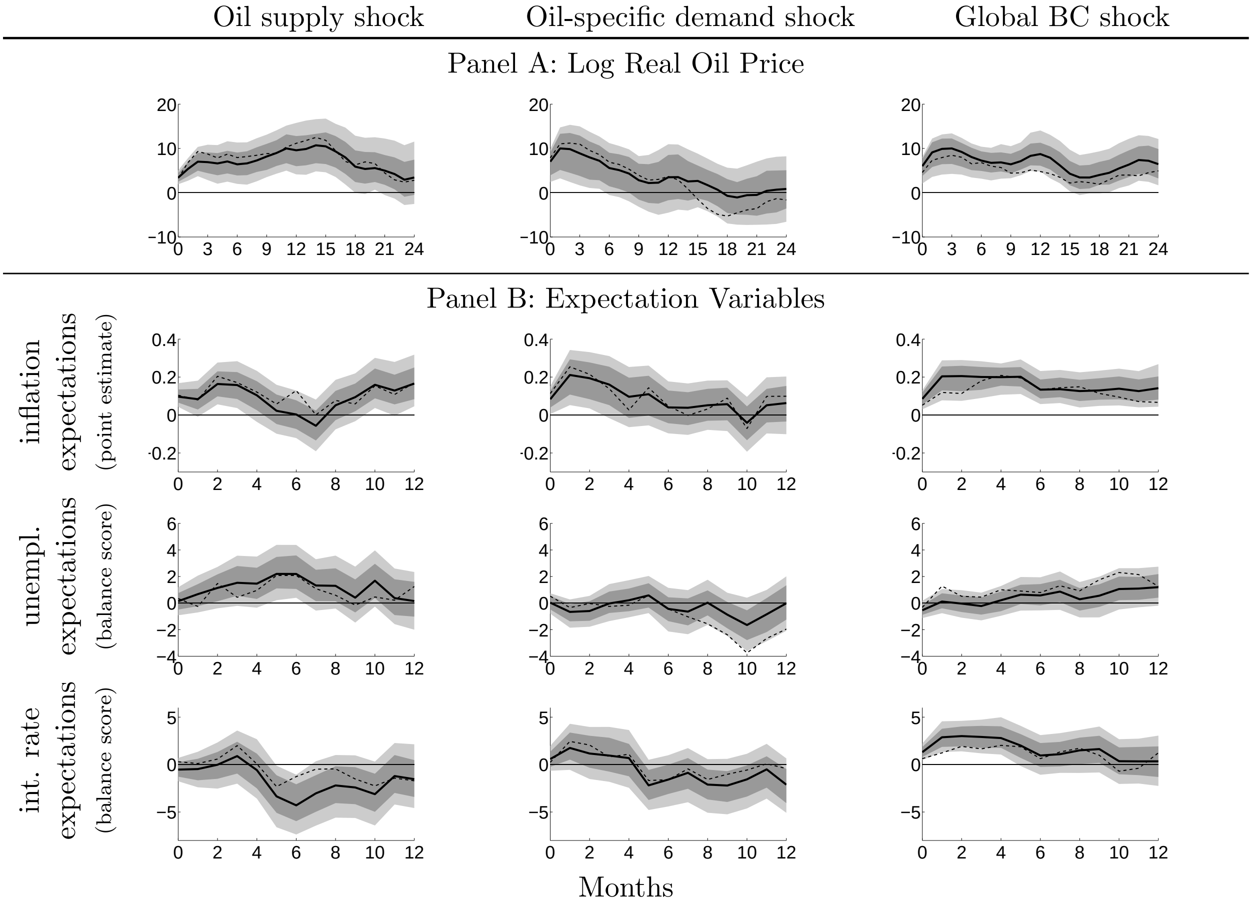
Notes: Sign restrictions are imposed on impact.

Figure 1: Impulse response functions: macroeconomic variables



Notes: The solid lines represent the pointwise median response, whereas the dashed lines represent the closest to median response selected as proposed in Fry and Pagan (2011). The bands represent the distribution of the set-identified models (we indicate the 5th and 16th percentiles as well as the 86th and 95th percentiles).

Figure 2: Impulse response functions: survey expectations



Notes: Inflation expectations enter the VAR as average point estimates in percent. Unemployment and interest rate expectations are summarized by a balance score index. The solid lines represent the pointwise median response, whereas the dashed lines represent the closest to median response selected as proposed in Fry and Pagan (2011). The bands represent the distribution of the set-identified models (we indicate the 5th and 16th percentiles as well as the 86th and 95th percentiles).

Table 3: Forecast error variance decomposition (in percent)

	h	Oil supply shock	Oil-specific demand shock	Global BC shock
		Panel A: Macroeconomic Variables		
inflation rate	0	1.03 (0.27, 2.41)	5.10 (0.85, 10.73)	11.06 (4.99, 16.45)
	6	3.18 (1.15, 7.11)	21.05 (4.36, 43.63)	49.05 (25.27, 66.32)
	12	3.20 (1.09, 8.07)	17.42 (3.81, 40.40)	55.07 (31.22, 72.17)
	24	5.00 (2.51, 9.95)	15.93 (5.39, 32.67)	44.28 (26.11, 58.61)
unempl. rate	0	0.71 (0.12, 1.84)	0.17 (0.02, 0.67)	0.14 (0.01, 0.66)
	6	4.38 (1.60, 8.45)	1.03 (0.39, 2.66)	6.18 (2.67, 10.75)
	12	3.45 (1.25, 8.64)	1.11 (0.41, 3.45)	4.07 (1.97, 9.75)
	24	6.25 (2.04, 13.92)	3.86 (1.08, 11.01)	10.47 (5.27, 19.94)
spliced FFR	0	0.86 (0.17, 1.89)	0.26 (0.02, 0.86)	0.13 (0.01, 0.49)
	6	2.30 (0.52, 5.58)	2.23 (0.72, 5.78)	5.42 (1.78, 10.29)
	12	2.34 (0.58, 6.63)	1.86 (0.81, 4.27)	3.50 (1.52, 8.66)
	24	4.59 (1.29, 11.62)	3.07 (1.13, 7.33)	3.63 (1.56, 8.40)
		Panel B: Expectation Variables		
inflation expect.	0	3.15 (1.77, 5.14)	2.00 (0.23, 4.99)	7.69 (4.07, 10.88)
	6	5.07 (2.57, 8.46)	9.51 (2.95, 21.47)	29.31 (17.02, 39.69)
	12	6.25 (4.09, 10.19)	8.78 (3.87, 19.92)	30.61 (18.69, 40.42)
unempl. expect.	0	0.17 (0.02, 0.80)	0.11 (0.01, 0.53)	0.19 (0.01, 0.85)
	6	2.83 (0.96, 6.13)	1.12 (0.52, 2.80)	2.18 (0.82, 5.09)
	12	3.30 (1.59, 6.52)	2.53 (1.22, 5.37)	4.57 (1.88, 10.24)
int. rate expect.	0	0.12 (0.01, 0.51)	0.62 (0.06, 1.98)	1.67 (0.46, 3.62)
	6	2.08 (1.01, 3.81)	3.18 (1.62, 5.77)	7.14 (3.95, 11.79)
	12	3.24 (1.65, 7.25)	5.01 (2.37, 9.27)	6.79 (4.30, 11.83)

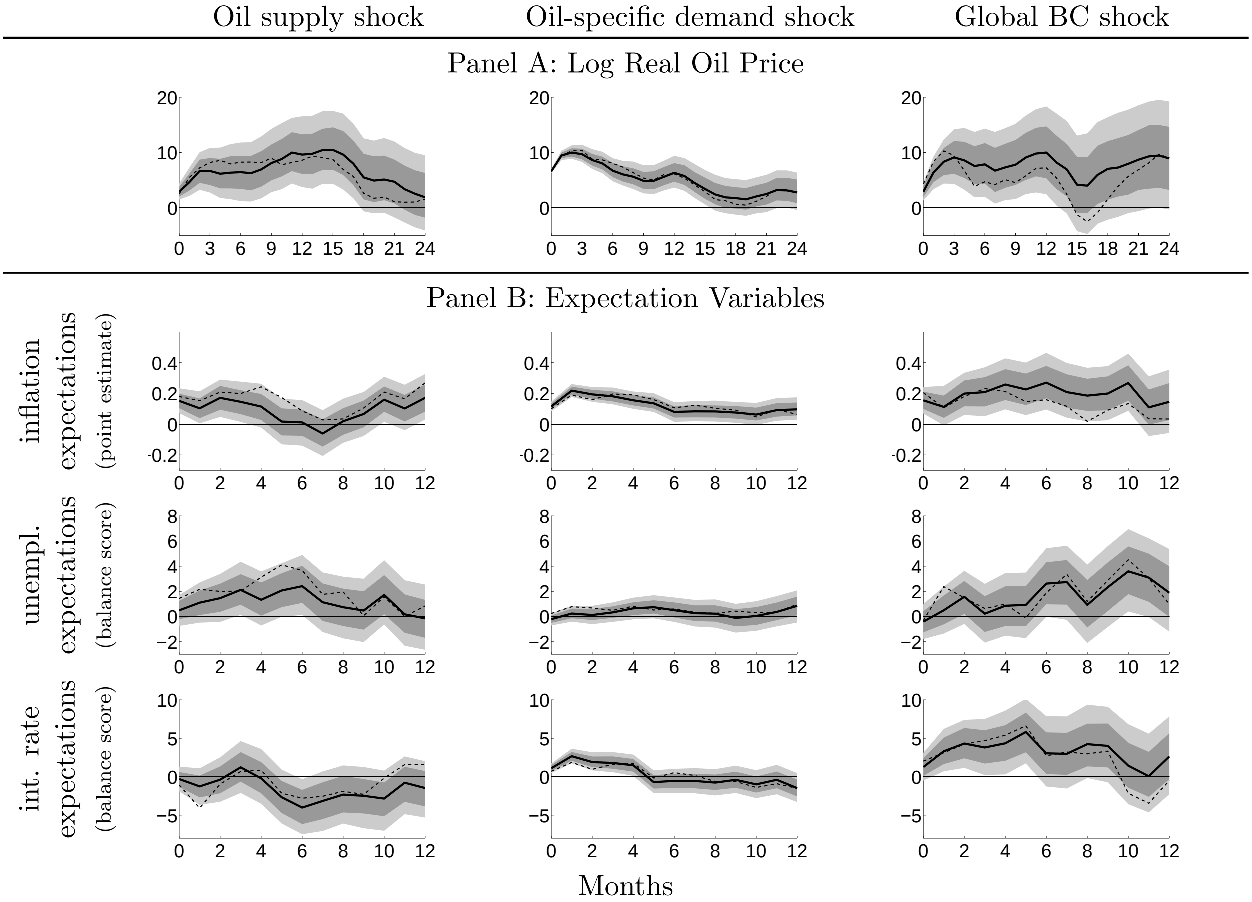
Notes: We indicate the median of the distribution of FEVDs computed for each set-identified model for the respective horizon h in months, together with the 16th and the 84th percentile of the distribution of the FEVDs.

Table 4: Restrictions on impulse response functions: recursive identification

	Oil supply shock	Global BC shock	Oil-specific demand shock	Residual shock 1	Residual shock 2	Residual shock 3
Oil production		0	0	0	0	0
Real activity			0	0	0	0
Real price of oil				0	0	0
Inflation expect.					0	0
Unemployment expect.						0
Interest rate expect.						

Notes: We normalize shocks such that the real price of oil increases on impact.

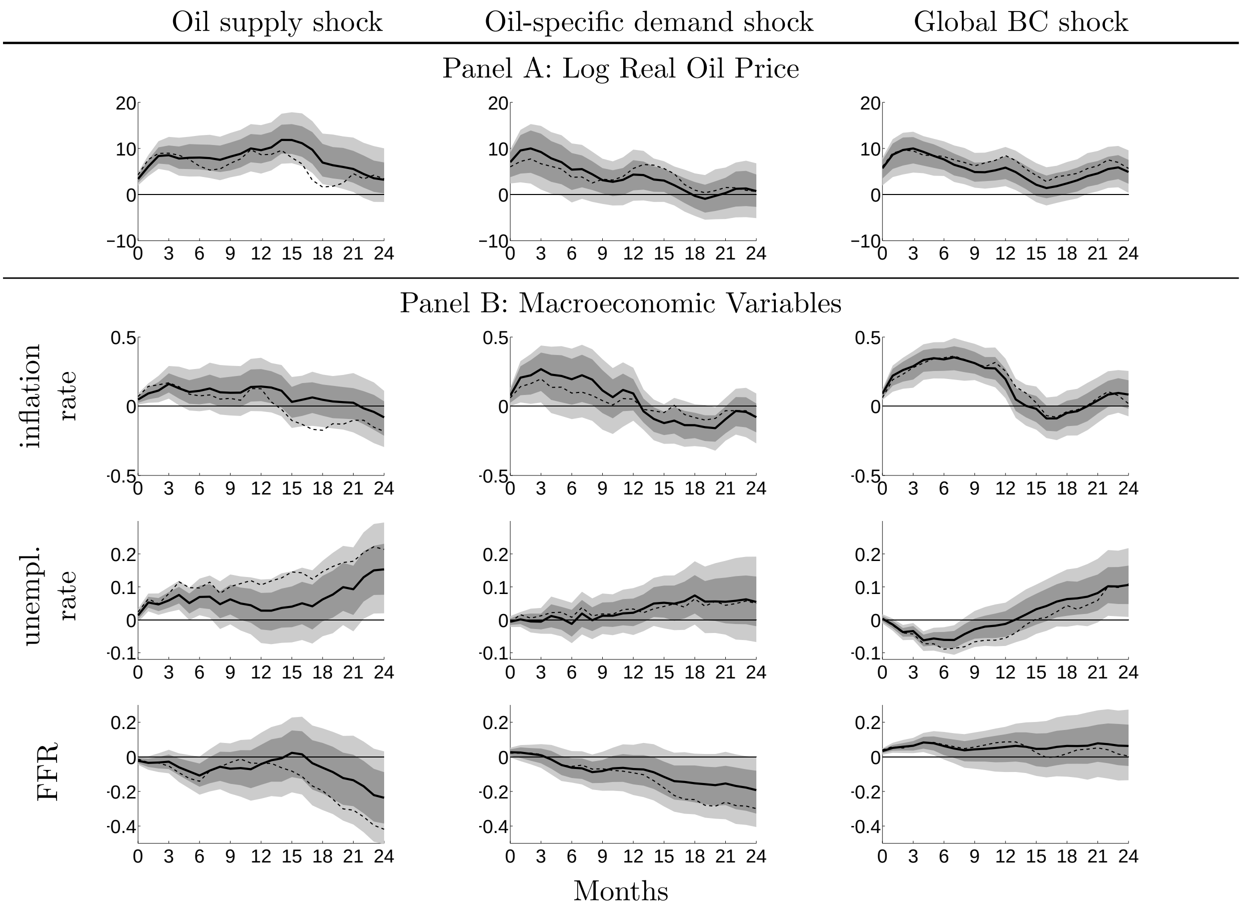
Figure 3: Impulse response functions: recursive identification



Notes: Inflation expectations enter the VAR as average point estimates in percent. Unemployment and interest rate expectations are summarized by a balance score index. The solid lines represent the pointwise median response, whereas the dashed lines represent the closest to median response selected as proposed in Fry and Pagan (2011). The bands represent the distribution of the set-identified models (we indicate the 5th and 16th percentiles as well as the 86th and 95th percentiles).

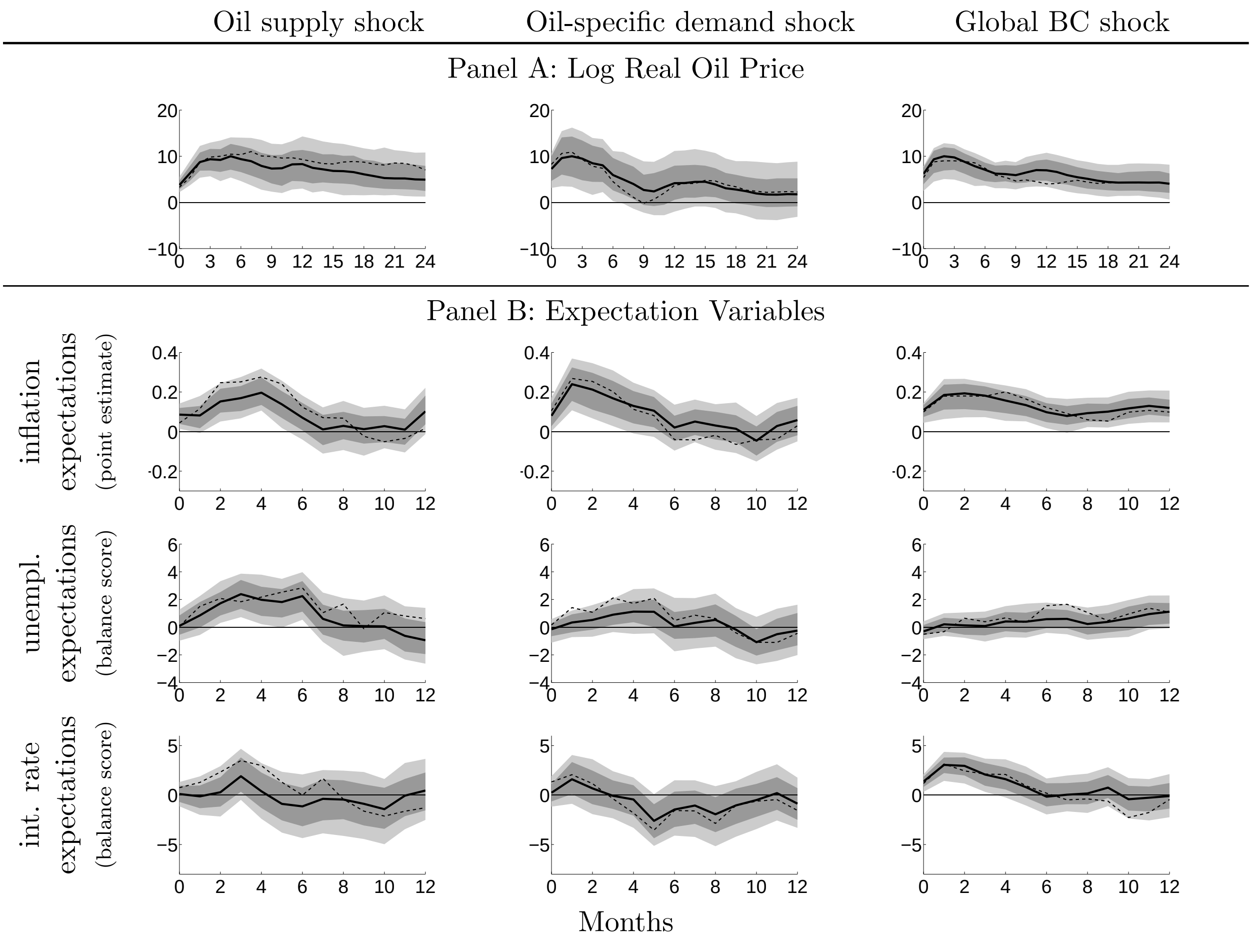
Appendix

Figure A.1: Impulse response functions: Estimation with the FFR for the entire sample



Notes: The solid lines represent the pointwise median response, whereas the dashed lines represent the closest to median response selected as proposed in Fry and Pagan (2011). The bands represent the distribution of the set-identified models (we indicate the 5th and 16th percentiles as well as the 86th and 95th percentiles).

Figure A.2: Impulse response functions: estimation with 12 lags



Notes: Inflation expectations enter the VAR as average point estimates in percent. Unemployment and interest rate expectations are summarized by a balance score index. The solid lines represent the pointwise median response, whereas the dashed lines represent the closest to median response selected as proposed in Fry and Pagan (2011). The bands represent the distribution of the set-identified models (we indicate the 5th and 16th percentiles as well as the 86th and 95th percentiles).

Table A.1: Forecast error variance decomposition (recursive identification; in percent)

	h	Oil supply shock	Oil-specific demand shock	Global BC shock
		Panel A: Macroeconomic Variables		
inflation rate	0	0.43 (0.06, 1.31)	1.80 (0.67, 3.45)	14.91 (12.00, 18.50)
	6	1.42 (0.42, 3.74)	8.43 (4.41, 14.13)	63.13 (56.31, 69.83)
	12	1.79 (0.63, 4.61)	13.31 (7.05, 21.55)	62.50 (53.84, 70.72)
	24	3.93 (1.91, 7.97)	13.11 (7.42, 21.42)	49.41 (40.84, 58.15)
unempl. rate	0	0.78 (0.16, 1.99)	0.20 (0.02, 0.82)	0.12 (0.01, 0.51)
	6	4.78 (2.00, 9.26)	4.45 (1.75, 8.38)	2.48 (0.75, 5.51)
	12	3.79 (1.34, 8.84)	3.31 (1.39, 7.68)	2.01 (0.95, 4.78)
	24	5.21 (1.92, 12.14)	4.62 (2.42, 9.18)	11.47 (5.45, 20.64)
FFR	0	0.87 (0.18, 2.13)	0.19 (0.02, 0.84)	0.17 (0.01, 0.75)
	6	3.14 (0.85, 6.77)	1.70 (0.53, 4.10)	5.54 (2.55, 9.93)
	12	2.89 (0.73, 7.51)	1.79 (0.57, 5.14)	3.15 (1.74, 6.43)
	24	4.57 (1.37, 11.60)	2.21 (0.95, 6.57)	4.13 (1.92, 9.08)
		Panel B: Expectation Variables		
inflation expect.	0	2.65 (1.24, 4.34)	2.04 (0.80, 3.73)	8.66 (6.36, 11.57)
	6	3.72 (1.80, 6.89)	7.72 (3.88, 13.24)	33.65 (26.70, 40.23)
	12	5.21 (3.05, 8.60)	10.39 (5.44, 17.06)	31.44 (24.15, 38.93)
unempl. expect.	0	0.20 (0.02, 0.82)	0.15 (0.02, 0.66)	0.19 (0.02, 0.78)
	6	3.11 (0.98, 6.86)	1.72 (0.80, 3.74)	1.66 (0.63, 3.99)
	12	3.34 (1.55, 7.38)	4.43 (1.80, 9.78)	2.70 (1.29, 6.03)
int. rate expect.	0	0.15 (0.01, 0.63)	0.37 (0.03, 1.26)	2.09 (0.92, 3.86)
	6	2.09 (1.03, 3.97)	4.33 (1.70, 8.67)	6.07 (3.80, 9.35)
	12	3.32 (1.43, 7.20)	5.54 (2.38, 10.73)	6.74 (4.28, 10.09)

Notes: We indicate the median of the distribution of FEVDs computed for each set-identified model for the respective horizon h in months, together with the 16th and the 84th percentile of the distribution of the FEVDs.

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Martin Geiger, Johann Scharler

How do consumers interpret the macroeconomic effects of oil price fluctuations? Evidence from U.S. survey data

Abstract
We use survey data to study how consumers assess the macroeconomic effects of structural oil market shocks on the U.S. economy using vector autoregressive models. To structurally decompose oil price changes, we impose sign restrictions on impulse responses. We find that the survey respondents' expectations are qualitatively in line with the actual developments in most cases. Nevertheless, survey respondents underestimate the adverse effects of oil market shocks in some cases. We also find that respondents expect the central bank to stabilize inflation as well as output and that expectations are consistent with a standard Taylor rule.

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