E C O N O M I C S B U L L E T I N

Oil Prices, aggregate economic activity and global liquidity conditions: evidence from Turkey

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Abstract

When compared to the previous literature which analyzes oil price changes and real economic activity for countries influencing world demand and/or supply, this study is first of its kind in investigating the relation within the context of a small open economy, Turkey. Parallel to the results of Blanchard and Gali (2007) for developed economies, we first report for Turkey that the negative response of real output to oil price increases have diminished since the early 2000s. Other than using different versions of oil price changes and real output growth, which are the standard variables used in the empirical literature, in our next set of estimations we also include variables to account for global liquidity conditions. Once these variables are incorporated, we unveil that the negative impact of oil price changes on aggregate economic activity is significant even in the post-2000 period.

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1. Introduction

There is a vast empirical literature on the interaction between crude oil price changes and real economic activity. While the majority of the previous studies support the existence of the supply-side cost effects, recent findings question the validity of a negative impact of oil price increases on real output growth.

Hamilton (1983), in a seminal paper, finds a negative and significant relationship between real oil price changes and the U.S. GNP growth, using a multivariate VAR analysis. Mork (1989) argues for the presence of asymmetry and documents that while oil price increases impede real GNP growth, oil price decreases do not have any statistically significant impact. Using a volatility-based specification, Lee, *et al.* (1995) verify the presence of asymmetry, and find that the effects of oil price increases in an environment with stable prices are more drastic when compared to an environment where oil prices change frequently. Hamilton (1996), in order to better capture the asymmetry, introduces another specification of prices based on the increase over previous year's maximum price. He argues that even after controlling for asymmetry, the unfavorable effects of oil price changes on aggregate output growth still persist.

Other developed economies have also been empirically investigated. For example, Jiménez-Rodríguez and Sánchez (2005) document that excluding Japan, the unfavorable effects of oil prices are statistically valid for the sample of net oil importers, as well as an oil exporter, the United Kingdom.

Blanchard and Galí (2007) argue that the negative effects of oil price changes for most of the developed economies ceased to exist in the early 2000s. They explain this phenomenon as being a consequence of more sound monetary policies of experienced central banks, more flexible wage contracts, smaller share of petroleum in production, and smaller and less frequent unfavorable shocks to aggregate output other than oil prices.

This study investigates the effects of oil price changes on real output for a net oil importing small open economy, Turkey.[1] In terms of econometric modeling, Turkey differs from the previously investigated developed economies in three aspects. First, being a small open economy, Turkey's real GDP is not expected to influence world crude oil prices. Second, as an emerging market economy, global liquidity conditions have become an increasingly important determinant of the growth prospects in Turkey.[2] Also, as stated in the previous point, being a small open economy, Turkey cannot affect the global liquidity conditions. Third, the relationship between world oil prices and global liquidity conditions is ambiguous. As a result of rising oil prices, capital account surpluses of OPEC and other major oil exporting

[1] According to Energy Information Administration (EIA) Online Database, in terms of oil endowments, Turkey is not as fortunate as many other Middle Eastern countries. As of 2006, Turkey produces approximately 42,500 barrels of crude oil per day whereas the demand for consumption is around 619,000. Turkey's annual crude oil consumption constitutes 35% of her primary source of energy consumption, is slightly higher than 3% of her GDP and corresponds to 0.73% of total world crude oil consumption. Turkey's high degree of reliance on oil as a primary source of energy and high dependency on imports underlines the strategic importance of oil prices for the Turkish economy.

[2] Alper (2002) shows that for Turkey, capital inflows are strongly procyclical and lead the cycle by one quarter.

countries could improve global liquidity conditions. On the other hand, the resultant capital account deficits of oil importers will have the opposite effect. Accordingly, this study uses a structural VAR approach to model these econometric issues utilizing monthly data on Turkey from 1991 to 2007. We first follow the previous literature and ignore the potential effects of global liquidity conditions. Our findings are in parallel to the results of Blanchard and Galí (2007) for developed economies, and we report for Turkey that the negative response of real output to oil price increases have diminished since the early 2000s. Other than using different specifications for oil price changes and real output growth, which are the standard variables used in the empirical literature, in our next set of estimations we also include variables to account for global liquidity conditions. Once the global liquidity conditions are included in the estimations, we unveil that the negative impact of oil price changes on aggregate economic activity is still significant even after 2000.

The outline of the paper is as follows. In section 2, the data and methodology are described. In section 3, we present the empirical results and section 4 concludes.

2. Data and Variable Definitions

We first give data sources and the definitions of the variables used in the estimations. Monthly Brent crude oil prices are obtained from the IMF's International Financial Statistics database. We obtained real oil price series through dividing the nominal oil prices by the deseasonalized U.S. CPI. The deseasonalized U.S. consumer price index (CPI) excluding energy prices are obtained from the online database of the St. Louis Federal Reserve Bank. Data on Turkish real GDP, Turkish industrial production index, overnight interest rates are obtained from Central Bank of Turkey's online database. Turkey's quarterly real GDP data are converted into monthly frequency using the monthly industrial production index following Friedman's (1962) method. Monthly domestic interest variable is obtained by averaging the daily simple interest weighted average interbank overnight interest rate variable. The two measures of global liquidity used are the Fed Funds Rate (FFR) and the implied volatility of the S&P 500 index options (VIX). The FFR data are obtained from St. Louis Fed, and the VIX data are from Chicago Board of Exchange online databases.

We first deseasonalized real oil price and Turkish real GDP variables by Census X-12 method. Next, we took the natural logarithms and then first-differenced the series. They are found to be stationarity. VIX and interest rate variables are also found to be stationary at levels.

We next turn to the issue of which variable would be best to use for proxying oil price changes. We use four different specifications: oil price increase variable due to Mork (1989), Scaled Oil Price Increase (SOPI) due to Lee *et al.* (1995), Net Oil Price Increase based on the previous three years (NOPI) due to Hamilton (1996) and the simple log difference.[3]

[3] Hamilton (2003) argues that SOPI and NOPI perform better than the rest of the asymmetric price specifications in capturing the effects of oil price shocks. For a different volatility-based specification, see Ferderer (1996).

Oil price increase variable due to Mork (1989) is defined as:

$$o_t^+ = \begin{cases} o_t & \text{if } o_t > 0 \\ 0 & \text{else.} \end{cases} \tag{1}$$

where o_t denotes log-difference of oil price.

Converting the proposed specification of Lee *et al.* (1995) AR(4)-GARCH(1,1) for quarterly into AR(12)-GARCH(1,1) for monthly data, SOPI is defined as:

$$o_t = \alpha_0 + \alpha_1 o_{t-1} + \alpha_2 o_{t-2} + \ldots + \alpha_{12} o_{t-12} + u_t \tag{2}$$

where

$$(u_t | u_{t-1}) \sim N(0, \sigma_t^2) \qquad \sigma_t^2 = \gamma_0 + \gamma_1 \sigma_{t-1}^2 + u_{t-1}^2 \tag{3}$$

$$SOPI_t = \max\{0, (\hat{u}_t / \hat{\sigma}_t)\} \tag{4}$$

Following Hamilton (1996), NOPI based on maximum price over 36 months is defined as:

$$NOPI_t^{36} = \max\{0, p_t - max(p_{t-1}, p_{t-2}, \ldots, p_{t-36})\} \tag{5}$$

where p_t denotes the natural logarithm of nominal oil price.

In order to estimate the effects of oil price changes, we first employed a standard bivariate VAR with each of the real oil price variable specification and real Turkish GDP. Next, we also incorporate global liquidity conditions and estimate multivariate structural vector autoregressions (SVARs) with each of the real oil price specifications, FFR, VIX, domestic interest rate, and real GDP, respectively. Here the FFR and VIX variables, so called the "push factors", are used to proxy global liquidity and the domestic interest rate variable serves as a "pull factor", and also captures the impact of central bank reactions to significant oil price changes.

In the estimations, other than the endogenous variables, we included a constant and a dummy variable which takes the value of 1 for Turkey's 1994 and 2001 crises, and 0 otherwise. We determined lag-length of the bivariate VAR and SVAR models by log-likelihood criterion. After estimating the reduced form, structural form solution is attained using the pre-imposed restrictions on the system. Impulse-response analyses are then conducted.

3. Methodology and Estimation Results

We start by estimating a standard bivariate VAR with each of the oil price specifications and the real GDP growth for Turkey for the 1991:2-2007:10 period[4]. Estimation results we

[4]Even though data span of oil price and real output variables are larger, because domestic interest rate variable and VIX variable are available since 1990, our estimation is constrained to the 1991:2-2007:10 period. The log-likelihood criterion based lag length is 13 months, which is in accordance with the 4 quarterly lags of Hamilton (1983, 1996, 2001), Hooker (1996), Mork (1989), Jiménez-Rodríguez and Sánchez (2005), among others.

present for our initial set of estimations are for the log-differenced real oil price specification.[5] Figure 1 depicts the accumulated response of Turkish real output to Brent oil price change impulses.[6] Aggregate output responds negatively albeit insignificantly to oil price shocks. Blanchard and Galí (2007) report insignificant response of real output to oil price shocks since the 2000s. In order to see whether the response of Turkish real output to oil price shocks is different or not in the 2000s, we next separate the sample period into two subperiods with respect to the year 2000 in an *ad hoc* manner and estimate the bivariate VARs for the two subperiods.

The accumulated response functions presented in Figures 2 and 3 reveal that the macroeconomic impact of oil price shocks are indeed different in the 2000s for Turkey. For the 1991:2-1999:12 period, as illustrated in Figure 2, real output is significantly and negatively affected by rising crude oil prices. The significant and negative response of real output to oil price increase is robust, except for the NOPI specification.[7] For the 2000:1-2007:10 period, as illustrated in Figure 3, aggregate output does not respond significantly to oil price changes. Since we divided the sample into two in an *ad hoc* manner, we further investigated the time-varying behavior of response of real GDP to real oil price. Using rolling bivariate VAR with a window length of 107 months, we derived the three-dimensional time-varying accumulated responses of real GDP, as illustrated in Figure 4.[8] The accumulated impulse-response graph verifies the gradually declining impact of oil prices on real output across time, and confirms that our findings were not as a result of arbitrary sample separation, but as a result of structural alteration at the beginning of 2000.

We next incorporate global liquidity conditions into the picture and analyze the impact of oil prices on real output given the global liquidity conditions for a small open economy using an SVAR model.

Suppose y_t denotes the vector of all endogenous variables in the model which are the real oil price, FFR, VIX, the domestic interest rate and the real output, respectively. α, δ, β_i and Γ_i, $(i = 0, 1, 2, ..., p)$ denote the coefficient matrices associated with the constant and the endogenous variables in the structural and reduced form VAR models, respectively. Finally, p denotes the lag length.

The structural form VAR(p) regression equation can be written as:

$$\beta_0 y_t = \alpha + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots + \beta_p y_{t-p} + u_t \tag{6}$$

where $u_t \sim N(0, \Sigma_u)$ denote the structural form innovations.

[5] Estimation results for the bivariate VAR model are robust to the choice of oil price specification. All estimation results are available from the authors upon request.

[6] Following the empirical literature on oil prices, we use accumulated responses since the response of aggregate output exhibits an oscillating pattern.

[7] NOPI variable, by design, filters out gradual increases and is intended to capture only large changes in oil prices. Insignificant impact of NOPI variable is not surprising given the lack of abrupt oil price changes in our sample

[8] The initial 107 months cover the 1991:2 - 1999:12 period.

The reduced form VAR(p) can then be written as:

$$y_t = \delta + \Gamma_1 y_{t-1} + \Gamma_2 y_{t-2} + \ldots + \Gamma_p y_{t-p} + \varepsilon_t \tag{7}$$

where $\Gamma_i = \beta_0^{-1}\beta_i$, $\delta = \beta_0^{-1}\alpha$ and $\varepsilon_t \sim N(0, \Sigma_e)$ denote the reduced from innovations and relate to the structural shocks through $\varepsilon_t = \beta_0^{-1}u_t$ so that $\Sigma_e = (\beta_0^{-1})\Sigma_u(\beta_0^{-1})'$.

Next we discuss how we impose short-term restrictions on β_0^{-1} and estimate the SVAR.

We first consider real oil prices. Although there is an ongoing controversy about the source of oil price changes, the orthodox point of view regard oil price changes as a result of supply-side, rather than demand-side reasons. Accordingly, we assume that oil price is not influenced by other variables in the system contemporaneously. In other words, shocks on global liquidity conditions and Turkish interest rates and real output do not affect oil prices in the same month. Since Turkey is a small open economy, the assumption that oil price changes are contemporaneously unaffected by Turkey's interest rate and real aggregate output can be considered as appropriate. Hence, the structural and the reduced form innovation terms are related as follows: $\epsilon_{ot} = b_{11}u_{ot}$.

As for the Federal Funds Rate variable, FFR, we assume that the Federal Open Market Committee responds to real oil price changes contemporaneously in order to achieve price stability and not to the rest of the variables in the system. As before, it is safe to assume shocks to Turkey's domestic interest rate and real output is not an important determinant of the unexpected changes to FFR. Hence the FFR innovations could be expressed as: $\epsilon_{ft} = b_{21}u_{ot} + b_{22}u_{ft}$.

The implied volatility index, VIX, is another important indicator of global liquidity conditions and is assumed to be affected by the real oil prices as well as the FFR but not from other variables in the system contemporaneously. Therefore innovations to the VIX is assumed to be represented as: $\epsilon_{vt} = b_{31}u_{ot} + b_{32}u_{ft} + b_{33}u_{vt}$.

The domestic interest rate is assumed to respond to changes in real oil prices and global liquidity conditions contemporaneously. We assume that the Central Bank of Turkey, due to fear of price increases would respond to an increase in the oil prices and a deterioration in the global liquidity conditions to the extent that it affects domestic prices through exchange rate pass through. We also assume that since output is observed with a lag, Central Bank of Turkey and hence the policy rate is contemporaneously not affected by real output shocks and may respond with a lag. Hence, the interest rate equation could be expressed as: $\epsilon_{it} = b_{41}u_{ot} + b_{42}u_{ft} + b_{43}u_{vt} + b_{44}u_{it}$

The final variable in the system which is the real output of Turkey is assumed to be contemporaneously related to Federal Funds Rate, implied volatility index, and domestic interest rate, but not the real oil price changes. The rationale for this assumption is that the actualization supply-side effects of oil price changes is a timely process, the production decision changes due to changing input costs does not take place contemporaneously but with a lag.[9] Therefore the innovation terms of the real output equation is assumed to take the form: $\epsilon_{yt} = b_{52}u_{ft} + b_{53}u_{vt} + b_{54}u_{it} + b_{55}u_{yt}$

[9] Previous empirical studies using quarterly data assume a contemporaneous relation between output and

Combining these 5 equations, the relationship between reduced and structural form innovations may be written as:

$$\begin{bmatrix} \epsilon_{ot} \\ \epsilon_{ft} \\ \epsilon_{vt} \\ \epsilon_{it} \\ \epsilon_{yt} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ b_{21} & b_{22} & 0 & 0 & 0 \\ b_{31} & b_{32} & b_{33} & 0 & 0 \\ b_{41} & b_{42} & b_{43} & b_{44} & 0 \\ 0 & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix} \begin{bmatrix} u_{ot} \\ u_{ft} \\ u_{vt} \\ u_{it} \\ u_{yt} \end{bmatrix} \tag{8}$$

where ε_{ot}, ε_{ft}, ε_{vt},ε_{it}, ε_{yt} are the reduced form; u_{ot}, u_{ft}, u_{vt}, u_{it}, u_{yt} are the structural form innovation terms of real oil price, FFR, VIX, Turkey's domestic interest rate and real GDP, respectively.[10]

Similar to the bivariate VAR, log-likelihood criterion,indicated the optimal length to be 13. We present the accumulated response of aggregate output from the SVAR model for the full sample in Figure 5. In contrast to the results obtained from the bivariate VARs, the accumulated response of real GDP to real oil price shocks is negative and significant and does not die off until 8 months after the shock. Other than the direct response of real output to oil shocks, two other variables response are worth noting. The responses of both the Federal Funds Rate and the Turkey's overnight interbank rate to oil price impulses are positive and significant. This finding is similar to previously reported empirical results, and may be attributed to two major reasons: First, at macro level, central banks respond to oil price shocks and increase interest rates in order to suppress inflationary pressure. Second, at micro level, agents who believe that the shocks could be temporary are inclined to borrow funds to smooth their consumption, which cause a rise in interest rates.

When the sample period is divided with respect to the year 2000, the accumulated responses of aggregate output to oil price shocks derived from SVAR are found to be negative and significant in both periods, as illustrated in Figures 6 and 7. While the significance and magnitude of the responses are more stable and powerful up to 2000, in contrast to Blanchard and Galí's (2007) findings, real output responds negative and significantly to real oil price increases even in the post-2000 period.

We also derived the time-varying accumulated response of real GDP to an oil price shock for the multivariate SVAR framework, and presented the results in Figure 8. We found that the behavior of real output responds relatively stable over time, with the exception of the financial crisis years of 1994 and 2001. Furthermore, in contrast to Blanchard and Galí's (2007) findings, the magnitude of the real output response to an oil price shock is found to be gradually increasing in absolute value. This essentially implies that when the global liquidity conditions and the domestic interest rates are accounted for, the negative and significant effect of oil prices on real output persist even in the post 2000 period.

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oil prices. However, we use monthly data and such an assumption would be erroneous. Nevertheless, our results are robust to this specification.

[10] Our findings are robust with respect to the use of other short-term restrictions, including Cholesky recursive factorization.

4. Conclusions

In this study, we investigated effects of energy price changes on aggregate economic activity of Turkey, empirically. Turkey, a small open economy, differs from the previously empirically investigated countries since she cannot influence world oil demand and/or supply, and prices accordingly. Following the financial account liberalization of Turkey since end-1990s, we incorporated the financial and global liquidity conditions into the model. We report that when the global liquidity conditions are excluded, the accumulated response of real output to oil price innovations are found to be statistically insignificant in the post-2000 period. However, with the global conditions, the negative and significant impact of oil price shocks persist. Further, we document that both the Fed funds rate and the Turkish overnight interest rate respond positively to oil price increases and that there is no significant relationship between oil price changes and the implied volatility index. We conclude that the inclusion of the global liquidity conditions in the relation between aggregate economic activity and oil price changes is an important issue for a small open economy such as Turkey.

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Figure 1:

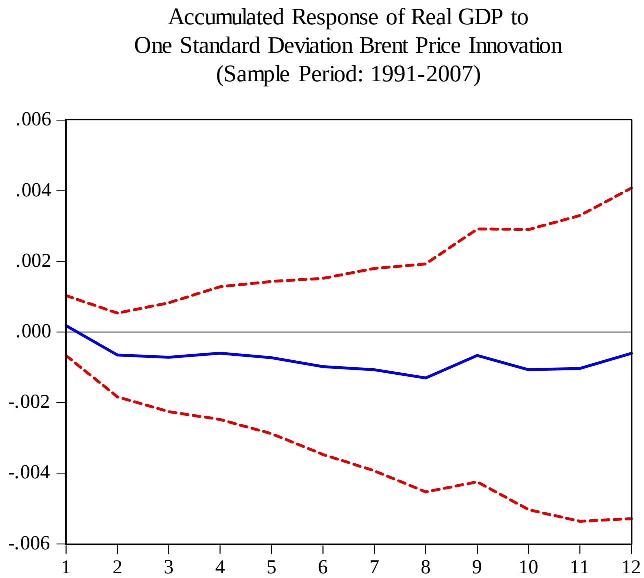
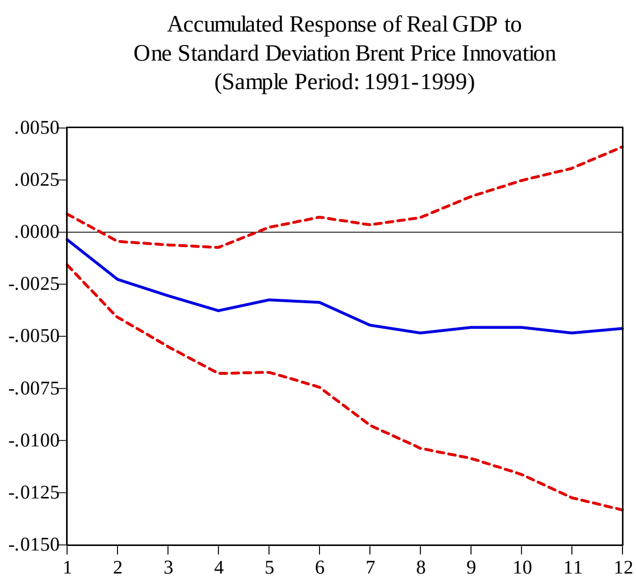


Figure 2:



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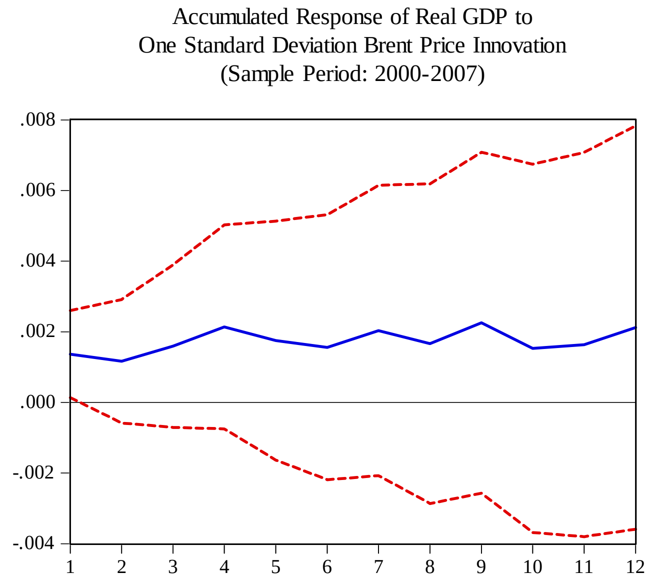
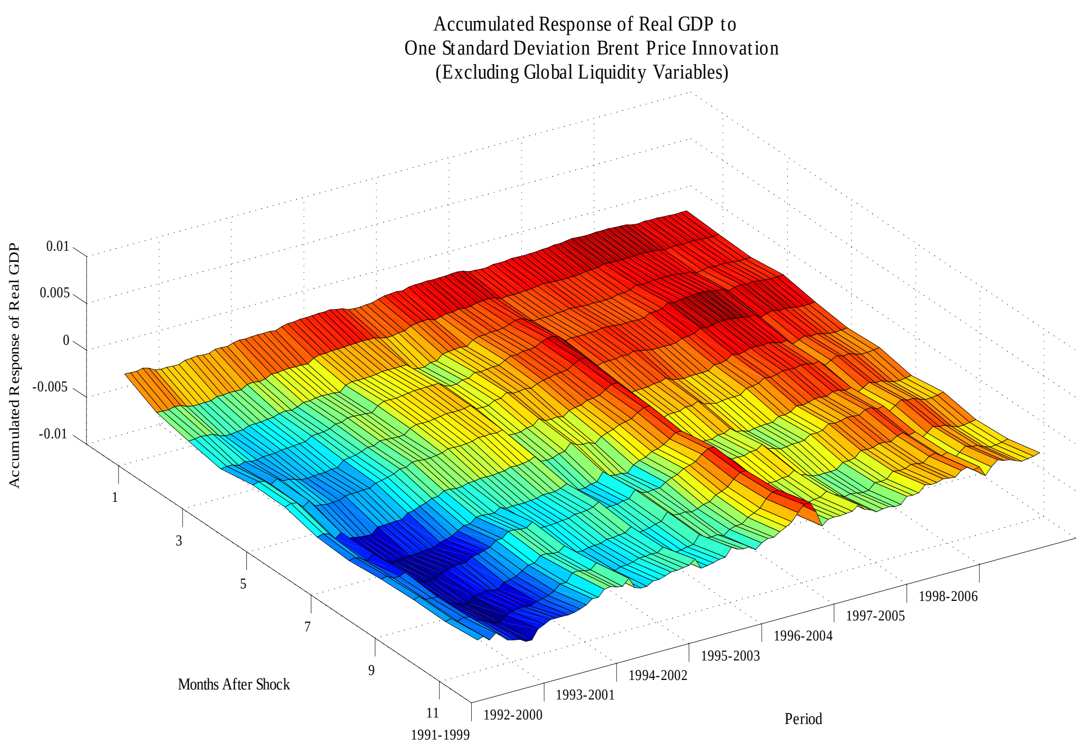


Figure 4:



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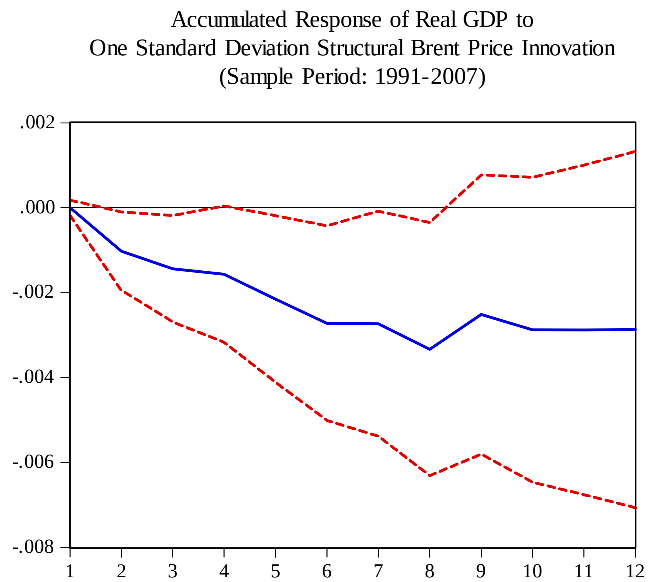

Figure 6:

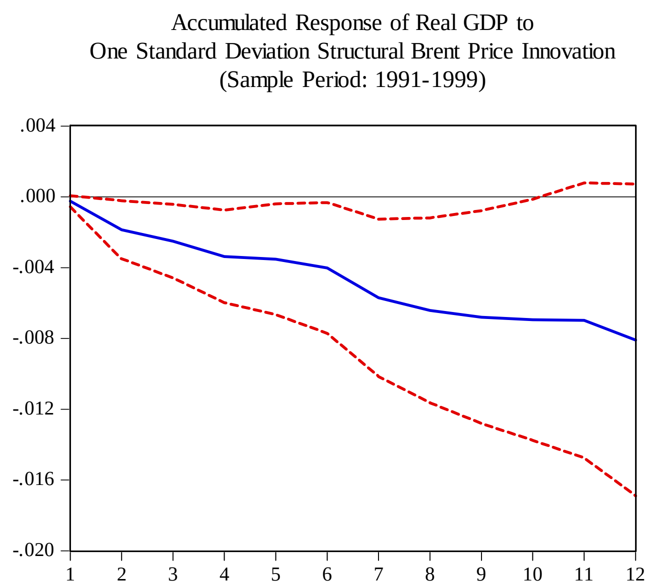

Figure 7:

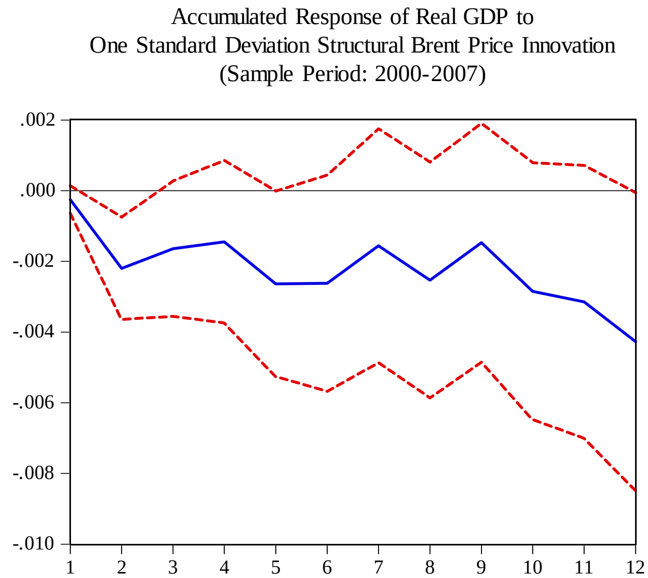

Figure 8: