The transmission of UK monetary policy across national borders: Investigation of the impact on oil prices

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***Abstract*—** Does UK monetary policy affect world oil prices? Long term low interest rates and expansionary monetary policy enhanced by consequences of financial crisis are blamed for increases in oil prices. Therefore this paper explores the links between monetary policy changes and the volatility of oil prices. The aim is to identify the inventory and supply channels of transmission mechanism between UK monetary policy and oil market by estimating a SVAR model. Focusing primarily on UK monetary policy this paper contributes to an up-to-date evaluation of the effect of UK monetary policy shocks on oil prices at national, international and global level. Results show that UK monetary policy has statistically significant impact on oil prices through inventory channel at national and international level but small effect at global level. Although, surprisingly loose UK monetary policy has significant impact on OPEC oil supply rather than European oil supply. The contribution of the expansionary policy effect is sizeable and comparable with the effect of larger economies. Considering that the UK economy is set for a slow recovery with prognosis of low interest rates for the next years, particular attention must be paid to the transmission of monetary policy across national borders.

Keywords: monetary policy, oil prices, transmission mechanism, global responsibility, SVAR model
JEL classification: E52, F62, Q02,

1 INTRODUCTION

The decades of stability of commodity prices was interrupted in 2005. Since then, unprecedented volatility and new price peaks have opened a discussion on the factors driving the commodity prices. The explanation is not straightforward since higher commodity prices coincided with lower interest rates in most of the developed countries as well as a continued devaluation of the US dollar. Therefore, the factors contributing to rises in commodity prices are matters of controversy. Nevertheless, several explanations of volatility in commodity prices have been developed recently. While Trostle (2008) identified a number of reasons with the main ones being excess demand, expansion of bio-fuels and devaluation of the US dollar. Similarly, Akram (2009) and Kilian (2009) state that increased demand from emerging economies has contributed substantially to the growth in commodity prices. However, the spill-over effect should be also considered. High crude oil prices are assumed to contribute through cost-push effects to rises in other commodities or contribute to shifts in demand for agricultural commodities, particularly bio-fuels, as a substitute for crude oil. Krichene (2008) and Taylor (2009) see expansionary monetary policy particularly low interest rates and devaluation of the US dollar as main contributors to increases in commodity prices. Frankel (2013) used survey data to measure the effect of speculations and found that economic activity, easy monetary policy as well as speculations have subscribed for changes in inventories which along with other drivers consequently pushed the commodity prices up. However, even his results are interesting, in his model, the possibility of non-linearity in the effects of growth of inventories as well as possible non-stationarity of series has not been tested. His model might therefore suffer from spurious regression and autocorrelation that may lead to invalid results. In addition to previous findings, Baffes and Haniotis (2010) argue that fiscal expansion in many countries and the ease monetary policy created an environment that favoured high commodity prices. Important contributing factors include low past investment in extractive commodities, inclusion of commodities into the portfolio of investment funds as well as geopolitical concerns in energy markets. Even if several supportive studies on the role of speculative activity and high commodity prices can be found (Pyndick and Rotemberg, 1990, Nikos, 2008). Gilbert (2007) refused the impact of speculations in case of the prices of metals but found the evidence for other commodities such as soybeans. Although all these factors may act as drivers of commodity prices, it is convenient to consider the size of the effect and a possible combination of more factors rather than a few. Although there are many reasons behind the increases in commodity prices, this paper focuses on the monetary policy channel outlined by Working (1949) and later adopted by Frankel (2006). Frankel (2006) distinguishes between channels of how monetary policy can affect commodity prices. Specifically, it is possible to distinguish between inventory channel, supply channel and speculation channel. This paper focuses on the first two types. The inventory channel has a rationale in the theory of storage which explains increases in commodity prices when interest rates are set too low. The effect of low interest rates can be also explained by the theory of overshooting. Loose monetary policy leads to rises in commodity prices until these prices are considered as overvalued. This is the point at which there is a future expectation of depreciation which is sufficient to compensate for the lower interest rate. Even if Frankel (2006) made an important contribution to the knowledge about relationship between monetary policy and movements in commodities, his analysis has often been criticised due to disadvantages of using linear bivariate regression models estimated by OLS which does not enable to investigate the dynamic interaction between variables. In contrast to his study, Arora and Tanner (2013) use VAR framework to generate the response of oil prices to the US interest rates during the period from 1975-2012. Their results confirm Frankel's results and show the inverse short-term relationship confirming that this represents a monetary policy channel therefore the US monetary actions may have direct impacts on the oil prices. However, even their results are without doubt interesting and encourage a discussion on the relative importance of this channel for monetary policy changes as well as for oil price variation the drawback of their study can be found in the period analysed. During the last 37 years, the US monetary policy went though important changes which should be also considered. Most recently financial crisis which has affected policy makers' decisions significantly. Therefore the extension to their study could be an investigation on the break-even points and whether the changes in monetary policy also led to changes in size of the effect on commodity prices. Similarly, study of Anzuini et al. (2010) focuses on the US as the largest oil consuming economy in the world and analyses the period from 1970 to 2009 without taking into consideration the changes in monetary policy during such a long period. Krichene (2007) used VAR model to formulate a short-run model with implication of monetary policy in order to analyse world oil and gas market. His results support the assumption of importance of monetary policy and conclude that incorporating interest rates and exchange rates in the model can help to generate a reliable forecast of oil and gas prices. Nevertheless, his model is set for period 1970 to 2006 and uses annual data which limits the sample to minimum observation. This will understandably also limit the value of model. Similary to previous studies, Krichene also did not consider the possibility of structural breaks in his model. The importance of investigating for structural breaks can be explained in two ways. Firstly, if there is a structural break (e.g. change in monetary policy) SVAR model cannot be applied for the whole sample (see Lucas, 1968). Second point that needs to be considered is that in the case of the existence of a structural break, the effect of monetary policy before and after the change may differ. Thus by ignoring the possibility of structural break, important information may be overlooked thus any conclusion from the model may be considered as incomplete or misleading. As presented in previously mentioned studies the main focus is on U.S. monetary policy and its effect on the world commodity markets or alternatively the effect of developments in global economy on the world commodity markets. Without doubt this approach may uncover some important information, none of the studies considered the impact of monetary policy on commodity markets at different levels thus in respect to national level, an international level in line with global level. Moreover, even the main focus is on the U.S., with an exception of a few studies on other countries, there is a lack of empirical evidence in case of the UK. This paper therefore introduces an investigation on the validity of Frankel's assumption of different channels with an implication on the UK monetary policy. In addition, it extends Frankel's study to distinguishing between the impacts on different levels. Therefore the aim of this paper is to investigate the effects (if any) of monetary policy shocks on commodity prices through inventory channels at national, international and global levels. Considered variables for this investigation are UK industrial oil stocks, OECDEurope oil industry stocks and OECD oil stocks. The assumption behind the distinguishing between inventory stages is based on the size of the economy and possible differentiation of importance. A model which distinguishes between impacts of the shock is assumed to contribute to a better understanding of a country's position in a global context. A similar approach is applied to supply channels. While Anzuini et al. (2010) examine the effect on the world supply, the model introduced in this paper does not only investigate the impact on the world supply but it also considers the countries aggregation. Therefore when investigating the supply channel, the model examines the effect of a monetary policy shock on World supply, EU27 supply, IEA supply, OECD supply and OPEC supply.

The majority of studies focus on the transmission mechanism from US monetary policy to commodity prices given the importance to the size of the US economy and its international position. This paper investigates the validity of an argument that smaller economies may also have a global impact therefore the contribution to higher commodity prices should be measured as well. Even if there is a rational assumption of a smaller size effect of UK monetary policy compared to the effect of the US monetary policy a cumulative effect needs to be considered as well. Presented paper offers a view from a different perspective by measuring the actual contribution of expansionary UK monetary policy to developments in commodity prices (thus possible endogenous relationship) which consequently (through imported inflation) may affect the UK economy by causing imbalances in prices and price inflation.

2 DATA SET AND ECONOMETRIC MODEL

2.1 DATA SET

The selection of data used for modelling the relationship between monetary policy and commodity prices has the advantage of capturing the relationship with a focus on country specific. Similar to the work of Anzuini et al. (2010), the dataset consists of monthly variables from September 1992 to May 2013. The impact of liquidity is measured as the monetary aggregate M4, collected from the Bank of England official database. The inclusion of money supply serves as an investigation on the indirect channel of how monetary policy shocks can affect commodity prices. Nevertheless, the existing literature on indirect channels seems to be limited especially in the case of the UK. To investigate the indirect channel we use the 3- months Treasury Bills rate. The importance of inclusion the interest rates has been well explained by Frankel (2007) who states that low interest rates consequently lead to reduction of the opportunity costs from carrying inventories but also speculative positions what consequently through arbitrage increases pressure on spot prices and understandably on futures as well. Moreover since the indirect channel, as stated by Barsky and Kilian (2004), represents the transition through expectation about growth and inflation we include data about industrial production index, collected from ONS official database. Headline consumers price inflation represents the expectations about inflation channel and data has been collected from ONS. Even if the estimated model is a five-variable SVAR, since the developed model investigates two different channels at national, international and global level overall there are twelve variables. The group of core four economic variables CPI, M4, 3-months Treasury bills and IPI which represents monetary shock, new variables introduced to the transmission mechanism model can be split into two groups. The inventory channel includes monthly data during the period 1992-2013 published by EIA in billions on UK oil industry stocks, OECD Europe oil industry stocks and OECD oil industry stocks. The information about oil stocks excludes those in hold of government since government's oil stocks are assumed to be affected by other variables rather than monetary policy which is out of the scope of this paper. Therefore the inventory channel is investigated exclusively at industry level. The inclusion of UK oil industry stocks in the model enables investigation of the behaviour of industry within unrestricted relationship. Therefore the effect of monetary policy shock on oil industry stocks at national level can be examined. Similar approach is applied to supply channel. While Anzuini et al.(2010) examine the effect on the world supply, the model introduced in this paper not only investigates the impact on the world supply but it also considers the countries aggregation. Therefore when investigating the supply channel, the model examines the effect of monetary policy shock on the World supply, EU27 supply, IEA supply, OEDC supply and OPEC supply. These possible transmission channels have not been, to the best of the author's knowledge, investigated so far.

2.2 THE EFFECT OF UK MONETARY POLICY: MODEL SPECIFICATION AND ESTIMATION

The modelling strategy used for analysing the impact of monetary policy on commodity prices found in works of Akram (2009), Anzuini et al. (2010) and Arora and Tanner (2012) is VAR method. The applicability of VAR model strategy can be acceptable in large open economies and since these studies focus on the US monetary policy results from VAR model can be reliable. However, it can be argued that this method is not efficient in the models of small open economies such as the UK where the aim is to develop models that are influenced by the core variables however they themselves have little feedback into the core variables (Garratt et al.,2006). More precisely commodity prices such as oil prices can be treated as exogenous to the domestic economy since their prices are set outside the UK economy. Therefore it can be assumed that decisions of small open economies such as the UK economy do not influence the rest of the world significantly thus international events can be determined as exogenous. Contrary to previous research on this topic, due to lack of evidence for the UK, we apply different approach arguing that there may be occasions when movements in macroeconomic variables in the UK might provide important contemporaneous indicators of movements in commodity markets. Therefore, the approach adopted in our model treats variables as endogenous. This assumption is important since the main aim is to investigate the impact of changes in the UK monetary policy in line with the investigation of transmission of UK monetary policy across national borders and the effect on pricing in national as well as international oil markets.

2.2.1 MODEL SPECIFICATION

Since the use of VAR models requires the imposition of restrictions on the model, the formulation of identifying restrictions is restricted to those common to a variety of theoretical models. To investigate the transmission of monetary policy shock on inventory channel and supply channel, a five–variable SVAR model is developed where the fifth variable represents an inconstant variable in respect to measurement. The effects of these five shocks on system variables are evaluated to determine which are statistically significant and how long they remain significant. The structural VAR representation:

$$A_0 X_t = \alpha + \sum_{i=1}^{p} A_j x_{t-j} + e_t$$

Where p is the lag order[1], and e_t denotes the vector of serially uncorrelated structural innovations. The reduced-form VAR representation is:

$$x_t = A_0^{-1}\alpha + \sum_{i=1}^{p} A_0^{-1} A_i X_{t-1} + e_t$$

If A_0^{-1} is known, the dynamic structure represented by structural VAR can be calculated from the reduced-form VAR coefficients, and the structural shocks e_t can be derived from estimated residuals $e_t = A_0 e_t$. Coefficients in A_0^{-1} are unknown, so identification of structural parameters is achieved by imposing theoretical restrictions to reduce the number of unknown structural parameters to be less than or equal to the number of estimated parameters in the VAR residual variance–covariance matrix. When applied to the model, the data vector are logs of monthly data on Treasury bill, M4, CPI, IP, X_{oil}, where M4 is the money supply, CPI is the consumer price

[1] Lags lenght is estimated using AIC

index, IPI is industrial production index, and X_{oil} represents oil industrial inventories $\{UK_{stock}, OECD_{stock}, OECDEU_{stock}\}$ in inventory channel and $\{world_{supply}, EU27_{supply}, IEA_{supply}, OECD_{supply}, OPEC_{supply}\}$ in oil supply channel.

The following equations represent identifying restrictions. All restrictions are zero (exclusion) restrictions.

[█(e↓MS@e↓treasury@e↓CPI@e↓ipi@e↓oil)] = [■(1 @ 〖 α〗↓21 @0 @0 @ 〖 α〗↓51)■(〖 α〗↓12 @1 @0 @0 @

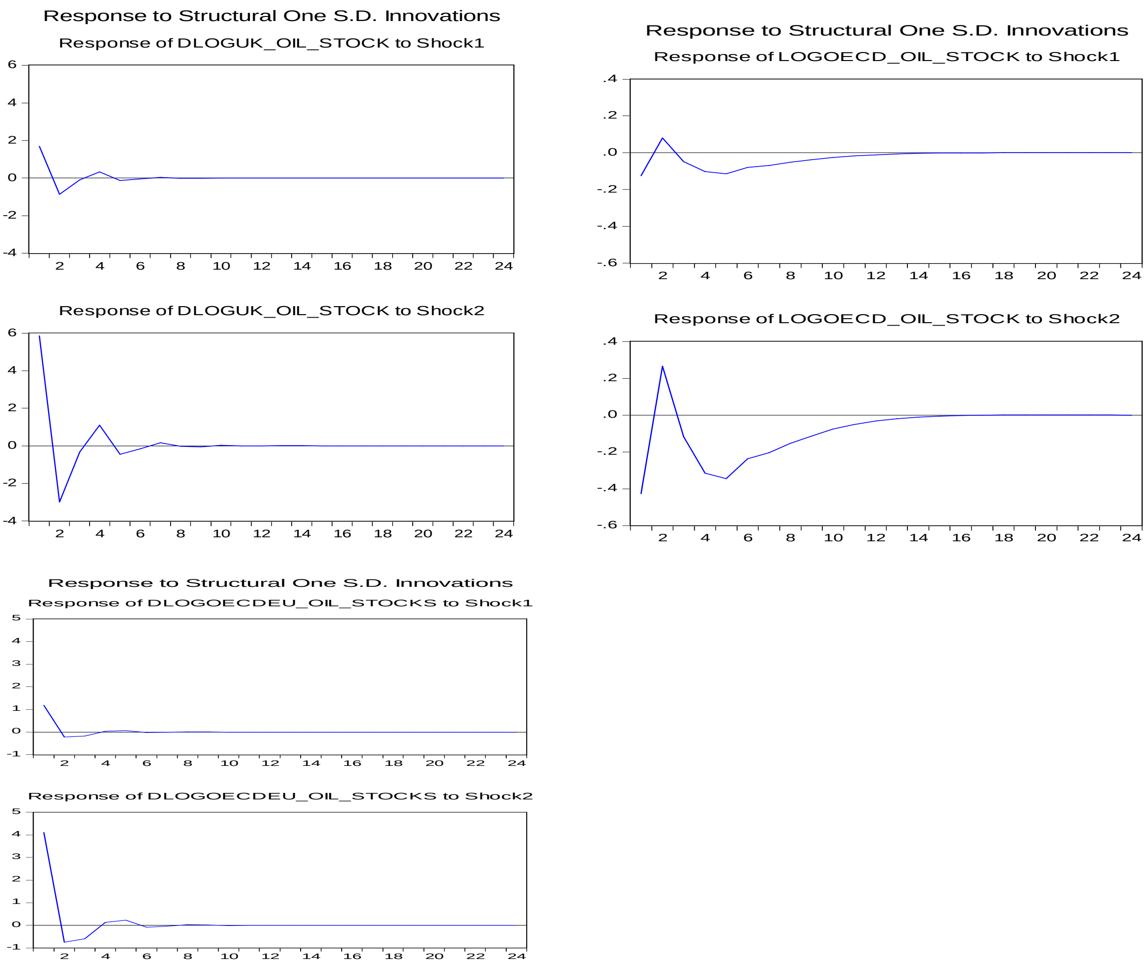
where e_{MS}, $e_{treasury}$, e_{CPI}, e_{ipi} and e_{oil} are the structural disturbances and u_{MS}, $u_{treasury}$, u_{CPI}, u_{ipi} and u_{oil} are the residuals representing unexpected movements of each variable by construction. The recursive structure of the structural VAR model is achieved by assuming that not all variables respond to shocks contemporaneously. The money supply equation is assumed to be a reaction function of the Bank of England which sets the interest rate (or money) after observing the current value of money (or interest rate) and the oil supply/oil stocks however does not consider the current value of output and price level. According to Kim (1999) this assumption is valid since there is an information delay in the case of output and price level while commodity information and in money supply is published monthly. The interest rate, money and the commodity price index are assumed not to affect real activities contemporaneously while in commodity equation (supply/inventory) all variables are assumed to have contemporaneous effects.

3 FINDINGS

3.1 INVENTORY CHANNEL

Holding oil inventories has a cost not only in terms of the fee due to the owner of the storage facilities, but also because of the opportunity cost of using money to buy oil which goes into storage and is not immediately burnt instead of investing the amount needed at the risk-free rate. Understandably, this cost will be lower in an environment of low interest rates and higher in an environment of higher interest rates. Therefore while loose monetary policy may generate incentives to accumulate inventories, thereby raising the demand for oil as well as its price, tight monetary policy will lead to giving up inventories due to more attractive investment. To investigate whether this channel appears to be at work the model introduced in this paper measures the impact of the monetary policy shock on crude oil. The first estimated SVAR investigates the impact of monetary policy shock on oil industry stocks at national level. The upper part of structural VAR model presented in Appendix A shows the matrix form and bottom part estimated coefficients with standard errors. Low standard errors for estimated coefficients suggest that identifying restrictions are correct. The estimated values of C(1), C(5) and C(7) are positive which implies that the interest rates increase after observing unexpected increases in monetary aggregate, inflation and output. The last line of matrix in upper table shows the estimated equation for UK industrial oil inventories. The coefficients are significant except of inflation (-6.137). Interestingly, higher values for coefficients have been estimated for money supply and interest rates while lower value for industrial production suggests lower importance. Results become even more interesting when comparing within national, international and global level. In Appendix B, results for European inventory channel also shows that money supply and interest rates play important role nevertheless lower values of their coefficients suggest still significant however lower importance compared to national level. While in the previous two models the estimated coefficients have low standard errors and are significant, in case more global context (Appendix C) the importance of previous coefficients is questionable. Surprisingly, money supply does not seem to be an explanatory variable for the movements in inventories since -0.98 <0.05. The coefficient also has high standard error (0.62). The only coefficient with low standard error and sufficient significance is inflation which in previous models was not explanatory. From the results in Appendix C it can be assumed that the movements in global oil inventories will be dependent on other variables than those included in this model. Nevertheless, these results are rational and also expected. As already noted earlier the assumption of lower (if any) effect of UK monetary policy at global level can be to a certain level explained by the size of the economy and its relative global role. More accurate conclusions can be driven from impulse response functions which show the response of oil inventories to the monetary shock and has been estimated in two ways. First shock represents the unexpected movements in money supply while second shock represents an unexpected movement in interest rates. The results of impulse response function can be found in Figure 3.1.

Figure 3.1: Impulse responses to the monetary policy shock



The argument presented by Frankel (2007) is that high interest rates lead to decreases in firms' desire to carry inventories while low interest rates have an opposite effect. From Figure 3.1 upper left graph shows response of UK industrial oil inventories to structural shock in monetary policy. While first shock represents the response of UK oil inventories to shock in money supply, the main shock is increase in interest rates. Oil inventories response to one per cent increase in interest rates by sharp 9 per cent drop in first three months. The effect of the shock dies of after 8 months confirming Frankel's short-term assumption. Interestingly the impulse response of oil inventories in OECDEurope countries on monetary policy shock shows smaller but significant response. In the first three months the inventories drops by more than 5 per cent as a response to increase in interest rates however as in previous case, the effect dies in eight month. A different effect can be observed when estimating the effect of UK monetary shock on industrial oil inventories of all OECD countries, in other words when estimating the global impact. In contrast to national or international level, the global impact is very small since a one per cent increase in interest rates leads to a very small increase of 0.2 per cent in second month followed by a decrease in oil inventories in the following four months. The effect dies in a year after the shock. Indeed a smaller impact at global level is not surprising. However even if the impact is not as strong as at national or international level results are comparable with Anzuini et al. (2010) who came to similar conclusion when analysing the impact of US monetary policy shock on OECD inventories.

Since the results show significant effect of UK monetary shocks at all levels it may be interesting to investigate the relative contribution of shocks to overall oil inventories fluctuations. This can be done by means of a forecast error variance decomposition, which measures the percentage share of the forecast error variance due to a specific shock at a specific time horizon. Results presented in Table 3.1 report the forecast error variance decomposition of the oil inventories at all levels with respect to the monetary shocks. In all cases, the shock to interest rates explains movements in oil inventories the most however it does not explain all the fluctuations in prices. Overall, it can be concluded that UK monetary policy shock particularly unexpected movements in interest rates, help to predict movements in oil inventories however cannot explain all fluctuations especially at global level. This result is in line with study of Barsky and Kilian (2004) and Frankel (2007) who conclude that the most significant impact on commodity prices can be caused by interest rates.

Table 3.1: Variance decomposition of the monetary policy shock

UK_oil_stock

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	9.889051	4.189802	87.65216	0.048707	0.016805	8.092525
2	11.70665	4.201569	87.69998	0.041328	0.017513	8.039612
3	11.79481	4.202336	87.68293	0.043740	0.017310	8.053683
4	12.03716	4.203734	87.66733	0.043241	0.017149	8.068551
5	12.03725	4.203504	87.66544	0.043936	0.017207	8.069918
6	12.04569	4.203227	87.66610	0.043855	0.017238	8.069577
7	12.04579	4.203223	87.66608	0.043856	0.017258	8.069581
8	12.04996	4.203247	87.66587	0.043861	0.017256	8.069769
9	12.05000	4.203248	87.66585	0.043876	0.017257	8.069764
10	12.05005	4.203241	87.66587	0.043877	0.017258	8.069757
11	12.05005	4.203241	87.66587	0.043878	0.017259	8.069757
12	12.05010	4.203241	87.66586	0.043879	0.017259	8.069758

Factorization: Structural

OECD_oil_stock

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	1.140766	4.307551	88.67762	0.272167	0.038378	6.704287
2	1.212814	4.330715	89.84939	0.115694	0.019458	5.684746
3	1.296790	4.345779	89.85884	0.080028	0.023353	5.692004

4	1.323053	4.349433	89.97193	0.073217	0.021754	5.583664
5	1.342038	4.352515	90.05955	0.066381	0.023154	5.498401
6	1.357656	4.351353	90.13626	0.062525	0.023690	5.426169
7	1.372957	4.352520	90.18990	0.059631	0.024651	5.373302
8	1.385164	4.352596	90.22927	0.058228	0.025123	5.334781
9	1.395436	4.352864	90.25948	0.056900	0.025561	5.305193
10	1.403586	4.352889	90.28265	0.055863	0.025855	5.282744
11	1.410576	4.353009	90.30030	0.055047	0.026108	5.265532
12	1.416332	4.353085	90.31401	0.054448	0.026292	5.252164

Factorization: Structural

OECDEU_oil_stock

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	6.661911	5.139348	85.09991	0.097787	0.038168	9.624788
2	10.39939	5.144962	85.20899	0.089532	0.038196	9.518325
3	12.72004	5.140747	85.22115	0.091223	0.038378	9.508503
4	12.87588	5.140211	85.23079	0.090783	0.038751	9.499470
5	12.88179	5.139956	85.22994	0.090678	0.038723	9.500705
6	12.90503	5.139927	85.23163	0.090564	0.038741	9.499136
7	12.91540	5.139923	85.23162	0.090565	0.038741	9.499149
8	12.91934	5.139911	85.23166	0.090565	0.038746	9.499123
9	12.92300	5.139911	85.23165	0.090569	0.038746	9.499122
10	12.92410	5.139911	85.23166	0.090569	0.038746	9.499118
11	12.92413	5.139912	85.23166	0.090570	0.038746	9.499117
12	12.92420	5.139912	85.23166	0.090570	0.038746	9.499117

Factorization: Structural

3.2 Supply channel

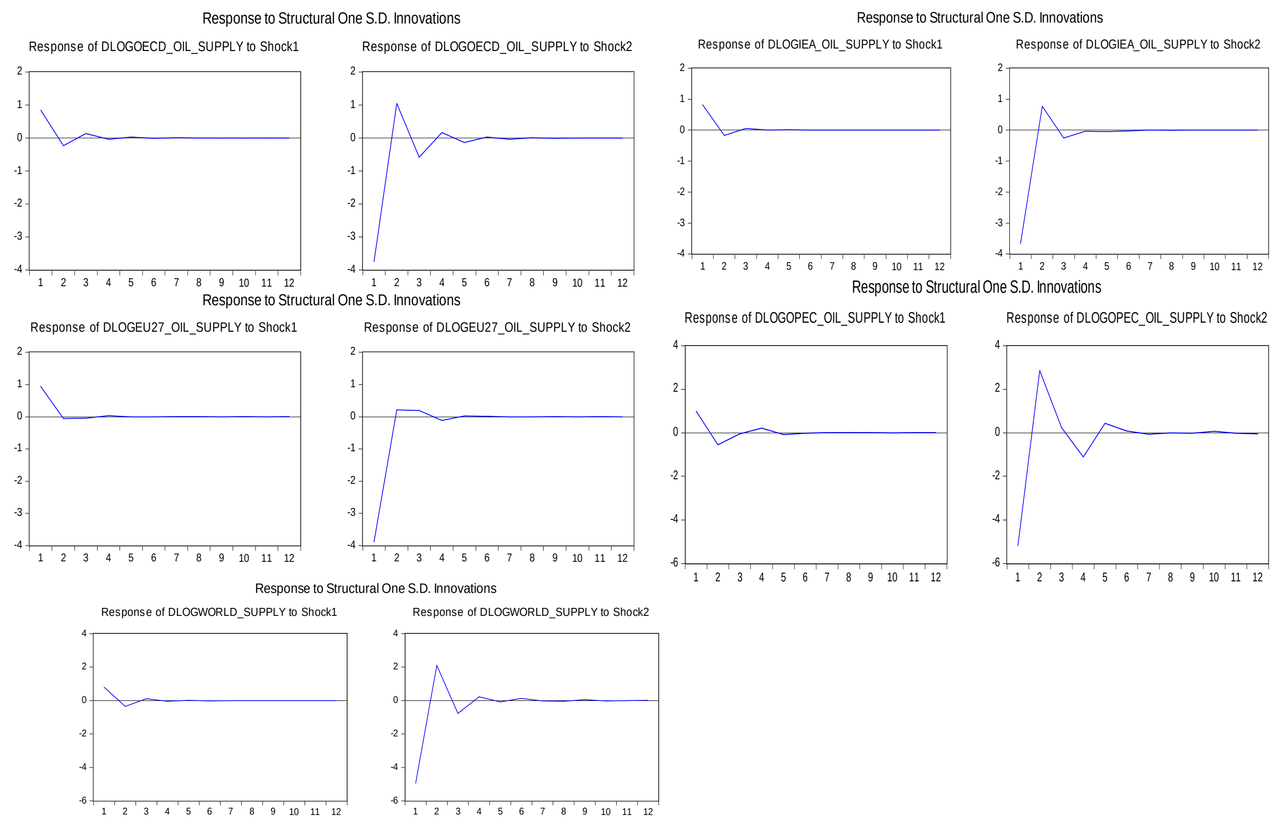
An environment of loose/tight monetary policy will not only impact on the fundamentals of the oil market via the incentives to accumulate/give up inventories. Low interest rates policy causes that the opportunity cost of leaving oil in the ground with the expectation of selling it later for a higher price will be higher. Therefore, producers will prefer to extract oil immediately and invest the revenue when monetary policy is tight and postpone the extract of oil during low interest rates. This understandably has a negative effect on oil supply. The second estimated SVAR investigates the impact of monetary policy shock on oil supply at national level. However in this case, the effect of loose monetary policy is estimated. Since there is an assumption of lags between monetary policy decisions and movements in oil supply since oil producers do not react to short term disturbances in monetary policy but make decisions based on long term developments we put a long-term restrictions on monetary policy shock.

The upper part of SVAR model presented in Appendix D shows the matrix form and bottom part estimated coefficients with standard errors. Low standard errors for estimated coefficients suggest that identifying restrictions are correct.

The last line of matrix in upper table shows the estimated equation for IEA oil supply. The coefficients are significant except of inflation (-0.277) as well as interest rates (-16.44). Interestingly higher values for coefficients have been estimated for money supply and lower value of coefficient for industrial production.

Results become even more interesting when comparing within national, international and global level. In Appendix E, results for European oil supply also shows that money supply and interest rates play an important role nevertheless lower values of their coefficients suggest even higher importance compared to results from IEA. Interestingly, compare to previous results in this case, inflation coefficient is significant only in the case of OPEC while in the rest of the models, the money supply seems to be an explanatory variable. Therefore it can be assumed that the oil supply of EU countries is affected by movements in inflation and industrial production in the UK. While in previous model the estimated coefficient of inflation was significant, in the case of a more global context (Appendix F) the importance of inflation in relation to OECD oil supply is again questionable. Also interest rates as well as money supply coefficient show significant levels, their values are lower than in previous cases suggesting that other variables might be more explanatory for movements in OECD oil supply. While in the case of European countries oil supply the coefficients for UK interest rates and inflation are not significant, different results can be found in the case of oil net exporting countries as well as world oil supply. Higher significance of inflation rate and interest rate in case of OPEC oil supply (Appendix G) signalize that the impact of UK monetary policy on oil supply might be higher than expected. While lower coefficients in previous cases suggest that at European level, there are explanatory variables which influence the movements in oil supply other than UK monetary policy. These results could be assumed since the position of European countries in terms of oil supply follows rather than leads the oil supply in global context. SVAR models for OPEC oil supply and the World supply (Appendix G and H) shows similar results since the UK inflation does not seem to be explanatory variable at 5 per cent confidence. Nevertheless, the interest rates with significant coefficients in both cases seem to be an important explanatory variable of movements in oil supply. When plotting the impulse response function of oil supply at different levels as a response to monetary policy shocks, interesting results can be observed (Figure 3.2). The assumption here is that lower interest rates lead to decreases in oil supply due to lower opportunity cost of leaving oil in the ground since there is an expectation of selling it later for a higher price. Therefore a loose monetary policy leads to decreases in oil supply.

Figure 3.2: Impulse response to monetary policy shock



The structural impulse response analysis helps to distinct dynamic responses of oil supply at different levels. The upper left graph presents the response of IEA oil supply to the expansionary monetary policy shocks. While a one per cent increases in money supply together with one per cent acceleration of inflation lead to 0.5 per cent decrease in IEA oil supply, a one per cent cut in interest rate slightly increases the oil supply however the effect dies soon in the third month. Similar, however smaller, response is obtained from the response of EU 27 oil supply and OECD oil supply to the shock in UK monetary policy. These results indicate that a smaller response is assumed to be due to international position of these countries as oil suppliers. Unlike European countries, the response of OPEC oil supply to expansionary shock is a short term one per cent decrease in oil supply as a response to lower interest rates. Overall results of the UK position and the global importance of policy makers' decisions can be observed from the bottom left graph. The response of world oil supply to the UK expansionary monetary policy is small, only about 0.3 per cent decrease. However these results are comparable to the response of world oil supply to the shock in US monetary policy. Results of a similar study by Anzuini et al. (2010) show that oil supply tends to respond by slight increase in short term however the effect dies in the third month after the shock confirming a partially role of monetary policy in explaining movements in oil supply.

Since we are interested in how important each shock in UK economy is in explaining the movements in oil supply at national, international and global level, these questions are addressed by computing forecast error variance decomposition based on the estimated structural VAR model. Variance decomposition analysis with Cholesky decomposition allocates each variable's forecast error variance to the individual shocks. These statistics measure the quantitative effect that the shocks have on the variables (Appendix I).

The results of variance decomposition suggest that in all the cases movements of oil supply are to the significant extend explained by its own movements however the importance of inflation in explaining movements oscillates about 10 per cent in case of IEA oil supply while only about 7 per cent in case of EU countries. As oil producers set production level based on their prediction about future developments in world economy, policy decisions in the UK are taken into consideration however they cannot be taken as explanatory variables for movements in oil supply.

4 Robustness check

During the evaluated period few changes in monetary policy occurred as a result of economic changes at national as well as international level, it is necessary to incorporate these changes into our investigation and process of testing the robustness of our model. Specific interest is in post-crisis transmission of UK monetary policy on oil prices since we assume that quantitative easing approached by central banks as a consequence of financial crisis can question the validity of our model.

In respect to these events, we use Chow test for capturing the changes in monetary policy operational procedures. The stability is evaluated by estimating the model on a sample which contains only single known break point. During the period of interest 1992-2013 few known break points could be identified.

- 1992 Oct - 1997 April (Beginning of Inflation targeting)

- 1997 May- 2007 November (BoE independence in November 1997. However, other changes can be found, such as: the inflation target was changed to 2.5% with 1% tolerance range, better transparency in terms of regular monthly monetary meetings between the Chancellor of the Exchequer and the Governor of the Bank of England, public advices of the BoE to the Chancellor of the Exchequer)

- 2007 Dec – 2013 May (The official beginning of financial crisis is taken the date 6 December 2007 when the Bank of England cut interest rates by a quarter of a percentage point to 5.5%. This cut was shortly, on 13 December 2007, followed by an announcement of the central banks (Federal Reserve, European Central Bank, the BoE and central banks of Canada and Switzerland) to provide billions in loans to banks in order to ease the availability of credit (Edmonts et al. 2010).

Given the above list of possible changes in operating procedures and the need of having a sufficient number of observations on either side of the potential break, the focus is on following specific dates:

- BoE independence in May 1997. The sample period is set from October 1992 to July 2001 given an equal period before the change and after the change.
- Financial crisis in December 2007. The sample period is set from November 2006 to November 2008.

The stability is evaluated for inventory channel as well as for supply channel in respect to above known potential break points. As results from Chow test (Appendix J) show, for the inventory channel, the BoE's independence in May 1997 also meant a structural break in monetary policy.

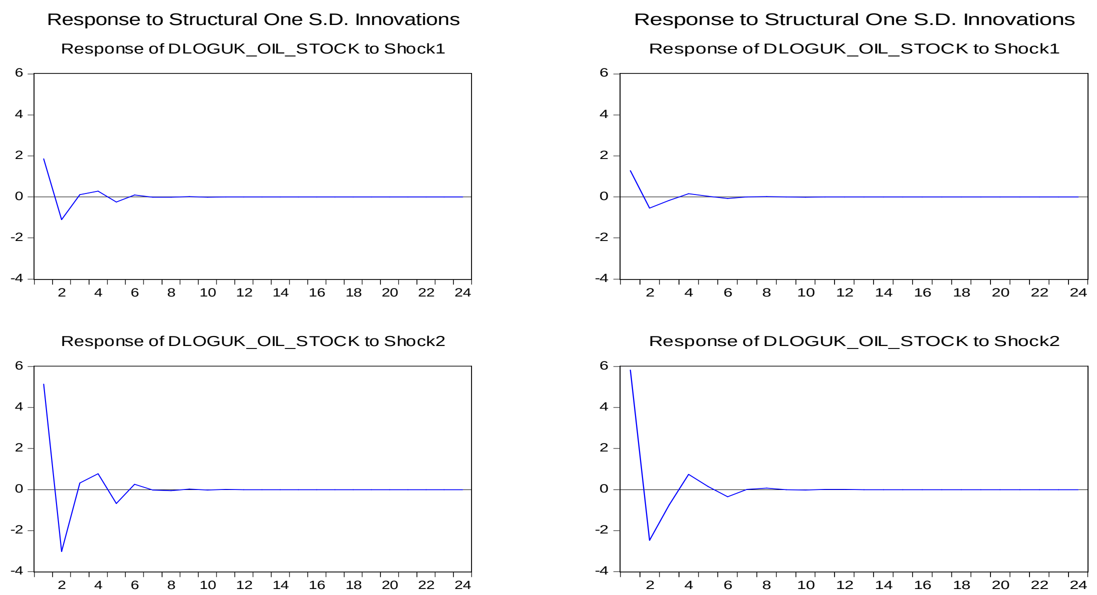
As mentioned, holding oil inventories has an opportunity cost of using money to buy oil which goes into storage and is not immediately burnt instead of investing the amount needed at the risk-free rate. The day when the independence was officially given to the BoE is considered as a positive move to better transparency since interest rates set by government were often questioned. As outlined by Mihalov (2007) in his investigation on whether a shift to instrument independence affects central bank behaviour when already operating in inflation targeting goal, the greater autonomy of the BoE has played an important role. His estimations show that during the period after obtaining the operating independence, response of the BoE to inflationary pressures ultimately increased with anchored inflation through the output gap. Therefore it can be assumed that higher level of transparency and credibility helped to anchored inflation expectations as well as expectations about future development in interest rates. Therefore in relation to the model of transmission mechanism results from Chow test (Appendix J) also confirm these results since the null hypothesis of no structural break can be rejected, for stability the models for the UK inventory channel (1.430>0.2312), OECDEU inventory channel (1.2455>0.298) as well as for OECD inventory channel (1.331>0.265), leading to the necessity of splitting the period into pre and after-independency period. Different results can be observed from the Chow test for the supply channel where the null hypothesis can be rejected only in the case of OPEC oil supply (0.712>0.587) and the World oil supply (0.886>0.477), while the rest of the models show no structural break on this date.

The investigation for the second possible structural break is beginning of financial crisis in the UK. The rationale of assuming financial crisis to be a reason for changes in monetary policy can be found in the aim of monetary policy before the crisis which was to achieve low and stable inflation. The policy framework was inflation targeting with a short-term interest rate as an instrument. The importance of short-term interest rate on market rates and the wider economy is significant thus setting of interest rates was done judgementally using a wide variety of macroeconomic signals but in a manner that could be approximated with reference to Taylor rule. However as outlined by Joyce et al.(2012) the way interest rates are set has changed after the financial crisis.

Due to the size of the recession Taylor rule would recommend negative nominal interest rates. However market interest rates are effectively bounded close to zero thus the standard central bank interest rates at or close to zero and the usually reliable relationship between changes in official interest rates and market interest rates also broken, other forms of monetary policy needed to be considered. Thus it can be clearly assumed that financial crisis which is dated from November 2007 also meant a structural break. As results from Chow test show (Appendix J), surprisingly in this case the null hypothesis of no structural break can be reject only in case of the UK oil industry stocks (1.323255>0.3493) and OECD oil industry stock (0.967>0.481) while for OECDEU oil industry stock this date does not represent a structural break. Interestingly, for the supply channels the null hypothesis cannot be rejected in any of the cases. Therefore, all supply channel models are stable in respect to the financial crisis suggesting that transmission of UK monetary policy after the crisis has not changed. Even if the null hypothesis of no structural break cannot be rejected this conclusion cannot be applied for the entire period since there is also a possibility of unknown breaks. However, given the importance of the role of transparency and credibility in inflation targeting framework, unknown breaks that can be classified as changes in monetary policy are not likely to appear however cannot be rejected. Therefore even if the unknown breaks in transmission mechanism developed in this paper are not investigated, further research can be carried out by focusing on after-crisis period. However, since the crisis is still present, to approach this research a longer period needs to be considered.

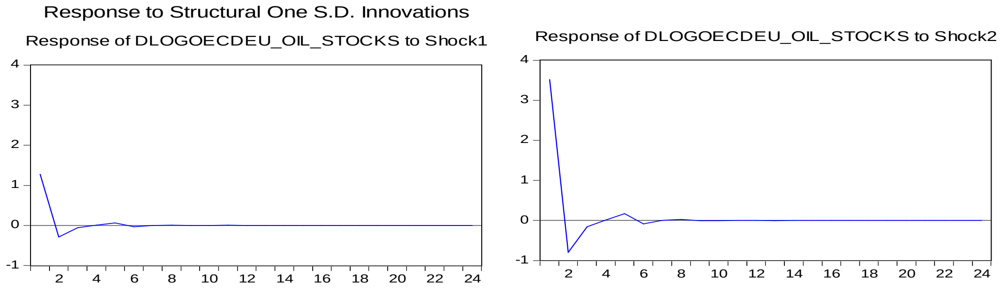
To account the structural break, each of the models with structural break is re-estimated again. The re-estimated SVAR models can be found in Appendix K. The impulse response function of UK oil industry stock to an unexpected movement in money supply (Shock 1) as well as the response to unexpected movement in interest rate (Shock 2) has not changed significantly when compared to the response estimated for a whole period (Figure 4.1).

Figure 4.1: Impulse response functions of UK oil inventory before and after the structural break



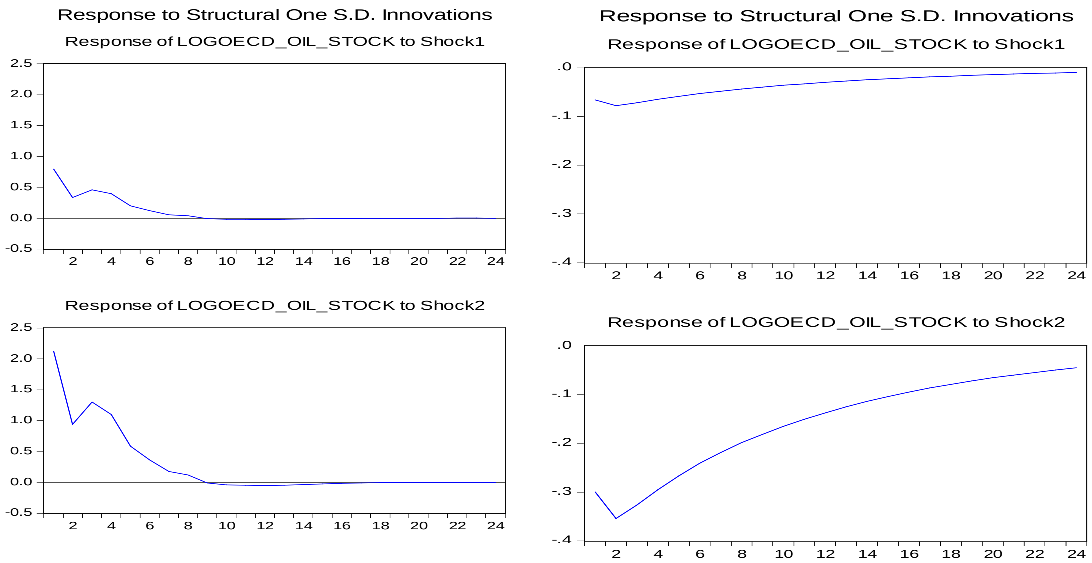
Slightly smaller response to the second shock can be found during the first period. Interestingly, during the period before the crisis the response of UK oil stock to an unexpected increase in interest rates is stronger than it was before the BOE operational independency while the response to the shock in money supply is smaller. To some extend this can be explained by better transparency of policy decisions as well as credibility of the BOE which consequently helps to anchor expectations (Mihov, 2007). When investigating the impulse response of OECDEU oil stock to the money supply before the BOE's operational independence and comparing it to the response estimated for the whole period, the size of the response has not changed (Figure 4.2).

Figure 4.2: Impulse response functions of OECDEU oil inventory



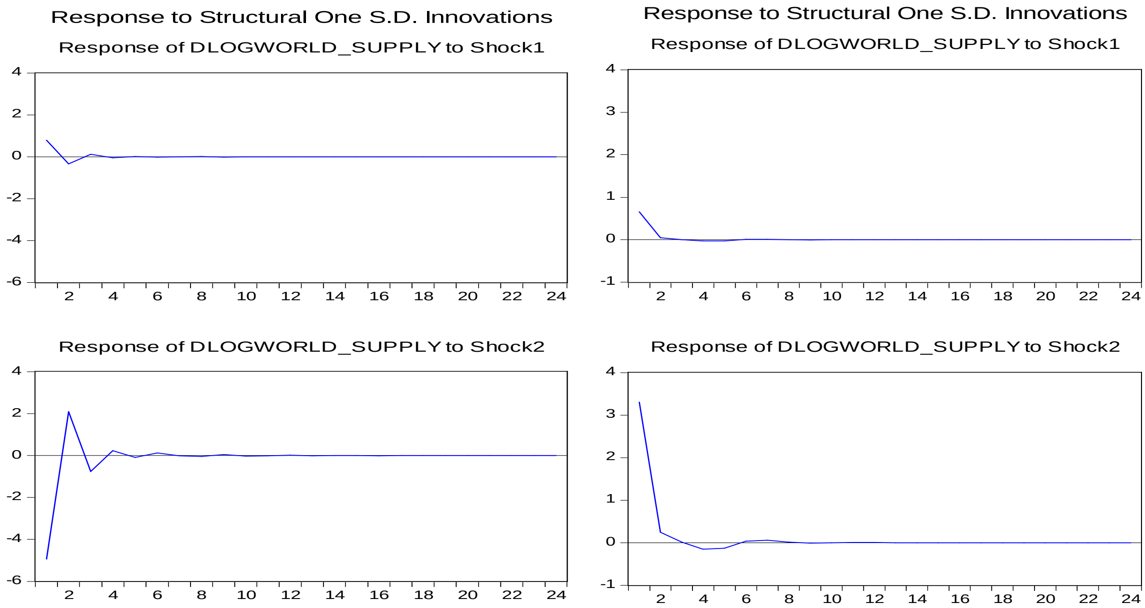
However, the response to the innovation in interest rates, the size of the response is slightly smaller than for the whole period even the same in principle. Therefore, it can be concluded that before the BOE's operational independence, the decisions of holding oil stock in EU countries was slightly less responsive to the policy decisions. In contrast to the results from impulse response function for the UK oil stock and OECDEU oil stock, the results of impulse response function for OECD oil stock differs significantly in respect to the both periods.

Figure 4.3: Impulse response functions of OECD oil inventory before and after the structural break



While decreasing response to the innovations in money supply as well as in interest rates can be observed in the first period, the response seems to be smaller but increasing before the financial crisis. This contrasting response of OECD oil stock to the money supply shock and interest rate shock after the BOE's independence is interesting and given the importance to the size of the response after 1997. The response of OPEC oil supply to the shock in money supply has not changed significantly before and after the BOE's independence. The response to the shock in interest rates is significantly stronger. While during the period of inflation targeting when interest rates were set by the Government (graph in the left) the shock in interest rates driven the oil supply up by 7 per cent. The response of oil supply after the BOE's independence show a drop by 5 per cent in first two months following the shock. Similar results can be obtained from the reaction of World oil supply before and after the BOE's independence. Before the 2007M05 a unit shock to the money supply depressed the world oil supply by 1 per cent and after the BOE's independence, the reaction is 0.8 per cent so slightly weaker than before. However, even if money supply does affect the World oil supply, the effect is not as strong as in case of interest rates. It is interesting that in both cases (OPEC oil supply and World oil supply) the effect of oil supply changed the direction after the operational independence of the BOE.

Figure 4.4: Impulse response of world supply



A unit shock in 3-months Treasury bills, before the breaking point, led to a raise in World oil supply by more than 6 per cent. While after the breaking point the world oil supply dropped by 3.1 per cent. Even the size of the effect is not as strong as before, the actual change in direction is interesting

5 CONCLUDING REMARKS

The SVAR model of UK monetary policy and crude oil markets estimated in this paper serves as an evaluation of the transmission of UK monetary policy across national borders particularly on international oil markets. The SVAR approach allows us to decompose price and quantity data into monetary policy shocks investigate the transmission mechanism of the impact of monetary policy shocks on variables of interest by impulse response and variance decomposition analysis. One of the key results is that expansionary UK monetary policy leads to a statistically significant decline in OPEC oil supply, while there is less statistically significant effect on European oil supply movements. The effect of tight monetary policy seems to have the most significant effect on UK industrial oil stock and European industrial oil stock, confirming assumption of decline in firms' desire to carry inventories. The impact on the World industrial oil stocks is lower however comparable with the effect of US monetary policy. The response to the innovation in interest rates, the size of the response is slightly smaller than for the whole period even with the same in principle. Therefore, it can be concluded that before the BOE's operational independence, the decisions of holding oil stock in EU countries was slightly less responsive to the policy decisions. In contrast to the results from impulse response function for the UK oil stock and OECDEU oil stock, the results of impulse response function for OECD oil stock differs significantly in respect to the both periods.

BIBLIOGRAPHY

Akram, F (2009) `Commodity prices, interest rates and the dollar.` *Energy Economics*, 31, pp. 838-851.

Anzuini, A., Lombardi, J., Pagano, P. (2010). `The impact of monetary policy shocks on commodity prices.` *European Central Bank working paper* No. 1232, pp. 5-27.

Arora, V., Tanner, M., (2013) `Do oil prices respond to real interest rates?` *Energy Economics*, 36, pp. 546–555.

Baffes, J., Haniotis, T., (2010) `Placing the 2006/08 Commodity Price Boom into Perspective.` The World Bank Policy Research Working Paper 5371, Available at: http://econ.worldbank.org [Accessed 02 July 2013].

Bank of England. (2012). *Statistical Interactive Database*. [online] Available at: http://www.bankofengland.co.uk/boeapps/iadb/Index.asp?first=yes&SectionRequired=I&HideNums=-1&ExtraInfo=true&Travel=NIx [Accessed 20 February 2012].

Barsky and Kilian (2004) `Oil and the Macroeconomy since 1970s.` *Journal of Economic perspectives*, 18, pp. 115-134.

Bernanke, B., Gertler, M., Watson,M., Sims, Ch., Friedman, B.(1997): `Systematic Monetary Policy and the Effects of Oil Price Shocks.` *Papers on Economic Activity*, No. 1, pp. 91-157.

Bernanke, B., Boivin, J., Eliasz,P. (2005) `Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach.` *The Quarterly Journal of Economics*, 120 (1), pp.387-422.

Blomberg S., Harris, E., (1995) `The Commodity-Consumer Price Connection: Fact or Fable.` *FRBNY Economic Policy Review*, pp. 21-38.

Bordo, M. (1980) `The Effects of Monetary Change on Relative Commodity Prices and the Role of Long-Term Contracts.` *Journal of Political Economy*, 88 (6), pp. 1088-1109.

Clarida,G., Gertler, M. (2000) `Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory.` *The Quarterly Journal of Economics*, pp. 147-180.

Clarida, G, Gertler, M. (1998) `Monetary policy rules in practice: Some international evidence.` *European Economic Review* 42, pp.1033-1067.

Clarida, R., Gali,J., Gertler, M.(2000) `Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory.` *The Quarterly Journal of Economics*, 115 (1), pp.147-180.

Cecchetti, G., Moessner, R. (2008) `Commodity prices and Inflation Dynamics.` *BIS QuarterlyReview*, pp.55-66.

Deaton A., Laroque G. (1992) `On the Behaviour of Commodity Prices.` *Review of Economic Studies*, 59, pp. 1-23.

Dornbusch, R. (1976) `Expectations and Exchange Rate Dynamics.` *Journal of Political Economy*, 84, pp.1161-1176.

Edmonds,T., Jarrett,T., Woodhouse,J. (2010) `The Credit Crisis: Timeline.` *House of Commons*, SN/BT4991.

Frankel, J. (1985) `Commodity Prices and Money: Lessons from International Finance.` *American Journal of Agricultural Economics*, 66 (5), pp. 560-566.

Frankel, J. (2007) `The Effect of Monetary Policy on Real Commodity Prices.` *NBER working paper* No. 12713, pp.1-40.

Frankel, J., Hardouvelis, G. (1985) `Commodity Prices, Money Surprises and FED Credibility.` *Journal of Money, Credit and Banking,* 17 (4), pp.425-438.

Frankel, J., (2013) `Estimated Effects of Speculation and Interest Rates in a “Carry Trade” Model of Commodity Prices.` Paper presented to the International Conference organized by the IMF's Research Department [online] http://www.imf.org/external/np/seminars/eng/2012/commodity/pdf/frankel.pdf [Accessed 02 July 2013].

Furlong, F.,Ingenito, R. (1996) `Commodity Prices and Inflation.` *Federal Reserve Bank of San Francisco Economic Review*, 2, pp. 27-47.

Gilbert, Ch., L., (2010) `How to Understand High Food Prices.` *Journal of Agricultural Economics*, 61, pp. 398-425.

Gregorio,J. (2012) *Commodity prices, Monetary policy and Inflation.* Available: http://www.imf.org/external/np/seminars/eng/2011/tur/pdf/JDeG.pdf. Last accessed 15 September 2012.

Hanson,M. (2004) `The “Price Puzzle” Reconsidered.` *Journal of Monetary Economics*. 51 (7), pp.1385-1413.

Helbling, Thomas, (2012) `Commodity Prices and the Global Economy—A Retrospective.`*IMF Working Paper*

Joyce,M., Miles,D., Scott, A.,Vayanos,D. (2012) `Quantitative Easing and Unconventional Monetary Policy-An Introduction.` *The economic Journal* 122 (564), pp. 1053-1069.

Kilian, L., (2009) `Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market.` *American Economic Review*, 99 (3), pp. 1053-1069.

Kim, S. (1999) `Do monetary policy shocks matter in the G-7 countries? Using common identifying assumptions about monetary policy across countries.` *Journal of International Economics*. 48 (2), pp. 387-412.

Krichene, R., (2007) `An Oil and Gas Model.` *International Monetary Fund Working paper*, 07/135, Available at: http://www.imf.org/external/pubs/ft/wp/2007/wp07135.pdf [Accessed 02 July 2013].

Krichene, R. (2010) `Crude Oil Prices: Trends and Forecast.` *International Monetary Fund (IMF).* 08/133, pp.1-23.

Lucas, Jr., R., E., (1976) `Econometric Policy Evaluation: A Critique.` In: Bruner, K., Meltzer, A., H., (eds.) The Philips Curve and Labour Markets, Carnegie-Rochester Conference Series on Public Policy. *Journal of Monetary Economics,* 1, pp. 19-46.

Mihailov,A. (2007) Instrument independence with goal dependence: Lessons from the Bank of England’s Reaction Function. Working paper, University of Reading, [online] Available at http://www.personal.reading.ac.uk/~les05am/InstrIndepGoalDepBoERnFnJAShAMS070831.pdf [Accessed 20 February 2013].

Nikos, A., (2008) `Food Price Surges: Possible Causes, Past Experience and Long-term Relevance.` *Population and Development Review,* 34, pp. 599-629.

Nissanke, M. (2010) Issues and Challanges for Commodity Markets in the Global Economy: An Overview. In: Nissanke, M., Mavrotas, G. *Commodities, Governance and Economic Development under Globalization*. Hampshire: Palgrave and Macmillan, pp. 39-61.

Office for National Statistics. (2012) *Consumer price indices*. Available: http://www.ons.gov.uk/ons/publications/all-releases.html?definition=tcm:77-22462%3F. Last accessed 10th March 2012.

Orden, D., Fackler,P. (1989) `Identifying Monetary Impacts on Agricultural Prices in VAR Models.` *American Journal of Agricultural Economics*, 71. Pp. 495–502.

Pindyck, R., S., Rotemberg, J., J., (1990) `The Excess Co-movement of Commodity Prices.` *Economic Journal*, 100, pp. 1173–1189.

Roache, Sh. (2012) `China's Impact on World Commodity Markets.` *NBER Working paper*, 115 (1), pp.1-24.

Sargent,T. (1969) `Commodity price expectations and the interest rate.` *Quarterly Journal of Economics*. 83 (1), pp. 127-152.

Sims,A. (1992) `Interpreting the macroeconomic time series facts: The effects of monetary policy.` *European Economic Review,* 36 (5), pp. 975–1000.

Taylor, J., B., (2009) `The Financial crisis and the policy responses: An empirical analysis of what went wrong.` *NBER Working paper series 14631*, pp. 1-25.

Trostle, R. (2008) `Global Agriculture Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices.` Working paper. Economic research centre, United States department of Agriculture.

Working, H. (1949) `The Theory of Price of Storage.` *American Economic Review, (*39), pp.1254-1262.

APPENDIX

Appendix A : Inventory Channel – UK industry oil inventories

Structural VAR Estimates
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.268680	0.194436	1.381842	0.1670
C(2)	0.901628	0.290161	3.107340	0.0019
C(3)	3.047053	0.145585	20.92967	0.0000
C(4)	3.145565	0.253163	12.42503	0.0000
C(5)	0.092947	0.021420	4.339161	0.0000
C(6)	-0.211134	0.034405	-6.136824	0.0000
C(7)	0.045695	0.023332	1.958474	0.0502
C(8)	-0.015285	0.099504	-0.153616	0.8779
C(9)	0.089228	0.040312	2.213459	0.0269
C(10)	0.657689	0.129967	5.060413	0.0000

Log likelihood	-374.8930		
LR test for over-identification:			
Chi-square(5)	1636.716	Probability	0.0000

Appendix B: Inventory Channel – OECDEurope industry oil inventories

Structural VAR Estimates
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0

C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.268261	0.193026	1.389765	0.1646
C(2)	0.866241	0.256588	3.375995	0.0007
C(3)	3.048970	0.146714	20.78170	0.0000
C(4)	3.000006	0.235928	12.71577	0.0000
C(5)	0.104580	0.022785	4.589954	0.0000
C(6)	-0.227600	0.032518	-6.999113	0.0000
C(7)	0.050256	0.025048	2.006338	0.0448
C(8)	-0.003812	0.099504	-0.038309	0.9694
C(9)	0.054366	0.039627	1.371929	0.1701
C(10)	0.704983	0.115899	6.082738	0.0000

Log likelihood -342.8394
LR test for over-identification:
Chi-square(5) 1639.281 Probability 0.0000

Appendix C: Inventory channel - OECD industry oil inventories

Structural VAR Estimates
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.302769	0.178864	1.692736	0.0905
C(2)	-0.609546	0.620671	-0.982076	0.3261
C(3)	2.761231	0.136482	20.23151	0.0000
C(4)	-1.839225	0.296920	-6.194356	0.0000
C(5)	0.064267	0.018957	3.390146	0.0007
C(6)	0.330911	0.064546	5.126769	0.0000
C(7)	0.043023	0.020007	2.150426	0.0315
C(8)	-0.030189	0.099504	-0.303391	0.7616
C(9)	-0.040902	0.072459	-0.564483	0.5724
C(10)	-0.520704	0.129691	-4.014967	0.0001

Log likelihood -231.8365
LR test for over-identification:
Chi-square(5) 1292.232 Probability 0.0000

Appendix D: Supply channel - IEA oil supply

Structural VAR Estimates
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	-1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.201678	0.279193	0.722360	0.4701
C(2)	0.725889	0.015147	47.92299	0.0000
C(3)	-3.859246	0.208295	-18.52776	0.0000
C(4)	-3.294314	0.200311	-16.44596	0.0000
C(5)	0.040474	0.032477	1.246230	0.2127
C(6)	-0.003766	0.013577	-0.277383	0.7815
C(7)	0.052360	0.032780	1.597343	0.1102
C(8)	-0.024081	0.109764	-0.219387	0.8263
C(9)	0.113783	0.013583	8.376947	0.0000
C(10)	1.186718	0.135033	8.788358	0.0000

Log likelihood -276.2327
LR test for over-identification:
Chi-square(5) 1414.669 Probability 0.0000

Appendix E: Supply channel – EU27 oil supply

Structural VAR Estimates
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	-1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.223548	0.243170	0.919308	0.3579
C(2)	0.850946	0.245343	3.468391	0.0005
C(3)	-3.585949	0.175447	-20.43899	0.0000
C(4)	-3.573729	0.261709	-13.65536	0.0000
C(5)	0.033224	0.023849	1.393064	0.1636
C(6)	0.154781	0.028912	5.353584	0.0000
C(7)	0.054017	0.024127	2.238894	0.0252
C(8)	-0.033866	0.109764	-0.308538	0.7577
C(9)	0.125556	0.033534	3.744146	0.0002
C(10)	0.783093	0.175504	4.461981	0.0000

Log likelihood -284.3134
LR test for over-identification:
Chi-square(5) 1256.664 Probability 0.0000

Appendix F: Supply channel – OECD oil supply

Structural VAR Estimates

Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	-1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.203581	0.267404	0.761324	0.4465
C(2)	0.736103	0.014762	49.86327	0.0000
C(3)	-3.841388	0.204280	-18.80456	0.0000
C(4)	-3.289754	0.194511	-16.91292	0.0000
C(5)	0.042815	0.032523	1.316452	0.1880
C(6)	-0.007803	0.012787	-0.610264	0.5417
C(7)	0.055213	0.032861	1.680217	0.0929
C(8)	-0.024857	0.109764	-0.226454	0.8208
C(9)	0.117183	0.012816	9.143727	0.0000
C(10)	1.183503	0.120962	9.784081	0.0000

Log likelihood	-275.3933		
LR test for over-identification:			
Chi-square(5)	1429.744	Probability	0.0000

Appendix G: Supply channel – OPEC oil supply

Structural VAR Estimates
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	-1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	-0.176085	0.319077	-0.551855	0.5810
C(2)	0.517052	0.035759	14.45952	0.0000
C(3)	4.230002	0.252993	16.71981	0.0000
C(4)	2.527313	0.158753	15.91983	0.0000
C(5)	0.064344	0.042063	1.529719	0.1261
C(6)	-0.042068	0.009440	-4.456473	0.0000
C(7)	-0.003338	0.042651	-0.078260	0.9376
C(8)	-0.026318	0.109764	-0.239767	0.8105
C(9)	0.071626	0.010509	6.815917	0.0000
C(10)	1.750509	0.099529	17.58798	0.0000

Log likelihood	-279.2070		
LR test for over-identification:			
Chi-square(5)	1437.385	Probability	0.0000

Appendix H: Supply channel – World oil supply

Structural VAR Estimates
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 318 iterations

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	-1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.134916	0.407188	0.331337	0.7404
C(2)	0.383535	0.012760	30.05776	0.0000
C(3)	-5.509451	0.320064	-17.21357	0.0000
C(4)	-2.428215	0.157781	-15.38977	0.0000
C(5)	0.044520	0.041434	1.074492	0.2826
C(6)	-0.017350	0.006389	-2.715785	0.0066
C(7)	0.042451	0.041721	1.017510	0.3089
C(8)	-0.024713	0.109764	-0.225148	0.8219
C(9)	0.056092	0.006666	8.414300	0.0000
C(10)	2.241975	0.131362	17.06716	0.0000

Log likelihood	-270.5493		
LR test for over-identification:			
Chi-square(5)	1536.122	Probability	0.0000

Appendix I: Variance decomposition

World_oil_supply

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	24.05062	2.307149	89.22633	0.379042	0.019064	8.068415
2	29.51815	2.307476	89.19717	0.382881	0.018334	8.094137
3	29.72509	2.308539	89.20638	0.383182	0.018279	8.083616
4	31.18788	2.308574	89.20678	0.383397	0.018346	8.082907
5	32.88113	2.308576	89.20618	0.383469	0.018373	8.083405
6	33.04471	2.308568	89.20577	0.383500	0.018384	8.083772
7	33.08012	2.308567	89.20575	0.383503	0.018384	8.083800
8	33.15663	2.308567	89.20572	0.383503	0.018385	8.083827
9	33.17630	2.308568	89.20568	0.383504	0.018386	8.083860
10	33.17705	2.308568	89.20568	0.383505	0.018385	8.083859
11	33.18195	2.308568	89.20568	0.383505	0.018385	8.083860
12	33.18314	2.308568	89.20568	0.383505	0.018385	8.083863

Factorization: Structural

EU27 oil_supply

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	5.577740	5.049173	87.55889	0.024053	0.098653	7.269227
2	5.928536	5.047955	87.50398	0.062300	0.098450	7.287314
3	5.948135	5.049957	87.50052	0.066596	0.098434	7.284490
4	5.972862	5.050338	87.50032	0.068273	0.098662	7.282406
5	5.990624	5.050440	87.50018	0.068293	0.098664	7.282424
6	5.995739	5.050429	87.50015	0.068292	0.098666	7.282463
7	5.996779	5.050423	87.50011	0.068301	0.098670	7.282492
8	5.996866	5.050423	87.50011	0.068305	0.098670	7.282492
9	5.996884	5.050424	87.50012	0.068305	0.098670	7.282484
10	5.996890	5.050425	87.50012	0.068305	0.098670	7.282481
11	5.996896	5.050425	87.50012	0.068305	0.098670	7.282481
12	5.996899	5.050425	87.50012	0.068305	0.098670	7.282481

Factorization: Structural

IEA_oil_supply

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	10.13277	4.280493	87.28208	0.002581	0.098586	8.336257
2	10.13570	4.283279	87.24745	0.010847	0.098524	8.359900
3	12.05951	4.282903	87.24812	0.013763	0.098832	8.356380
4	12.23257	4.282862	87.24855	0.013794	0.098831	8.355964
5	12.33081	4.282853	87.24861	0.013791	0.098837	8.355907
6	12.33892	4.282848	87.24867	0.013792	0.098842	8.355851
7	12.34220	4.282849	87.24866	0.013792	0.098842	8.355858
8	12.34261	4.282849	87.24866	0.013792	0.098843	8.355859
9	12.34275	4.282849	87.24866	0.013792	0.098843	8.355858
10	12.34281	4.282849	87.24866	0.013792	0.098843	8.355858
11	12.34283	4.282849	87.24866	0.013792	0.098843	8.355858
12	12.34285	4.282849	87.24866	0.013792	0.098843	8.355858

Factorization: Structural

OECD_oil_supply

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	9.992188	4.385462	87.11816	0.004389	0.104860	8.387124
2	10.00680	4.386047	87.07887	0.008628	0.104163	8.422288
3	11.70804	4.385536	87.08699	0.008937	0.104314	8.414223
4	11.95476	4.385517	87.08533	0.008933	0.104284	8.415936
5	12.16522	4.385480	87.08594	0.008931	0.104297	8.415348
6	12.20619	4.385477	87.08587	0.008932	0.104296	8.415425
7	12.22232	4.385474	87.08591	0.008932	0.104297	8.415385
8	12.22648	4.385474	87.08591	0.008932	0.104297	8.415391
9	12.22798	4.385474	87.08591	0.008932	0.104297	8.415388
10	12.22854	4.385474	87.08591	0.008932	0.104297	8.415389
11	12.22873	4.385474	87.08591	0.008932	0.104297	8.415388
12	12.22880	4.385474	87.08591	0.008932	0.104297	8.415388

Factorization: Structural

OPEC_oil_supply

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	3.597895	3.125790	84.84849	0.500601	0.017620	11.50750
2	4.096694	3.125666	84.78594	0.501554	0.017482	11.56936
3	5.791132	3.125348	84.78546	0.501450	0.017454	11.57029
4	5.792436	3.124822	84.78461	0.500677	0.017163	11.57272
5	5.792732	3.124856	84.78607	0.500225	0.017143	11.57171
6	6.007272	3.124837	84.78609	0.500282	0.017144	11.57165
7	6.193007	3.124821	84.78628	0.500291	0.017146	11.57146
8	6.197696	3.124823	84.78625	0.500298	0.017146	11.57148
9	6.394208	3.124820	84.78621	0.500289	0.017155	11.57153
10	6.492816	3.124825	84.78603	0.500279	0.017162	11.57171
11	6.493492	3.124828	84.78600	0.500281	0.017162	11.57173
12	6.542971	3.124824	84.78597	0.500273	0.017165	11.57177

Factorization: Structural

Appendix J: Robustness check

UK oil inventory

Chow Breakpoint Test: 1997M05

Null Hypothesis: No breaks at specified breakpoints

Varying regressors: All equation variables

Equation Sample: 1992M10 2001M01

F-statistic	1.430335	Prob. F(4,83)	0.2312
Log likelihood ratio	6.066045	Prob. Chi-Square(4)	0.1943
Wald Statistic	5.721340	Prob. Chi-Square(4)	0.2209

OECDEU oil inventory

Chow Breakpoint Test: 1997M05

Null Hypothesis: No breaks at specified breakpoints

Varying regressors: All equation variables

Equation Sample: 1992M08 2001M01

F-statistic	1.245549	Prob. F(4,85)	0.2979
Log likelihood ratio	5.297335	Prob. Chi-Square(4)	0.2581
Wald Statistic	4.982198	Prob. Chi-Square(4)	0.2891

OECD oil inventory

Chow Breakpoint Test: 1997M05

Null Hypothesis: No breaks at specified breakpoints

Varying regressors: All equation variables

Equation Sample: 1992M08 2001M01

F-statistic	1.331513	Prob. F(4,85)	0.2649
Log likelihood ratio	5.652045	Prob. Chi-Square(4)	0.2267
Wald Statistic	5.326053	Prob. Chi-Square(4)	0.2554

IEA oil supply

Chow Breakpoint Test: 1997M05

Null Hypothesis: No breaks at specified breakpoints

Varying regressors: All equation variables

Equation Sample: 1994M02 2001M01

F-statistic	0.547364	Prob. F(4,67)	0.7015
Log likelihood ratio	2.411689	Prob. Chi-Square(4)	0.6605
Wald Statistic	2.189455	Prob. Chi-Square(4)	0.7010

EU27 oil supply

Chow Breakpoint Test: 1997M05

OECD oil supply

Null Hypothesis: No breaks at specified breakpoints

Varying regressors: All equation variables

Equation Sample: 1994M02 2001M01

F-statistic	0.585869	Prob. F(4,67)	0.6740
Log likelihood ratio	2.578458	Prob. Chi-Square(4)	0.6306
Wald Statistic	2.343475	Prob. Chi-Square(4)	0.6729

Chow Breakpoint Test: 1997M05

Null Hypothesis: No breaks at specified breakpoints

Varying regressors: All equation variables

Equation Sample: 1994M02 2001M01

F-statistic	0.568118	Prob. F(4,67)	0.6866
Log likelihood ratio	2.501624	Prob. Chi-Square(4)	0.6443
Wald Statistic	2.272473	Prob. Chi-Square(4)	0.6858

World oil supply

Chow Breakpoint Test: 1997M05

Null Hypothesis: No breaks at specified breakpoints

Varying regressors: All equation variables

Equation Sample: 1994M02 2001M01

F-statistic	0.712084	Prob. F(4,67)	0.5866
Log likelihood ratio	3.122524	Prob. Chi-Square(4)	0.5375
Wald Statistic	2.848337	Prob. Chi-Square(4)	0.5835

OPEC oil supply

Chow Breakpoint Test: 1997M05

Null Hypothesis: No breaks at specified breakpoints

Varying regressors: All equation variables

Equation Sample: 1994M02 2001M01

F-statistic	0.885716	Prob. F(4,67)	0.4774
Log likelihood ratio	3.864593	Prob. Chi-Square(4)	0.4246
Wald Statistic	3.542864	Prob. Chi-Square(4)	0.4714

Appendix K: Re-estimated models

UK oil inventory for BOE independency

Structural VAR Estimates
Sample (adjusted): 1992M10 1997M04
Included observations: 55 after adjustments
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations
Structural VAR is over-identified (5 degrees of freedom)

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.338281	0.215902	1.566828	0.1172
C(2)	0.969251	0.603694	1.605533	0.1084
C(3)	2.539769	0.174056	14.59168	0.0000
C(4)	2.691865	0.413319	6.512799	0.0000
C(5)	0.168318	0.024798	6.787680	0.0000
C(6)	-0.793085	0.069321	-11.44076	0.0000
C(7)	0.004065	0.033616	0.120914	0.9038
C(8)	-0.012869	0.134840	-0.095440	0.9240

C(9)	-0.017802	0.127442	-0.139687	0.8889
C(10)	0.463488	0.134652	3.442129	0.0006

Log likelihood	-170.4414			
LR test for over-identification:				
Chi-square(5)	874.0839		Probability	0.0000

Estimated A matrix:

1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.000000	0.000000	1.000000	0.000000
0.000000	0.000000	0.000000	0.000000	1.000000

Estimated B matrix:

1.268569	3.277667	-0.677645	-0.027627	1.176109
-0.204860	-0.497046	0.268862	0.018637	-0.333494
-0.904712	-2.487990	1.453531	-0.030002	-0.839888
-2.707639	-7.761769	3.128603	1.854338	-1.790221
1.852850	5.129777	-1.409511	-0.041995	1.895461

For crisis

Structural VAR Estimates
Sample (adjusted): 1997M06 2007M08
Included observations: 39 after adjustments
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations
Structural VAR is over-identified (5 degrees of freedom)

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.195519	0.419002	0.466631	0.6408
C(2)	0.693309	0.178005	3.894875	0.0001
C(3)	4.007777	0.339682	11.79862	0.0000
C(4)	3.185255	0.255709	12.45656	0.0000
C(5)	-0.003534	0.054677	-0.064632	0.9485
C(6)	0.107237	0.027013	3.969864	0.0001
C(7)	-0.091048	0.054680	-1.665104	0.0959
C(8)	-0.058813	0.160128	-0.367287	0.7134
C(9)	0.055428	0.032009	1.731645	0.0833
C(10)	1.451795	0.131876	11.00880	0.0000

Log likelihood	-137.2090			
LR test for over-identification:				
Chi-square(5)	646.8167		Probability	0.0000

Estimated A matrix:

1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.000000	0.000000	1.000000	0.000000

0.000000	0.000000	0.000000	0.000000	1.000000
Estimated B matrix:				
2.151055	9.122519	-0.118729	0.041016	3.151216
-0.184948	-0.797181	-0.045979	-0.046346	-0.336680
1.844844	8.499919	1.411379	-0.077226	2.618227
0.524327	2.389612	1.630581	0.003154	-2.390718
1.274867	5.831087	0.137456	0.080739	1.771782

OECDEU oil inventory (the BOE independence)

Structural VAR Estimates
Sample (adjusted): 1992M10 1997M04
Included observations: 55 after adjustments
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations
Structural VAR is over-identified (5 degrees of freedom)

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.339264	0.213385	1.589916	0.1119
C(2)	0.969514	0.591935	1.637873	0.1014
C(3)	2.534516	0.172658	14.67938	0.0000
C(4)	2.680220	0.407519	6.576924	0.0000
C(5)	0.186020	0.024929	7.461928	0.0000
C(6)	-0.855912	0.069121	-12.38274	0.0000
C(7)	0.004417	0.035364	0.124901	0.9006
C(8)	0.012641	0.134840	0.093746	0.9253
C(9)	-0.066049	0.134527	-0.490969	0.6234
C(10)	0.465388	0.130438	3.567894	0.0004

Log likelihood	-148.8814		
LR test for over-identification:			
Chi-square(5)	869.3869	Probability	0.0000

Estimated A matrix:				
1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.000000	0.000000	1.000000	0.000000
0.000000	0.000000	0.000000	0.000000	1.000000
Estimated B matrix:				
1.582574	4.121738	-1.064077	-0.080932	1.499495
0.321677	0.957280	-0.183524	-0.002206	0.212352
0.082756	0.258565	0.627108	-0.042572	0.188919
0.204134	0.309387	0.479455	1.814822	1.221042
1.276953	3.520800	-1.082472	-0.083637	1.321650

OECD oil industry stock (the BOE independence)

Structural VAR Estimates

Sample (adjusted): 1992M10 1997M05
Included observations: 56 after adjustments
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations
Structural VAR is over-identified (5 degrees of freedom)

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.346032	0.195944	1.765973	0.0774
C(2)	2.309172	0.410538	5.624745	0.0000
C(3)	2.481677	0.166234	14.92879	0.0000
C(4)	6.424619	0.310421	20.69648	0.0000
C(5)	0.063711	0.030432	2.093577	0.0363
C(6)	0.095341	0.069659	1.368674	0.1711
C(7)	-0.003041	0.031600	-0.096245	0.9233
C(8)	-0.047796	0.133631	-0.357674	0.7206
C(9)	0.076715	0.070815	1.083312	0.2787
C(10)	0.573561	0.077881	7.364575	0.0000

Log likelihood	-123.7392		
LR test for over-identification:			
Chi-square(5)	775.9843	Probability	0.0000

Estimated A matrix:

1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.000000	0.000000	1.000000	0.000000
0.000000	0.000000	0.000000	0.000000	1.000000

Estimated B matrix:

0.281472	0.499190	0.047507	-0.021893	0.323463
-0.253143	-0.656744	0.024207	-0.003479	-0.286404
-0.571506	-1.513642	0.896124	-0.087426	-0.331592
-2.632053	-7.113278	1.652176	1.808050	-0.900795
0.798558	2.125696	0.026353	0.032522	0.443830

OECD oil industry stock (Financial crisis)

Structural VAR Estimates
Sample (adjusted): 1997M06 2007M08
Included observations: 39 after adjustments
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations
Structural VAR is over-identified (5 degrees of freedom)

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.205015	0.427058	0.480064	0.6312
C(2)	-0.931815	0.559647	-1.665005	0.0959
C(3)	4.181203	0.386069	10.83018	0.0000
C(4)	-4.249065	0.283608	-14.98215	0.0000
C(5)	0.068694	0.051610	1.331001	0.1832
C(6)	-0.046672	0.068103	-0.685316	0.4931
C(7)	-0.101182	0.052770	-1.917430	0.0552
C(8)	-0.038717	0.160128	-0.241790	0.8089
C(9)	0.075549	0.068511	1.102716	0.2702
C(10)	-1.422971	0.070882	-20.07517	0.0000

Log likelihood	-14.95924			
LR test for over-identification:				
Chi-square(5)	467.2777		Probability	0.0000

Estimated A matrix:

1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.000000	0.000000	1.000000	0.000000
0.000000	0.000000	0.000000	0.000000	1.000000

Estimated B matrix:

0.308024	0.843943	-0.281980	0.009476	-0.643913
-0.029793	-0.100155	-0.010016	-0.039640	0.121771
-0.239728	-1.114476	1.311467	-0.135643	0.183083
0.879663	3.808067	2.439084	0.322980	1.458083
-0.066022	-0.299557	0.016595	0.006232	0.082366

OPEC oil supply (the BOE independence)

Structural VAR Estimates
Date: 04/02/13 Time: 16:47
Included observations: 37 after adjustments
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations
Structural VAR is over-identified (5 degrees of freedom)

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	-1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.168651	0.515837	0.326945	0.7437
C(2)	0.528110	0.172406	3.063175	0.0022
C(3)	-4.711130	0.447906	-10.51811	0.0000
C(4)	-2.750570	0.243524	-11.29487	0.0000
C(5)	0.066587	0.062898	1.058646	0.2898
C(6)	-0.211483	0.022250	-9.504821	0.0000
C(7)	0.000946	0.063844	0.014820	0.9882
C(8)	-0.073180	0.164399	-0.445137	0.6562
C(9)	0.040486	0.041278	0.980807	0.3267
C(10)	1.949705	0.100090	19.47957	0.0000

Log likelihood	-112.5563			
LR test for over-identification:				
Chi-square(5)	708.6181		Probability	0.0000

Estimated A matrix:

1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.000000	0.000000	1.000000	0.000000
0.000000	0.000000	0.000000	0.000000	1.000000

Estimated B matrix:

0.705862	-3.310379	-0.029930	0.004900	1.219456
-0.207428	0.991693	0.107505	-0.018259	-0.590623
-3.561631	18.46768	1.983259	-0.331813	-6.665114
4.957048	-25.98322	-1.281001	2.415888	10.52050
0.994104	-5.179333	-0.397830	0.074637	1.907402

World oil supply (the BOE independence)

Structural VAR Estimates
Sample (adjusted): 1994M04 1997M04
Included observations: 37 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 397 iterations
Structural VAR is over-identified (5 degrees of freedom)

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	-1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.146336	0.567629	0.257801	0.7966
C(2)	0.541159	0.217388	2.489371	0.0128
C(3)	-5.675228	0.493014	-11.51129	0.0000
C(4)	-3.361543	0.275363	-12.20768	0.0000
C(5)	0.066970	0.052360	1.279025	0.2009
C(6)	-0.214916	0.021289	-10.09517	0.0000
C(7)	0.002721	0.053505	0.050851	0.9594
C(8)	-0.066927	0.164399	-0.407100	0.6839
C(9)	0.050911	0.041250	1.234193	0.2171
C(10)	1.905360	0.127951	14.89127	0.0000

Log likelihood	-109.3603			
LR test for over-identification:				
Chi-square(5)	729.2527		Probability	0.0000

Estimated A matrix:

1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.000000	0.000000	1.000000	0.000000
0.000000	0.000000	0.000000	0.000000	1.000000

Estimated B matrix:

3.731091	-22.72335	-1.259200	0.290271	6.818439
-0.142613	0.806902	0.088912	-0.016520	-0.433663
-4.548653	28.11131	2.488981	-0.455280	-8.380105
2.873450	-18.22551	-0.583556	2.138839	6.574713
0.795055	-4.944310	-0.322258	0.072272	1.486802

Structural VAR Estimates
Sample (adjusted): 1997M05 2010M09
Included observations: 46 after adjustments
Estimation method: method of scoring (analytic derivatives)
Maximum iterations reached at 500 iterations
Structural VAR is over-identified (5 degrees of freedom)

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

1	C(3)	0	0	C(10)
C(1)	-1	C(5)	C(7)	0
0	0	1	C(8)	0
0	0	0	1	0
C(2)	C(4)	C(6)	C(9)	1

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	-0.181085	0.415048	-0.436298	0.6626
C(2)	0.676365	0.244541	2.765859	0.0057
C(3)	4.084165	0.301454	13.54821	0.0000
C(4)	3.377470	0.236484	14.28201	0.0000
C(5)	-0.110196	0.050036	-2.202325	0.0276
C(6)	0.197351	0.035081	5.625614	0.0000
C(7)	0.010728	0.052608	0.203929	0.8384
C(8)	-0.045510	0.147442	-0.308664	0.7576
C(9)	0.157506	0.045578	3.455741	0.0005
C(10)	1.464608	0.191659	7.641740	0.0000

Log likelihood	-150.3616		
LR test for over-identification:			
Chi-square(5)	827.5619	Probability	0.0000

Estimated A matrix:

1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.000000	0.000000	1.000000	0.000000
0.000000	0.000000	0.000000	0.000000	1.000000

Estimated B matrix:

-0.299209	-2.261289	-0.466582	-0.343364	-0.570769
-0.470717	-2.353225	-0.172610	-0.088229	-0.592578
1.791285	8.905078	1.831910	0.337020	2.864364
-8.760972	-45.68632	-0.843446	-0.656371	-11.78530
0.659564	3.307026	0.177298	0.158397	0.964017