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Oil shocks and the UK economy: the changing nature of shocks and impact over time

Stephen Millard and Tamarah Shakir

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Stephen Millard[(1)] and Tamarah Shakir[(2)]

Abstract

In this paper we examine how the impact of oil price movements on the UK economy differs depending on the underlying source of the shock, that is, whether the oil price has been driven by a supply, or demand, disturbance. In addition we employ an empirical framework with time-varying parameters to allow us to see how the impact of oil price shocks may have developed over time. In line with earlier studies on larger economies, we find that the source of the shock does indeed affect the size and nature of the eventual impact on the UK economy. Oil supply shocks typically lead to larger negative impacts on output and slightly higher increases in inflation relative to oil shocks stemming from shocks to world demand, which typically have smaller and largely positive, impacts on UK output. We find evidence that the nature of shocks in the world oil market has changed over time, with the oil price becoming more sensitive to changes in oil production. There is also evidence that the impact of oil shocks became much smaller from the mid-1980s onwards, although the impact has risen slightly since around 2004.

Key words: Oil price shocks, time-varying parameter VARs.

JEL classification: Q43.

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Summary

This paper examines the impact of oil price movements on the UK economy, exploring how the impact of these movements may have changed over time. Ever since the dramatic oil price spikes of the 1970s, and the global recessions that ran alongside, policymakers have paid close attention to fluctuations in globally traded oil prices and worried about the potential impact on economic growth and domestic price inflation. Recent years have once again seen large fluctuation in oil prices, with prices rising from $15 a barrel in 1998 to nearly $140 a barrel in 2008. This rise and the volatility in both the oil price and economic performance since have reopened the debate about how, and by how much, oil shocks affect economies and how monetary policy ought to respond.

Over the last 30 years a wide range of studies have attempted to examine the impact of oil prices on the macroeconomy. Many of these studies have found that oil price movements appear to have large impacts on the economy, much larger than the share of oil in costs would imply. But alongside this headline finding, many of the same studies also find that oil price movements appear to have had a smaller impact on activity and inflation since the mid-1980s. A number of alternative explanations have been put forward to explain why the impact of oil price movements may have become smaller over time. These explanations include falls in the share of oil in the economy, more flexible labour markets, and a better or more credible policy response, together with changes in the oil market itself.

The majority of studies of the relationship between oil prices and output and inflation have focused on the United States. But, we might expect the United Kingdom to be different as it is an economy that has transitioned from net oil importer in the 1970s to net exporter in the 1980s and early 1990s and returned to be a net importer again in the mid-2000s. So, in this paper we consider the impact of oil movements on the UK economy.

We aim to answer two questions. First, how does the effect of oil price movements on the UK economy depend on the nature of the underlying shock, ie, what caused the movement in oil prices in the first place? In particular, we identify three types of underlying source for oil price movements: oil supply shocks – which raise oil prices and reduce oil output and world output more generally – world demand shocks – which raise oil prices at the same time as world output is going up – and oil-specific demand shocks (essentially a residual) – which raise oil prices and output while reducing world output. Second, how have these effects changed over time? We do this by using a time-varying parameter structural vector autoregression (TVP-SVAR) approach to estimate these effects. A VAR is a set of equations which are each driven by lags of all the variables in the system and by error terms, modelling the dynamics of all the variables together in response to shocks. What makes it structural is that the assumptions listed above allow us to decompose (or 'identify') the fundamental shocks that together combine to make the equation errors, so that we can trace out the impact on the variables we look at from particular types of event. The time-varying aspect allows us to see how these effects might have changed over time by not restricting the estimated effects to be constant (unlike in normal SVARs).

We find that the source of the underlying shock to oil prices does matter for the response of the UK economy. Oil supply shocks lead to larger falls in output and increases in prices than world demand shocks, with the effects becoming much smaller from the mid-1980s onwards. World demand shocks are associated with a rise in output but had little effect on inflation prior to 2006, since when they have

been associated with a rise in inflation. Oil-specific demand shocks have a much smaller effect on inflation than oil supply shocks, though their effect on UK output is now similar. As a small economy, all innovations in the oil price are generally considered as exogenous to UK economic activity. That may tend to suggest that the exact source of the exogenous oil shock is of little relevance for policymakers. However, the findings in this paper suggest that even if the shock is still exogenous understanding its causes is important, as the ultimate impact for the UK is likely to be different.

We also found that the impact of different types of oil shocks on UK activity and prices has varied over time. In line with many other studies we found a fall in the impact of oil supply shocks on UK output and inflation from the mid-1980s onwards. But more unusually, we also found evidence that the impact of oil supply and demand shocks has increased since the mid-2000s. This timing coincided with the United Kingdom's transition from a net exporter to a net importer of oil. And this suggests that it may be useful to explore which channels may have been most affected, for example, the extent to which the exchange rate may have appreciated in response to oil price shocks while the United Kingdom was a net exporter, cushioning the effects on inflation of oil price rises on the rest of the economy.

1 Introduction

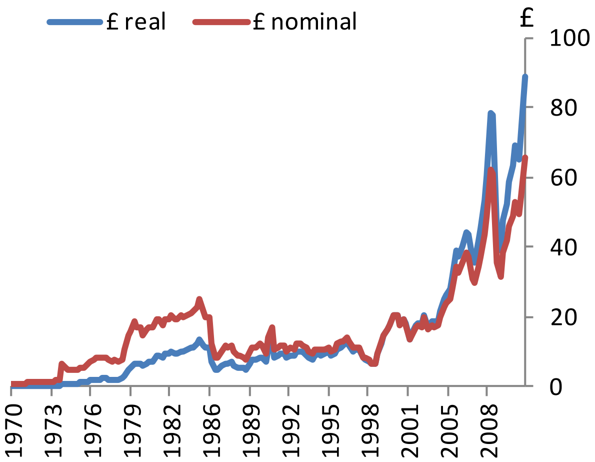
This paper examines the impact of oil price shocks on the UK economy, exploring how the impact of these shocks may have changed over time. Ever since the dramatic oil price spikes of the 1970s, and the global recessions that ran alongside, policymakers have paid close attention to fluctuations in globally traded oil prices and worried about the potential impact on economic growth and domestic price inflation. Recent years have once again seen large fluctuation in oil prices, with prices rising from $15 a barrel in 1998 to nearly $140 a barrel in 2008 (see Chart 1). This rise and the volatility in both the oil price and economic performance since have reopened the debate about how, and by how much, oil shocks affect economies and how monetary policy ought to respond.

Over the last thirty years a wide range of studies have attempted to examine the impact of oil shocks on the macroeconomy. Many of these studies have found that oil shocks appear to have large impacts on the economy (Hamilton (1983)). A typical rule of thumb is that a 10% exogenous supply shock to nominal prices (in most studies worth around just $3-$4 on a barrel) lowers US GDP by somewhere around 0.3-0.5%. That impact is much larger than the cost-share of oil in advanced economies alone would imply. But alongside this headline finding, many of the same studies (Bernanke *et al.* (1997), Hooker (2002), Hamilton (2009)) also find that oil price shocks appear to have had a smaller impact on activity and inflation since the mid-1980s. Specifically, many find evidence of a structural break around 1986 with the estimates of the peak real GDP impact falling from around 1-1.5% of GDP down to between 0.3 and 0.5%.

A number of alternative explanations have been put forward to explain why the impact of oil price shocks may have become smaller over time. These explanations can be considered in two broad categories. The first set appeal to ways in which the propagation of shocks has changed and include falls in the share of oil in the economy, erosion of nominal rigidities, for example via increased labour market flexibility, and a better or more credible policy response (Blanchard and Gali (2009)).The second set consider how the oil price shocks themselves have changed over time. Baumeister and Peersman (2008) find that the oil demand curve has become less elastic over time and that given changes in oil production tend to be associated with larger responses in the oil price. And a number of studies including Hamilton (2009) and Kilian and Vigfusson (2011) consider the possibility of asymmetric or non-linear effects leading to an unstable relationship between oil prices and the macroeconomy.

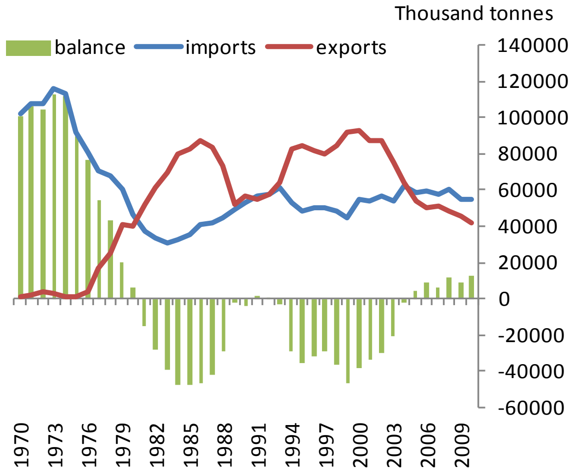
Recent research has sought to consider whether the nature of the underlying shock to oil prices might affect the impact on the economy. For example, Kilian (2009) identified three types of shock: (i) a shock to the supply of crude oil, (ii) a shock to global activity that increases the demand for oil, and (iii) a shock to oil demand that was specific to the oil market. By decomposing fluctuations in oil prices using this scheme, this work suggested that, between 1986 and 2008, 57% of oil price movements were related to oil supply, 27% to global activity, and the remainder to oil-specific demand shocks. Following from Kilian’s work on the United States, Baumeister *et al.* (2010) and Peersman and van Robays (2012) took this decomposition approach to cross-country data and found that the impact of oil price shocks on advanced economies differed significantly depending upon the underlying driver of the price move.

Chart 1: Real and nominal oil prices



Source: Datastream

Chart 2: UK crude oil trade balance



Source: DECC

In this paper we consider the impact of oil shocks on the UK economy, simultaneously considering two angles. First, we consider how the impact of oil shocks on the UK economy may depend on the nature of the underlying shock. Second, we explicitly model time variation in the effects using a time-varying parameter structural vector autoregression (TVP-SVAR) approach. Although previous literature (eg, Peersman and van Robays (2012)) has examined the effects of different types of oil shocks on the UK economy and other papers have used time-varying parameter models to analyse how the effects of oil (and other) shocks have changed over time, we believe that by drawing these two literatures together into one paper, this time-varying approach allows us jointly to consider how the oil shocks may have changed over time (the impulse) and how the propagation has changed over time (the response). This is important given that arguments have been made suggesting that both aspects matter. And examining time variation in the effects of these shocks is particularly pertinent for the United Kingdom as it is an economy that has transitioned from net oil importer in the 1970s to net exporter in the 1980s and early 1990s and returned to be a net importer again in the mid-2000s (Chart 2).

The majority of studies of the relationship between oil and the macroeconomy focus on the United States. There are a few cross-country studies, and these have found a variety of impacts. Jimenez-Rodriguez and Sanchez (2004) found that the impact of oil price increases on GDP was around a third larger for the United States than for euro-area economies and Japan. Baumeister *et al.* (2010) also found smaller impacts on euro-area GDP of oil supply shocks than on the United States, although similar impacts in the two areas from oil shocks driven by world activity. They also found quite different impacts on both activity and inflation from oil shocks depending on whether an economy was a net energy exporter or importer. In this regard, the United Kingdom provides an especially interesting case study. Harrison *et al.* (2011) studied the impact of permanent energy price increases on the UK economy using a calibrated DSGE model. Their framework suggested that the response to oil prices in the United Kingdom was likely to be very sensitive to changes in nominal rigidities and the response of policymakers. But crucially for us, they made no distinction between the different underlying shocks that might have caused oil prices to rise.

We find that the impact of oil shocks on the UK economy does differ according to the underlying source of the shock. Specifically, oil price shocks associated with oil supply shifts typically have

larger negative impacts on UK output and positive impacts on UK inflation. While oil price shocks stemming from innovations in world and oil-specific demand tend to be associated with smaller, positive effects on UK output and inflation. We also find that the impact of oil shocks especially oil supply shocks on the UK economy fell substantially around the mid-1980s. But we also find that that response of UK output and prices to all types of oil shock increased slightly from the mid-2000s.
The remainder of the paper is structured as follows. Section 2 discusses the data and the methodology we use to construct time-varying estimates of the effects of different shocks – all of which affect the price of oil – on the UK economy. Section 3 discusses our results concerning the properties of the shocks themselves and Section 4 their effects on UK macroeconomic variables. Section 5 concludes.

2 Data and methodology

We model the behaviour of quarterly real oil price inflation, $\Delta\ln P_O$, the quarterly growth rate of world oil production, $\Delta\ln O$, the quarterly growth rate of world demand, $\Delta\ln y_w$, the quarterly growth rate of UK real GDP, $\Delta\ln y_{UK}$, quarterly UK CPI inflation, π_{UK}, and the quarterly change in UK short-term interest rates, Δi_{UK}, using an SVAR framework with time-varying parameters.[1] We use sign restrictions to make a distinction between oil supply shocks, global demand shock and oil-specific demand shocks.

Specifically, we consider the following reduced-form time-varying-parameter (TVP) VAR:

$$\begin{aligned} &\mathbf{Y}_t = \mathbf{c}_t + \sum_{j=1}^{p} \mathbf{B}_{j,t}\mathbf{Y}_{t-j} + \mathbf{v}_t \\ &E(\mathbf{v}_t'\mathbf{v}_t) = \mathbf{R}_t \\ &E(\mathbf{v}_t'\mathbf{v}_s) = \mathbf{0} \text{ if } t \neq s \\ &E(\mathbf{v}_t) = \mathbf{0} \end{aligned} \tag{1}$$

where $\mathbf{Y}_t$ is the 6x1 vector $(\Delta\ln P_{O,t} \quad \Delta\ln O_t \quad \Delta\ln y_{w,t} \quad \Delta\ln y_{UK,t} \quad \pi_{UK,t} \quad \Delta i_{UK,t})'$, $\mathbf{v}_t$ is a vector of reduced-form errors, $\mathbf{c}_t$ is a vector of constants and the $\mathbf{B}_{j,t}$s are matrices of coefficients. We assume that the United Kingdom is 'small' in the sense that movements in UK variables have no effect on world variables. This implies that we can partition the $\mathbf{B}_{j,t}$s as:

$$\mathbf{B_{j,t}} = \begin{pmatrix} \mathbf{B_{j,11,t}} & \mathbf{0} \\ \mathbf{B_{j,21,t}} & \mathbf{B_{j,21,t}} \end{pmatrix} \tag{2}$$

where the $\mathbf{B}_{j,xy,t}$ matrices are 3x3 matrices to be estimated and $\mathbf{0}$ is a 3x3 matrix of zeros. This enables us to estimate the model in two distinct stages. In stage 1, we use the framework in Peersman and van Robays (2009) to capture supply and demand conditions in the oil market using an SVAR framework, applying sign restrictions on the relationships between the world variables to recover three structural shocks affecting oil prices: a shock to oil supply, a shock to world demand and a residual shock, which we call an 'oil-specific demand' shock. In stage 2, we then estimate the remaining three equations of the reduced-form VAR laid out in equation **(1)**.

[1] The construction of the specific data we use is described in Appendix 1.

The use of a two-stage procedure has three advantages. First, our approach enables us to keep the number of variables in the TVP-VAR manageable (less than 4) given the computational requirements associated with estimating larger VARs. Second, separating the process of identifying structural shocks in the oil market removes the need to employ further identification restrictions on the UK equations. Third, explicitly modeling the world oil market separately from its impact on the UK economy allows us to consider the question of whether time-variation comes primarily from changes in the nature of shocks – estimated in stage 1 – or the propagation of shocks through the UK economy – estimated in stage 2.

2.1 Stage1: World VAR

In the first stage, we estimate a TVP-VAR using world oil production, world demand and the real world oil price using quarterly data from 1965 Q2 to 2011 Q2. The first ten years of data were used as a training sample to generate priors for the actual sample period. The reduced-form VAR model is as follows:

$$\begin{aligned}
&\mathbf{Y}_{1,t} = \mathbf{c}_{1,t} + \sum_{j=1}^{p} \mathbf{B}_{j,11,t}\mathbf{Y}_{1,t-j} + \mathbf{v}_{1,t} = \mathbf{X}'_{\mathbf{1,t}}\boldsymbol{\beta}_{\mathbf{1,t}} + \mathbf{v}_{\mathbf{1,t}} \\
&E(\mathbf{v}'_{1,t}\mathbf{v}_{1,t}) = \mathbf{R}_{11,t} \\
&E(\mathbf{v}'_{1,t}\mathbf{v}_{1,s}) = \mathbf{0} \text{ if } t \neq s \\
&E(\mathbf{v}_{1,t}) = \mathbf{0}
\end{aligned} \tag{3}$$

where $\mathbf{Y}_1$ is the 3x1 vector $(\Delta \ln P_{O,t} \quad \Delta \ln O_t \quad \Delta \ln y_{w,t})'$ and *p*, the number of lags, is set to two. We allow for time variation in the VAR coefficients and covariance of the residuals by supposing that the coefficients evolve as driftless random walks:

$$\begin{aligned}
&\boldsymbol{\beta}_{1,t} = \boldsymbol{\beta}_{1,t-1} + \mathbf{e}_{1,t} \\
&E(\mathbf{e}'_{1,t}\mathbf{e}_{1,t}) = \mathbf{Q}_1 \\
&E(\mathbf{e}'_{1,t}\mathbf{e}_{1,s}) = \mathbf{0} \text{ if } t \neq s \\
&E(\mathbf{e}_{1,t}) = \mathbf{0}
\end{aligned} \tag{4}$$

The time-varying variance-covariance matrix for the errors, $\mathbf{R}_{1,t}$, evolves according to:

$$\mathbf{R}_{1,\mathbf{t}} = \mathbf{A}_{1,\mathbf{t}}^{-1}\mathbf{H}_{1,t}\mathbf{A}_{1,\mathbf{t}}^{-1'} \tag{5}$$

where $\mathbf{A}_{1,t}$ is a 3x3 lower triangular matrix with elements $a_{ij,t}$ capturing how the contemporaneous interactions between the endogenous variables vary over time and $\mathbf{H}_{1,t}$ is a 3x3 diagonal matrix with elements $h_{i,t}$, the stochastic volatilities:

$$\mathbf{A}_{1,t} \equiv \begin{bmatrix} 1 & 0 & 0 \\ a_{21,t} & 1 & 0 \\ a_{31,t} & a_{32,t} & 1 \end{bmatrix} \quad H_{1,t} \equiv \begin{bmatrix} h_{1,t} & 0 & 0 \\ 0 & h_{2,t} & 0 \\ 0 & 0 & h_{3,t} \end{bmatrix} \tag{6}$$

By splitting $\mathbf{R}_{1,t}$ in this way, we are able to assess the extent to which changes in the effects of shocks on the endogenous variables arise from changes in the shock processes themselves or changes in the propagation of them. Following Primiceri (2005) and Baumeister and Peersman (2008), we assume that the elements $a_{ij,t}$ evolve as driftless random walks

$$a_{ij,t} = a_{ij,t-1} + V_{ij,t} \tag{7}$$

while the elements $h_{i,t}$ evolve as geometric random walks

$$\ln(h_{i,t}) = \ln(h_{i,t-1}) + z_{i,t} \tag{8}$$

We estimate this model using Bayesian methods. An overview of the prior specifications and estimation strategy is provided in Appendix 2.

Having estimated our TVP-VAR, we then identify three structural shocks to oil prices, using the identifying restrictions suggested by Peersman and van Robays (2009) and Kilian (2009). Specifically, we used restrictions on the impact of each of our shocks as follows:

(i) Oil supply shocks: we define these as an exogenous shift of the oil supply curve moving oil production and oil prices in opposite directions. Such shocks could stem from disruptions to supply by natural disaster or changes in production quotas.

(ii) Global demand shocks: we define these as a shock that leads to a shift of world demand, oil production and oil prices in the same direction.

(iii) Oil-specific demand shocks: these are, essentially, residual shifts in the demand for oil not driven by economic activity. Such shifts could come about due to fears about the future supply of oil, or as a result of speculation.

Table A: Identification structure for oil shocks

Shock	Oil production	Oil price	World demand
Oil supply	<0	>0	≤0
World demand	>0	>0	>0
Oil-specific demand	>0	>0	≤0

Appendix 2 contains details of how these sign restrictions were implemented within our TVP-SVAR framework.

2.2 Stage 2: UK VAR

Having identified the shocks and obtained the responses of our world variables to these shocks, we then estimated the following reduced-form TVP-VAR:

$$\begin{aligned}
&\mathbf{Y}_{2,t} = \mathbf{c}_{2,t} + \mathbf{A_t}\mathbf{Y_{1,t}} + \sum_{i=1}^{p}\mathbf{B}_{i,21,t}\mathbf{Y}_{1,t-i} + \sum_{i=1}^{p}\mathbf{B}_{i,22,t}\mathbf{Y}_{2,t-i} + \tilde{\mathbf{v}}_{2,t} \\
&E\left(\tilde{\mathbf{v}}'_{2,t}\tilde{\mathbf{v}}_{2,t}\right) = \mathbf{R}_{2,t} \\
&E\left(\tilde{\mathbf{v}}'_{2,t}\tilde{\mathbf{v}}_{2,t}\right) = \mathbf{0} \text{ if } t \neq s \\
&E\left(\tilde{\mathbf{v}}_{2,t}\right) = \mathbf{0}
\end{aligned} \tag{9}$$

where $\mathbf{Y_2}$ is the 3x1 vector $\left(\Delta \ln y_{UK,t} \quad \pi_{UK,t} \quad \Delta i_{UK,t}\right)'$ and the number of lags, *p*, is again set to two.

We again impose the following structure on the time variation. First we define $\boldsymbol{\beta}_{2,t} = \begin{pmatrix} \mathbf{c}_{2,t} \\ \mathbf{A_t} \\ vec\left(\mathbf{B}_{21,t}\right) \\ vec\left(\mathbf{B}_{22,t}\right) \end{pmatrix}$. We then suppose that the coefficients evolve as driftless random walks:

$$\begin{aligned}
&\boldsymbol{\beta}_{2,t} = \boldsymbol{\beta}_{2,t-1} + \mathbf{e}_{2,t} \\
&E\left(\mathbf{e}'_{2,t}\mathbf{e}_{2,t}\right) = \mathbf{Q}_2 \\
&E\left(\mathbf{e}'_{2,t}\mathbf{e}_{2,s}\right) = \mathbf{0} \text{ if } t \neq s \\
&E\left(\mathbf{e}_{2,t}\right) = \mathbf{0}
\end{aligned} \tag{10}$$

Volatility is modelled as follows:

$$\mathbf{R}_{2,\mathbf{t}} = \mathbf{A}_{2,\mathbf{t}}^{\mathbf{-1}}\mathbf{H}_{2,t}\mathbf{A}_{2,\mathbf{t}}^{\mathbf{-1}\,'} \tag{11}$$

Where, again, $\mathbf{A}_2$ is a 3x3 lower triangular matrix with elements $a_{2,ij,t}$ and $\mathbf{H}_2$ is a 3x3 diagonal matrix with elements $h_{2,i,t}$. The elements of $\mathbf{A}_2$ again evolve as driftless random walks:

$$\begin{aligned}
&a_{2,ij,t} = a_{2,ij,t-1} + V_{i2,j,t} \\
&E\left(V_{2,ij,t}^2\right) = D_{2,ij} \\
&E\left(V_{2,ij,t}V_{2,ij,s}\right) = 0 \text{ if } t \neq s \\
&E\left(V_{2,ij,t}\right) = 0
\end{aligned} \tag{12}$$

And the elements of $\mathbf{H}_2$ again evolve as geometric random walks:

$$\begin{aligned} \ln(h_{i,t}) &= \ln(h_{i,t-1}) + z_{i,t} \\ E(z_{i,t}^2) &= g_i \\ E(z_{i,t} z_{i,s}) &= 0 \text{ if } t \neq s \\ E(z_t) &= 0 \end{aligned} \tag{13}$$

We again estimate this model using Bayesian methods. An overview of the prior specifications and estimation strategy is provided in Appendix 2.

Now, returning to our time-varying parameter VAR. We can rewrite equation **(9)** as:

$$\mathbf{B_t(L)Y_{2,t}} = \mathbf{c_{2,t}} + \mathbf{C_t(L)Y_{1,t}} + \tilde{\mathbf{v}}_{\mathbf{2,t}} \tag{14}$$

The response of UK variables to a unit shock to our world variables will then be given by the coefficients in the structural moving average representation:

$$\Delta\mathbf{Y_{2,t}} = \mathbf{B_t(L)^{-1}C_t(L)\Delta Y_{1,t}} \tag{15}$$

So, if the responses of the world variables to a given structural shock are denoted by the matrix lag polynomial $\mathbf{A_t(L)}$, then the responses of the UK variables to this shock will be given by:

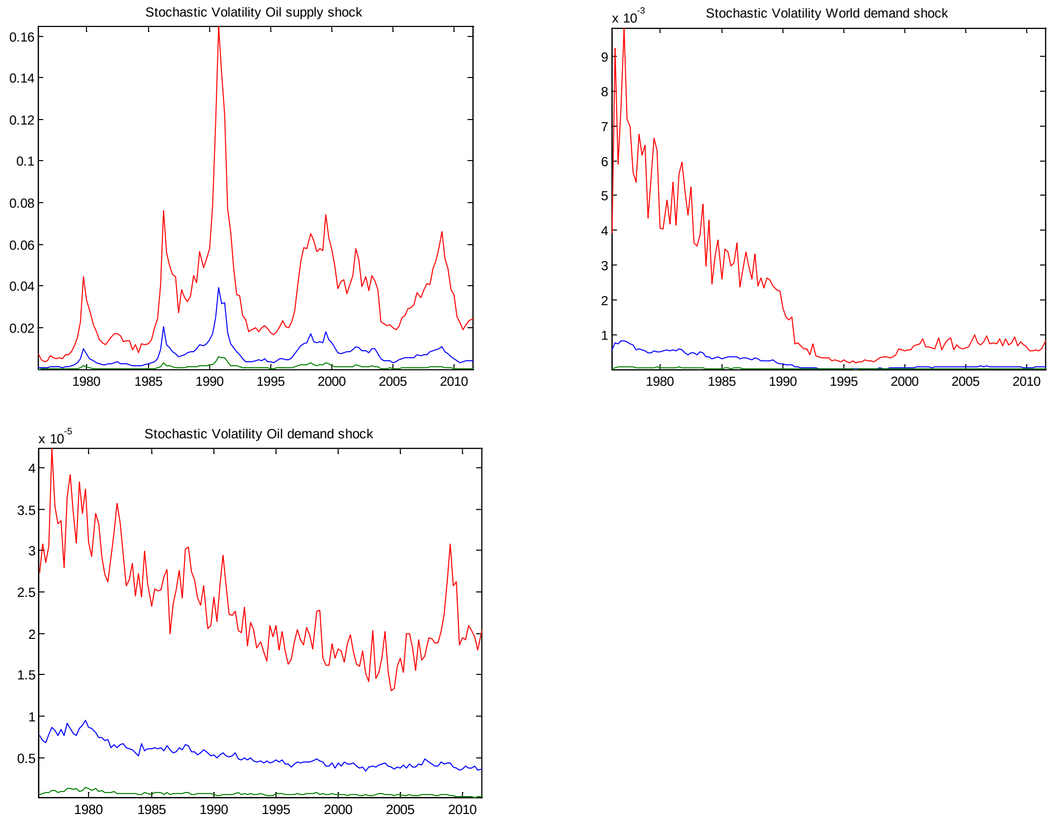
$$\Delta\mathbf{Y_{2,t}} = \mathbf{B_t(L)^{-1}C_t(L)A_t(L)\xi_t} \tag{16}$$

3 Estimated shocks

The estimation results are presented in the following sections. We start by discussing the estimated shock and their time-varying effects on world oil output and prices and world activity.

Chart 3 shows our median estimates (in blue) for the stochastic volatilities of our three shocks, together with the 16^{th} and 84^{th} percentiles (in green and red, respectively). Although the scale of these is not particularly informative, the relative stochastic volatilities, and their evolution over time, can tell us about which shock(s) have been most important and when. The oil supply shock is easily the most volatile of our shocks. Volatility spiked at around the start (1980) and end (1986) of the Iran-Iraq war and has more generally increased since the mid-1980s, with further spikes, as expected, around the time of the first Gulf War (1990/1), the late 1990s and the late 2000s. In contrast, volatility in the world demand shock has fallen dramatically since the 1980s, coinciding with the onset of the Great Moderation. The residual oil-specific demand shock has also become less volatile over time but was anyway far less volatile than the other two shocks.

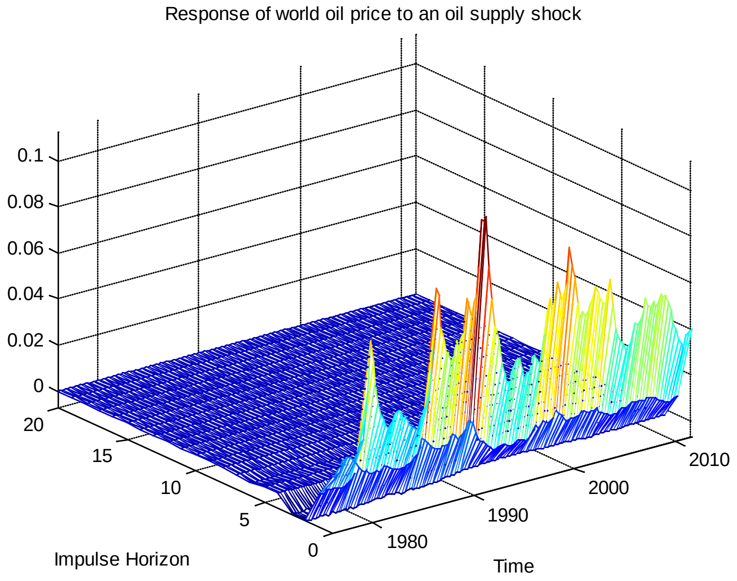
Chart 3: Stochastic volatilities

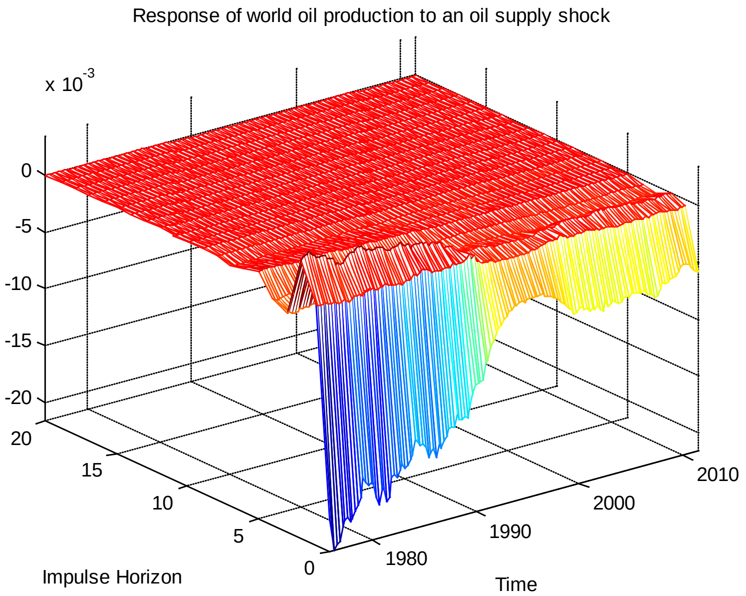


Charts 4 through 6 shows the median estimated effects of each of our identified shocks on the world price of oil and world economic activity and how these effects have changed over time. Unfortunately, these effects conflate changes in the effects of a given size of shock with changes in the average size of the shocks themselves. One approach would be to normalise the shock based on its effect on oil prices or oil production and we do this later when considering the effects of the shocks on the UK economy by examining the effect of a shock that raises oil prices by 10%. However, Baumeister *et al.* (2010) point out that the recent steepening of the oil demand curve means that this approach runs into problems when used to look at the effects of oil supply and demand shocks on the price of oil and oil production. Specifically, a comparison based on a given rise in oil prices implicitly assumes a constant price elasticity of demand for oil; given the steepening of the oil demand curve, it would now take a smaller shift in oil supply to generate the same rise in price. To get around that, we can examine the effect of a typical (ie, one standard deviation) shock.

Chart 4 suggests that the effect of a one standard deviation negative shock to the supply of oil on world activity has fallen over time and is now about half as large as it was in the late 1970s. This result has been well documented in the literature by, eg, Bernanke *et al.* (1997), Hooker (2002), Hamilton (2009) and Baumeister and Peersman (2008). But, in line with Baumeister and Peersman, we find that this pattern has not been observed in terms of the response of world oil prices to an oil supply shock. Here the response has been larger in the 2000s than previously, with the exception of the spikes around 1980, 1986 and 1990. We can also note that the effect of an oil supply shock on oil production itself is now much smaller – about a quarter the size – than it was in the late 1970s. This reflects the steepening of the oil demand curve emphasised by Baumesiter and Peersman.

Chart 4: Responses of oil price, oil production and world activity to an oil supply shock





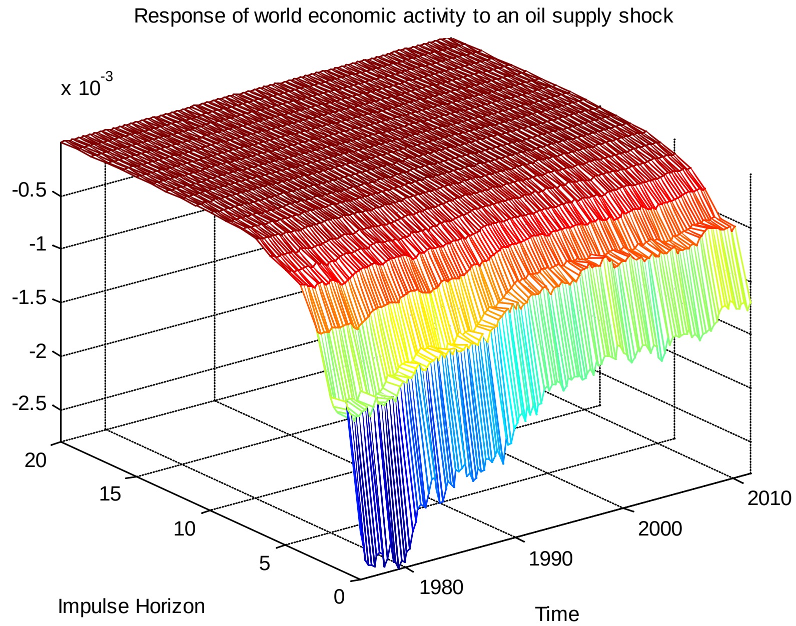


Chart 5: Responses of oil price, oil production and world activity to a world shock

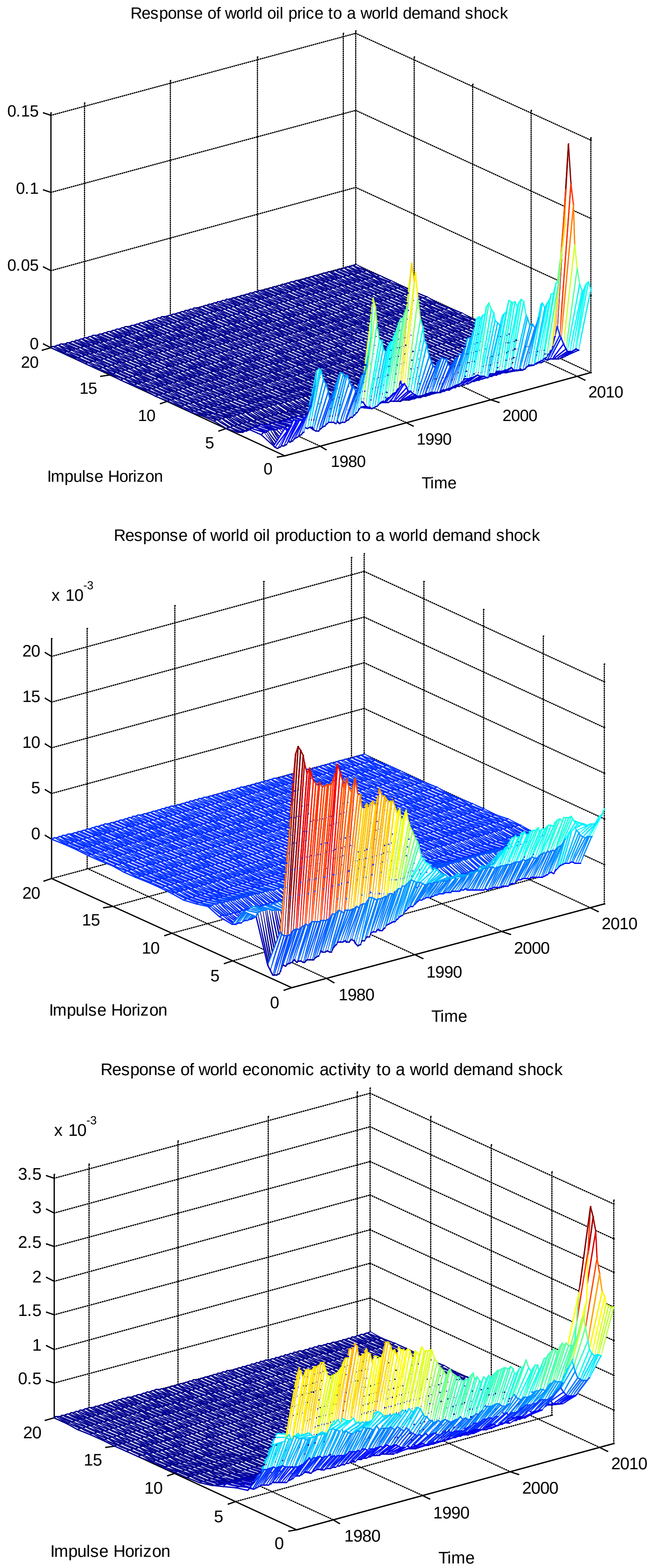


Chart 6: Responses of oil price, oil production and world activity to an oil-specific demand shock

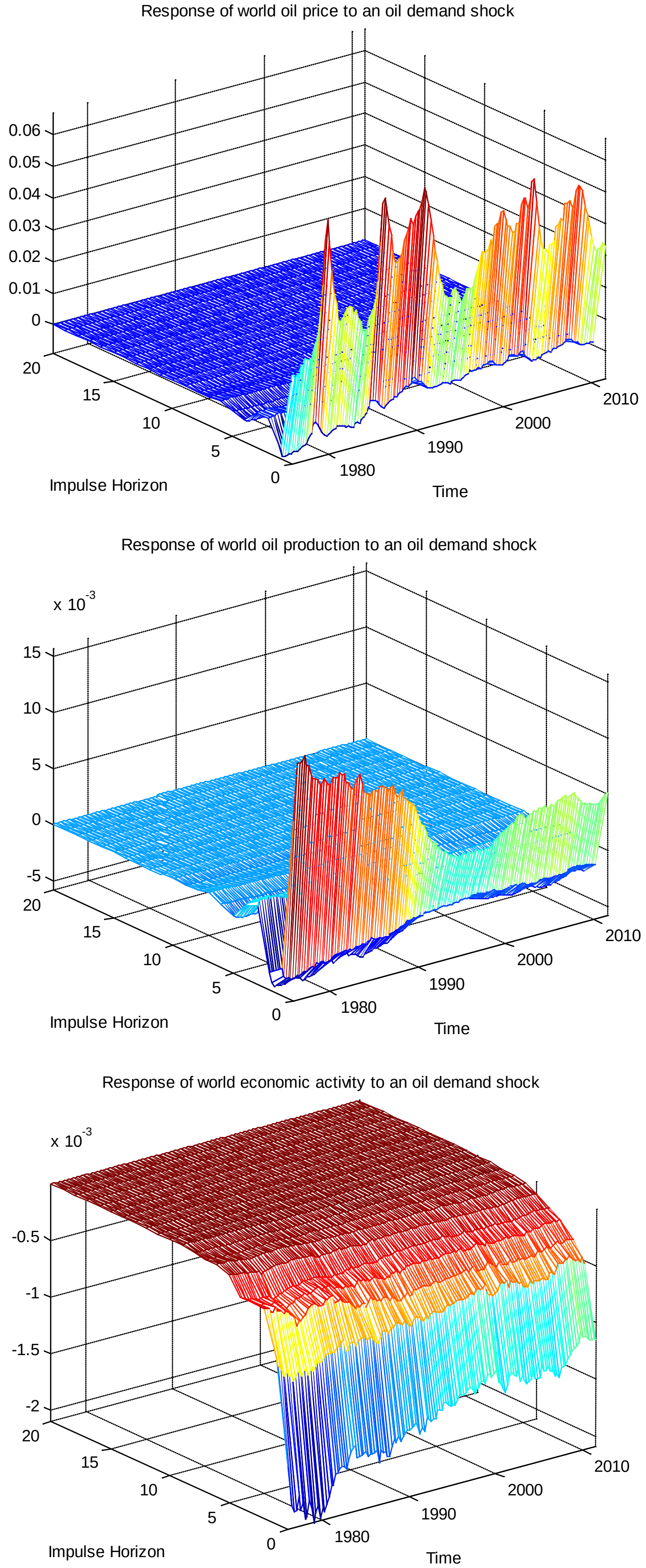


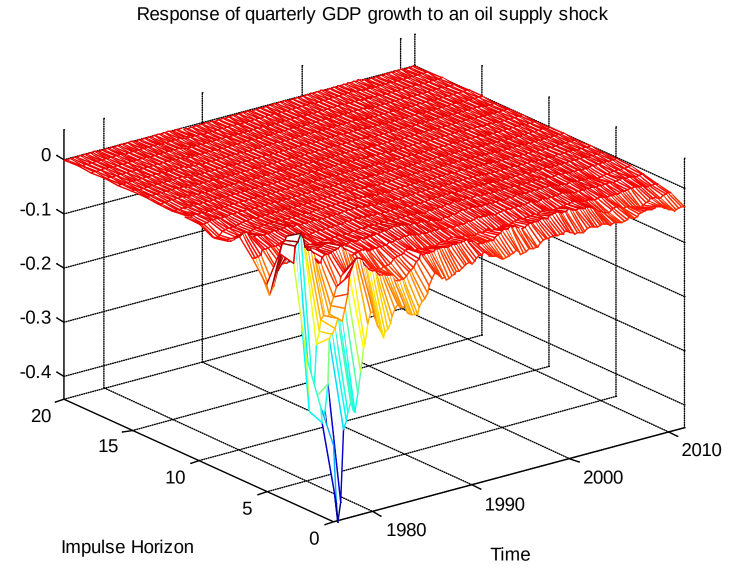
Chart 5 suggests that the identified positive shock to world demand seems to have had a much larger effect on the world oil price and world activity in the most recent period, ie, since just before the start of the financial crisis. In the decade prior to that, the effect of the shock on world activity had been lower than in the 1980s and early 1990s. The effect on the world oil price, on the other hand, was larger in the 2000s than it had been previously, again with the exception of the period around the first Gulf War. The effects of both a world demand shock and an oil-specific demand shock on oil production have been lower about 1990 suggesting that the oil supply curve has also steepened. This might reflect a drying up of new oil discoveries and less ability on the part of existing producers to increase their supply in the face of rising oil prices. Finally, Chart 6 suggests that the effect of the identified positive shock to oil-specific demand on world activity has fallen over time whereas there is no discernible pattern in its effect on world oil prices.

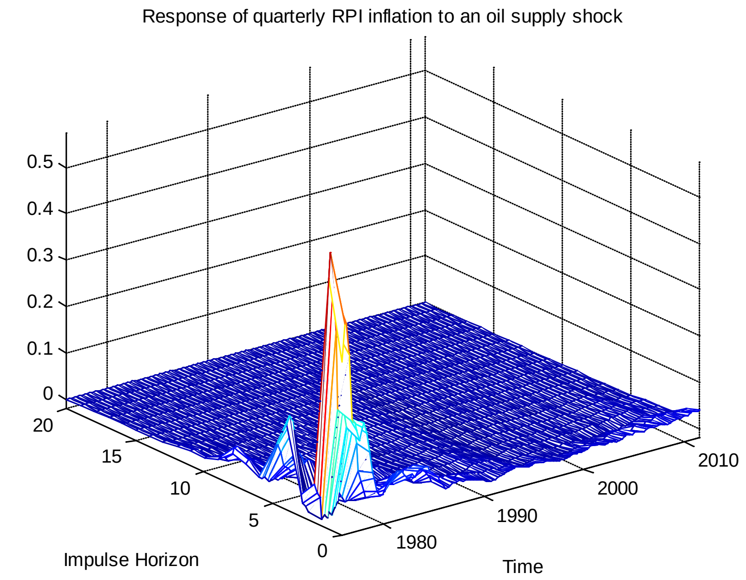
4 Effects of oil shocks on the UK economy

In this section, we consider the effects of our identified shocks on UK output and inflation implied by our TVP-SVAR model. These effects are derived under the assumption that the shocks are exogenous to UK inflation, output and monetary policy. Although the United Kingdom produces oil, its share of global oil production only peaked at 4% in 1995 and was 1.3% in 2011 according to the BP Statistical Review of World Energy June 2012. Equally, UK oil consumption has been less than 3% of world consumption since 1980. Given these data, our assumption of exogeneity seems justified. As a robustness check on this assumption, we examined the effects of the shocks within a VAR that contained UK non-oil GDP rather than total GDP and found that the results were little altered.

Charts 7 through 9 show the median estimated effects of each of our identified shocks on quarterly UK GDP growth, quarterly UK RPI inflation and the nominal interest rate. The responses are scaled so that they show the response to a shock that permanently raises the world price of oil by 10%. Our estimated suggest that all of our identified shocks had large effects on UK output and inflation in the late 1970s and early 1980s. However, since about 1986, by when the United Kingdom was a net oil exporter, our estimates suggest that the effects of all these shocks had become small. Looking at our estimates of the effects of the shocks on interest rates specifically suggests that interest rates hardly moved in response to oil price shocks, even during the late 1970s and early 1980s. The largest response was in the late 1970s to an oil supply shock; but, according to our model, even this amounted to only about 20 basis points in response to a 10% rise in oil prices. These results are in line with those of Peersman and van Robays (2012), except that they found little change in the response of GDP to oil-specific demand shocks in the period between 1986 and 2010 relative to the 1971-1985 period.

Chart 7: Responses of UK GDP growth, RPI inflation and interest rates to an oil supply shock





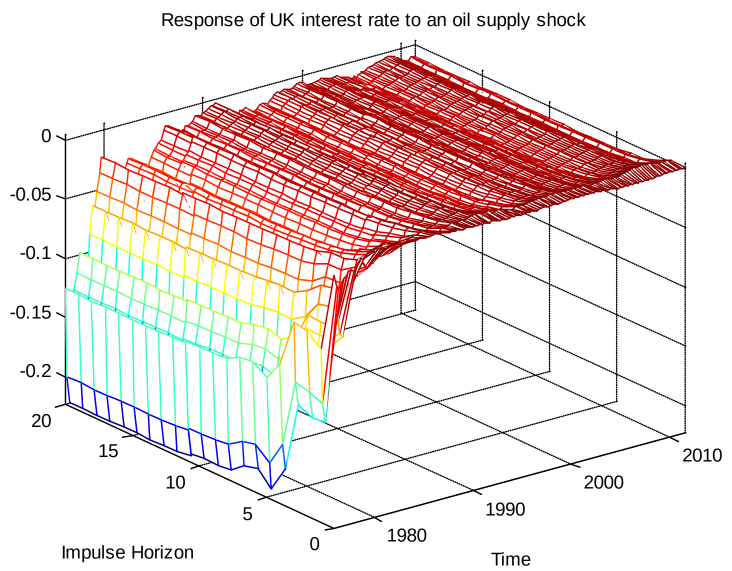


Chart 8: Responses of UK GDP growth, RPI inflation and interest rates to a world demand shock

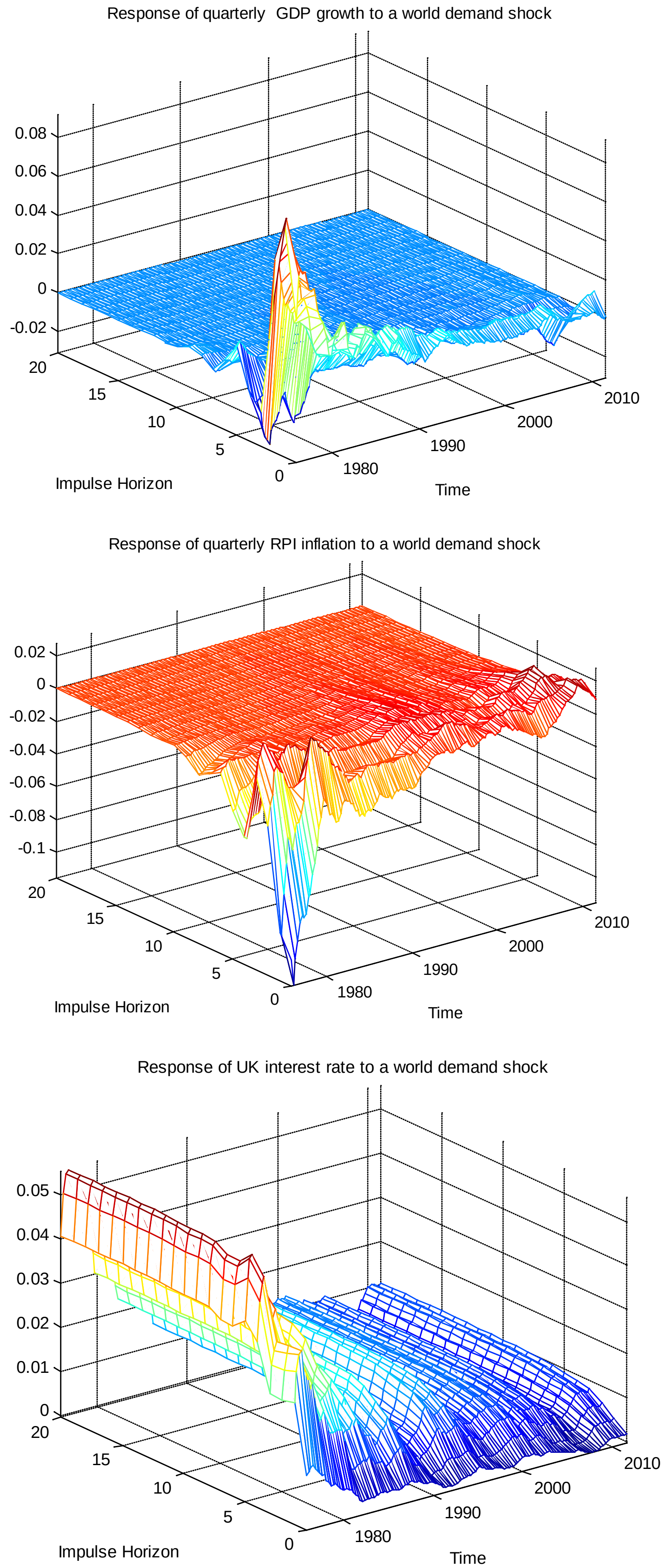


Chart 9: Responses of UK GDP growth, RPI inflation and interest rates to an oil-specific demand shock

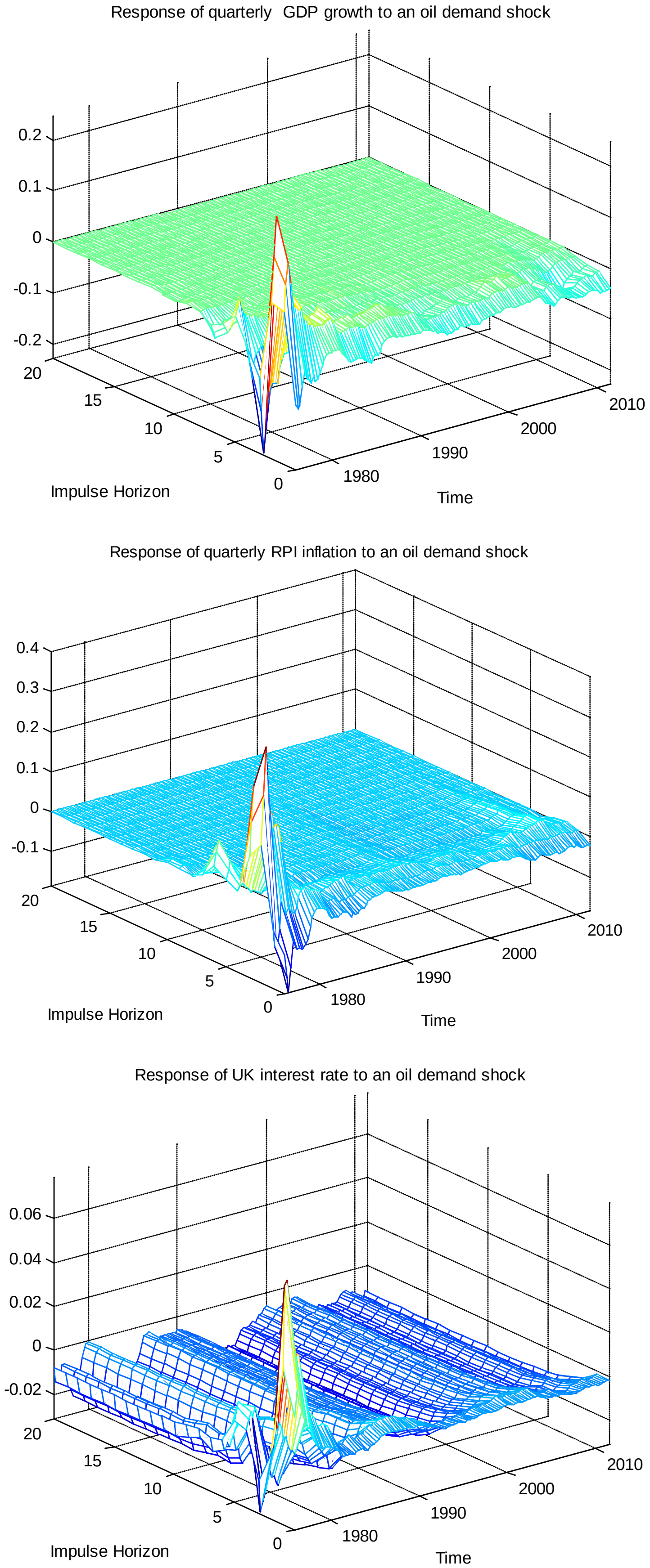


Chart 10: Impact of oil price shocks on the levels of UK GDP and RPI after four quarters

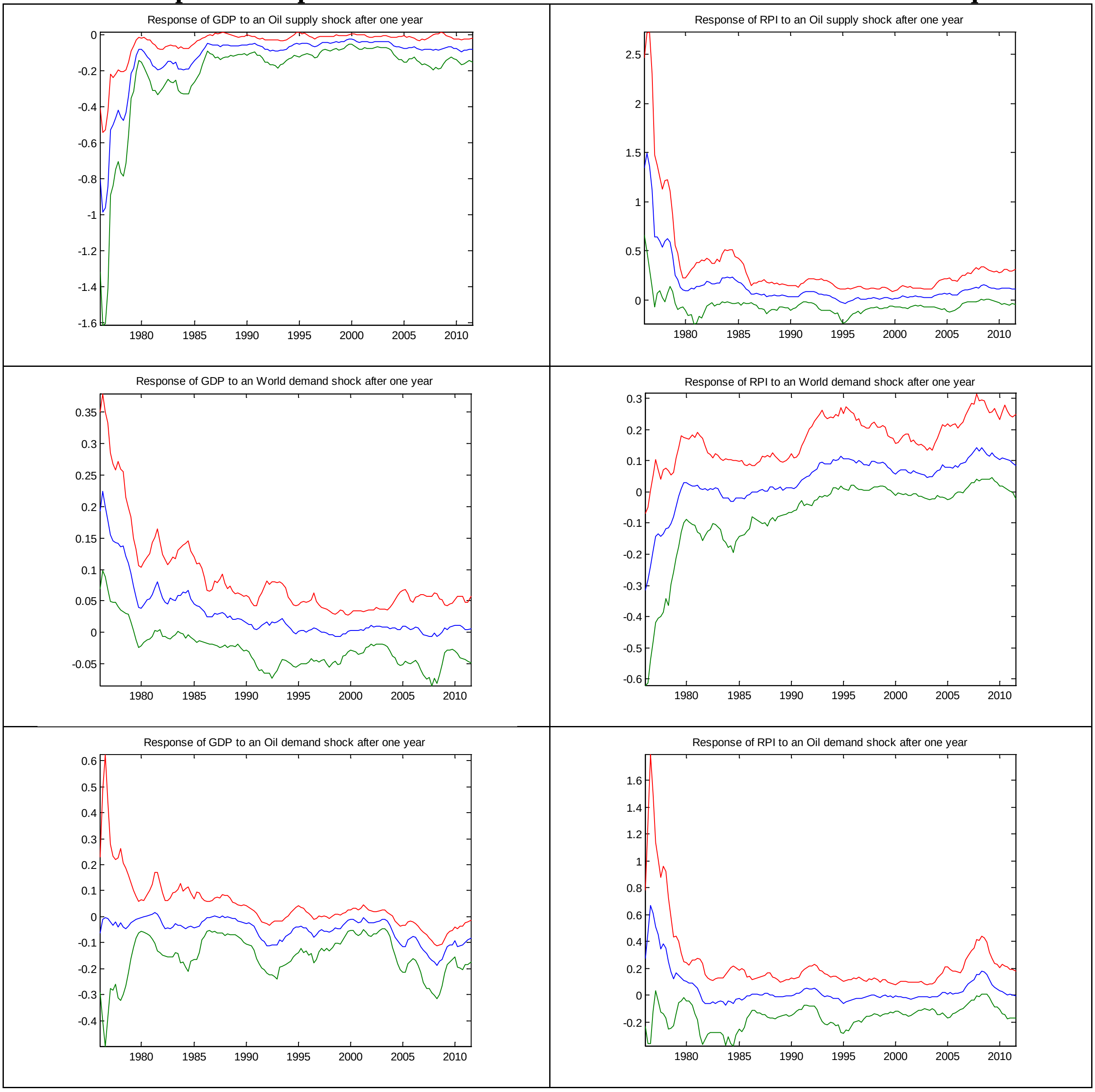


Chart 10 shows the median impact (in blue) on the levels of UK real GDP and RPI after four quarters to each of an oil supply, global demand and oil-specific demand shock that raise oil prices by 10% together with the 16th and 84th percentiles (in green and red, respectively). The response of UK GDP to an oil supply shock that increases prices by 10% is negative throughout the period, though the impact was much larger in the late 1970s than it is now. This might suggest that the negative effect of the shock on non-oil GDP was being somewhat counterbalanced by the positive effect coming from higher oil prices on UK oil production and exports. However, the sensitivity of UK GDP to oil supply shocks seems to have increased recently as the United Kingdom has become a net oil importer again. In contrast, the response of UK GDP to world demand driven oil price shocks is typically positive throughout the period, although the size of impact is much smaller and there is noticeably less variation in the sensitivity of UK GDP to this type of oil price shock. This may be a result of the compositional change in the UK economy from being a producer of energy-intensive manufactured goods towards less energy-intensive services. An identified world demand shock in our context is likely to be biased towards goods whose production is energy-intensive, since such a shock would likely raise oil prices by more than one that was not. Putting these facts together suggests that such shocks are likely to have less impact on the United Kingdom now than in the past. Meanwhile, the shocks described as 'oil-specific demand' have a negative impact on UK GDP throughout, but the sensitivity of UK GDP to this type of shock has increased noticeably after 2004. Again, the negative effect of higher oil prices on UK non-oil GDP outweighs any positive effect that might come via UK oil production and exports.

Table A provides the average median responses for the whole sample, and three sub-samples 1976-1986 and 1986-2004 and 2004-2011, together with the average of the 16th and 84th percentiles of the responses (in brackets). We split the sample in 1986 based on the results of Baumeister and Peersman (2008), who found that their TVP-VAR model exhibited a structural break in the behaviour of the oil market in 1986 Q1 but was stable thereafter. This date also coincides with the collapse of the OPEC cartel and is around the time that the Great Moderation started in the United States and has often been used in studies of the oil market. Table A highlights that, in line with the earlier literature, the impacts of all oil supply and world demand shocks after 1986 appears smaller than before, although the sensitivity of UK output to oil supply and oil-specific demand shocks has generally increased since 2004.

Table A: Average impact of oil shocks on UK output and inflation 1976-2011(a)

Average impact on UK GDP after 4 quarters			
	Oil supply shock	World demand shock	Oil-specific demand shock
1976-2011	-0.12	0.03	-0.05
	(-0.22,-0.04)	(-0.03,0.09)	(-0.15,0.04)
1976-1985	-0.29	0.09	-0.02
	(-0.48,-0.12)	(0.01,0.18)	(-0.19,0.16)
1986-2003	-0.05	0.01	-0.04
	(-0.11,-0.01)	(-0.04,0.06)	(-0.11,0.03)
2004-2011	-0.08	0.00	-0.12
	(-0.15,-0.01)	(-0.05,0.06)	(-0.21,-0.05)
Average impact on UK RPI after 4 quarters			
1976-2011	0.14	0.04	0.04
	(-0.06,0.35)	(-0.07,0.17)	(-0.16,0.24)
1976-1985	0.37	-0.05	0.12
	(-0.01,0.77)	(-0.22,0.10)	(-0.21,0.45)
1985-2003	0.04	0.06	-0.00
	(-0.09,0.16)	(-0.03,0.17)	(-0.16,0.13)
2004-2011	0.10	0.10	0.06
	(-0.05,0.27)	(0.01,0.25)	(-0.10,0.25)

(a) These are the average of the median estimates, they summarise the figures in Chart 6. (Average estimates of the 16th and 84th percentiles in brackets.)

In terms of the response of UK RPI after 4 quarters to each of the three oil shocks, oil supply shocks lead to increases in RPI throughout, as expected, although the impact on inflation appears to have fallen substantially since the late 1970s. The impact of world activity shocks on UK inflation is more mixed. From around 1980 until the early 1990s the impact on UK inflation was small.[2] But, from the mid-1990s the impact on UK inflation has generally been positive and has increased further since around 2005. The impact of the oil-specific demand shocks on UK inflation has been much more or less zero throughout the period. Again, we can notice that the inflationary effects of oil price movements, from whatever cause, have increased since around 2005.

In summary, we find that the impact of oil shocks on UK output and inflation varies according to the source of the underlying shock, that oil supply shocks are associated with larger negative impacts on output and larger positive impacts on inflation, that world demand shocks are associated with positive effects on output and (at least until recently) small effects on inflation, and that residual movements in oil prices – what we've termed 'oil-specific demand shocks' – are associated with negative effects on output, that are now of a similar magnitude to the effects of oil supply shocks, and small positive effects on inflation. These findings are in line with the general pattern of other studies (eg, Peersman and van Robays (2012)). While consistent with other studies, the finding that an economy of the United Kingdom's size, which is small relative to the rest of the world, would respond differently to different types of oil shock was not clear *a priori*.

Also consistent with many studies is the finding that the impact of oil supply shocks on output and inflation fell around the mid-1980s, specifically 1986. The time-varying parameters in our world SVAR do not support the view that this was caused by a reduction in the volatility of oil supply shocks. Rather, in line with the results of Baumeister and Peersman (2008), the effect of a typical oil supply shock on oil prices has increased and the effect of a given rise in oil prices on the UK economy has fallen. Furthermore, and also in line with the results of Baumeister and Peersman, this result suggests that recent oil price volatility has been driven by demand shocks rather than oil supply shocks.

But, our introduction of time-varying parameters into our analysis of the response of UK activity and prices to oil shocks reveals another change over time: the increased sensitivity of UK variables to oil shocks since the mid-2000s. This is not a pattern noted in studies of other economies, but its timing does coincide with the unique transition path of the UK from a net exporter of oil to a net importer around 2004.

5 Conclusions

In this paper, we have studied the changing nature of oil price shocks and their impact on the UK economy over time from the mid-1970s to 2011. We identified shocks to the world oil price from three types of underlying source: oil supply, world demand and oil-specific demand (essentially a residual). And we allowed for time variation in the responses of world variables to these shocks as well as in the responses of UK output and prices to these shocks. Although previous work has looked at the effects of different underlying shocks to oil on the UK economy and on the time-varying impact of oil supply shocks, we believe that our paper is the first to jointly consider time variation in a group of identified structural shocks to the oil price.

[2] We are unable to explain the negative effect on inflation of world demand shocks at the very start of our sample. We can only suggest that this results from the fact that UK inflation and world demand were highly negatively correlated during this period for reasons beyond the ability of the model to explain.

We found that the source of the underlying shock to oil prices does matter for the response of the UK economy. Oil supply shocks lead to larger falls in output and increases in prices than world demand shocks, with the effects becoming much smaller from the mid-1980s onwards. World demand shocks are associated with a rise in output, but had little effect on inflation prior to 2006, since when they have been associated with a rise in inflation. Oil-specific demand shocks have a much smaller effect on inflation than oil supply shocks, though their effect on UK output is now similar. As a small economy, all innovations in the oil price are generally considered as exogenous to UK economic activity. That may tend to suggest that the exact source of the oil shock is of little relevance for policymakers. However, the findings in this paper suggest that even if the shock is still exogenous understanding its causes is important, as the ultimate impact for the UK is likely to be different.

We also found that the impact of different types of oil shocks on UK activity and prices has varied over time. In line with many other studies we found a fall in the impact of oil supply shocks on UK output and inflation from the mid-1980s onwards. But more unusually, we also found evidence that the impact of oil supply and demand shocks has increased since the mid-2000s. This timing coincided with the United Kingdom's transition from a net exporter to a net importer of oil and is a key novel result in our paper. This result suggests that it may be useful to explore which channels may have been most affected, for example, the extent to which the exchange rate may have appreciated in response to oil price shocks while the United Kingdom was a net exporter, cushioning the effects on inflation of oil price rises on the rest of the economy. We leave this for future work.

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Appendix 1: Data

Model series	**Original sources**	**Transformations**
Oil prices, P_{oil}	OECD Economic Outlook, CRUDE OIL PRICE, FOB SPOT BRENT (US$) (AR) Quarterly US dollar Seasonally adjusted WDOCBRNTB Oil-price nominal U.S. Bureau of Economic Analysis (BEA) CHAIN-TYPE PRICE INDEX OF GDP QuarterlyUS prices Seasonally adjusted Index 2005=100 USGDP..CE	Natural logs Deflated by US GDP deflator using average year 2000 as base [nom oil price* (deflator /avg 2000 deflator)] Natural logs
Oil production, Q_{oil}	Spliced series 1965Q2-1973Q1 BP- OPEC producer PRODUCTION - CRUDE OIL Barrels thousands Volume- nsa Annual- with linear interpolation OPPDEOIL 1973Q1-2011Q2 US Dept of Energy CRUDE OIL PRODUCTION – WORLD Barrels thousands Volume- nsa Monthly- with quarterly averaging WDPCOBD.P	ln-ln(-1)
World demand, Y_{wld}	Spliced series 1965-1980 OECD GDP GDP - COMPARISON TABLE Quarterly national accounts by expenditure Volume seasonally adjusted Index 2005=100 OCOCMP03G 1980-2011 Q1 World GDP -	ln-ln(-1)
UK GDP, Y_{uk}	GDP AT MARKET PRICES (CVM) UKGDP...D Office for National Statistics (ONS), U.K. UK Sterling Pound milions 2008 CHND PRICES 1965Q2-2011Q2 ew:gbr01020	ln-ln(-1)
UK RPI, P_{uk}	RPI UKRPALL.F Office for National Statistics (ONS), U.K. Quarterly average of monthly index JAN 1987=100 not seasonally adjusted IDX Inflation Percent Retail Price Index 1965Q2-2011 Q2	ln-ln(-1)
UK short-term interest rates, i_{uk}	INTERBANK RATE - 3 MONTH (MONTH AVG) UKINTER3 Financial Times Quartelry average of monthly rate (percentage) tf:gb14019733316 1965Q2-2011Q2	Annualized 3 month rates, converted to simple 3-month rates t-t(-1)

Appendix 2: Estimation details

The VAR models described in the main text above are estimated using Bayesian estimation methods as in Mumtaz (2011). Specifically, following Mumtaz (2011), we combine the Carter-Kohn algorithm to draw β_t and $a_{ij,t}$ with the independence Metropolis-Hastings algorithm for the stochastic volatility.

The priors for the initial states of β_t and $a_{ij,t}$ are provided by using OLS estimation of a fixed coefficient version of the VAR model for the first 20 observations (i.e. 1965-1970). The priors for the hyper-parameters (**Q**, **D** and g) follow Mumtaz (2011).[3]

The combined algorithm then has the following steps:

(i) Conditional on $\mathbf{A}_t$, $\mathbf{H}_t$ and **Q**, draw β_t using the Carter and Kohn algorithm

Using the draw for β_t, calculate the residuals of the transition equation $\boldsymbol{\beta}_t - \boldsymbol{\beta}_{t-1} = \mathbf{e}_t$

(ii) Sample **Q** from an inverse Wishart distribution using the scale matrix $\mathbf{e}_t'\mathbf{e}_t + \mathbf{Q_0}$ and degrees of freedom T+T_0. And draw D_1 from the inverse Gamma distribution with scale parameter $\frac{V_{12,t}'V_{12,t} + D_{12,0}}{2}$ and degrees of freedom $\frac{T+T_0}{2}$ and $\mathbf{D}_2$ from the inverse Wishart distribution with scale matrix $\begin{pmatrix} V_{13} & 0 \\ 0 & V_{23} \end{pmatrix}' \begin{pmatrix} V_{13} & 0 \\ 0 & V_{23} \end{pmatrix} + \mathbf{D_{2,0}}$ and degrees of freedom T+T_0

(iii)Using β_t, $\mathbf{H}_t$, Q D_{12} and $\mathbf{D}_2$, draw $a_{ij,t}$ Conditional on these draws, calculate the residuals $a_{ij,t} = a_{ij,t-1} + V_{ij,t}$ and then calculate $\varepsilon_t = A_t v_t$

(iv)Draw for $\mathbf{H_t} = Var(\boldsymbol{\varepsilon}_t)$, apply the independence Metropolis Hastings algorithm to draw $h_{i,t}$ for i = 1…3 conditional on a draw for g_i.

(v) Finally, draw g_i, conditional on $h_{i,t}$ for i = 1…3, from the inverse Gamma distribution with scale parameter $\frac{(\ln h_{i,t} - \ln h_{i,t-1})^2 + g_{i,0}}{2}$ and degrees of freedom $\frac{T + v_{i,0}}{2}$

This algorithm is run 100,000 times of which the first 99,000 are 'burn in'.

Evidence for the convergence of the algorithm is provided by looking at retained draws. The charts in Appendix 3 plot the recursive means calculated using intervals of 20 draws for the 1000 retained draws of the VAR parameters.

We identify our three structural shocks via assumptions about the impacts of these shocks on the three world variables. In particular, we impose the sign restrictions given in Table AA.

[3] Mumtaz(2011) assumes Q and D are inverse Wishart $p(\mathbf{Q}) \sim IW(\mathbf{Q}_0, T_0)$ with a small scalar 0.0001 taken as a T_0 (so low weight on prior values), g is assumed to follow inverse gamma distribution.

Table AA: Sign restrictions

Structural shocks	World oil production	World oil price	World economic activity
Oil supply	<0	>0	≤ 0
World demand	>0	>0	>0
Oil-specific demand	>0	>0	≤ 0

These restrictions copy across to the expected signs of the elements of a matrix $\mathbf{A}_0$ such that $\mathbf{R}_t = \mathbf{A}_{0,t}\mathbf{A}'_{0,t}$. For example, we are imposing that the 2nd row, 2nd column element of $\mathbf{A}_0$ is greater than zero.

We can implement our sign restrictions as part of the Gibbs and Metropolis Hastings algorithm, once we're past the burn-in stage, by carrying out the following steps:

- Draw an *nxn* matrix **K** from the standard normal distribution
- Calculate the matrix **Q** from the *QR* decomposition of **K**
- Calculate the Cholesky decomposition of the current draw of $\mathbf{R}_t = \tilde{\mathbf{A}}_0\tilde{\mathbf{A}}'_0$
- Calculate the candidate $\mathbf{A}_0$ matrix as $\mathbf{A_0} = \mathbf{Q}\tilde{\mathbf{A}}_0$
- Check the candidate $\mathbf{A}_0$ matrix to see whether the restrictions imposed in Table A are satisfied across the three rows
- If we can, reshuffle our candidate $\mathbf{A}_0$ so that the first row corresponds to the oil supply shock, the second row corresponds to the world demand shock and the third row corresponds to the oil-specific demand shock and store the structural shocks $\boldsymbol{\xi}_{1-3,t} = \mathbf{A}_{0,t}^{-1}\mathbf{v}_t$ for t=1,…,T
- If not, try a new K matrix
- Repeat these steps for every retained draw of **R**

We then need to calculate impulse response functions and assess how these have varied over time. For the responses of oil production, oil prices and world output to the shocks, we can obtain these from the VAR using our estimates of $\boldsymbol{\beta}_t$ and $\mathbf{A}_0$. In particular, we can write the structural moving average representation of our system:

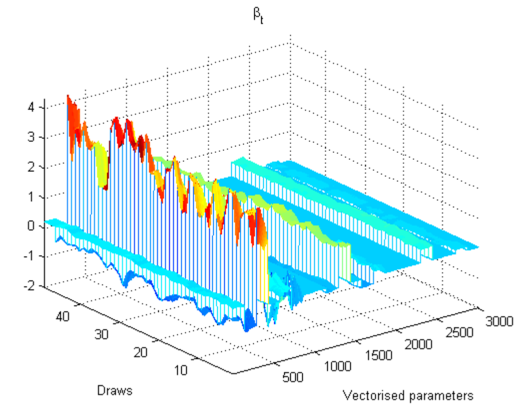
$$\mathbf{Y_t} = \mathbf{c_t} + \left(\mathbf{I_3} - \mathbf{B_{1,t}}L - \ldots - \mathbf{B_{p,t}}L^p\right)^{-1}\mathbf{A_{0,t}}\boldsymbol{\xi}_\mathbf{t} \quad \textbf{(A1)}$$

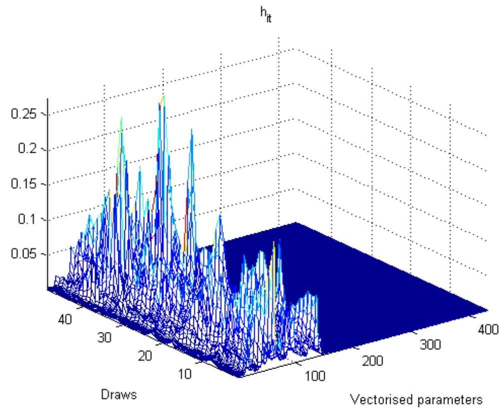
Where L is the lag operator and the coefficients on $\boldsymbol{\xi}_{t-j}$ represent the response of $\mathbf{Y}_{t+j}$ to a unit shock to $\boldsymbol{\xi}_t$. We need to normalise the shocks by their standard deviations. To calculate these we first normalise $\mathbf{A}_{0,t}$ by dividing each column with the main diagonal. Call this normalised matrix $\hat{\mathbf{A}}_{0,t}$. Then the time-varying stochastic volatility of the structural shocks will be given by:

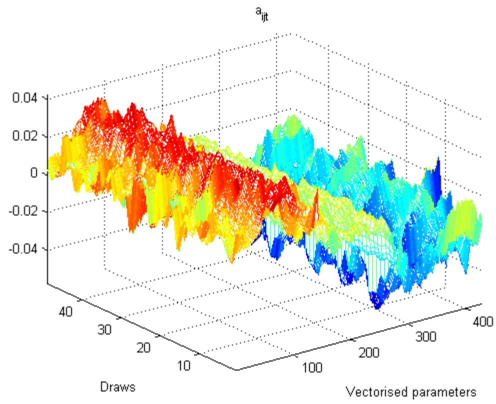
$$\hat{\mathbf{H}}_\mathbf{t} = \hat{\mathbf{A}}_{0,t}^{-1\prime}\mathbf{R}_t\hat{\mathbf{A}}_{0,t}^{-1} \quad \textbf{(A2)}$$

Appendix 3: Convergence of parameters

World VAR







UK VAR