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Working Paper

The effects of oil price shocks on the Iranian economy

Dresden discussion paper series in economics, No. 15/08

Provided in cooperation with:
Technische Universität Dresden

Dresden Discussion Paper Series in Economics

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ISSN 0945-4829

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Internet:

An electronic version of the paper may be downloaded from the homepage:
http://rcswww.urz.tu-dresden.de/wpeconomics/index.htm

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Abstract:

The Iranian economy is highly vulnerable to oil price fluctuations. This paper analyzes the dynamic relationship between oil price shocks and major macroeconomic variables in Iran by applying a VAR approach. The study points out the asymmetric effects of oil price shocks; for instance, positive as well as negative oil price shocks significantly increase inflation. We find a strong positive relationship between positive oil price changes and industrial output growth. Unexpectedly, we can only identify a marginal impact of oil price fluctuations on real government expenditures. Furthermore, we observe the "Dutch Disease" syndrome through significant real effective exchange rate appreciation.

JEL-Classification: E32; E37; Q32

Keywords: macroeconomic uctuations, oil price shocks, developing economies, Iran, VAR modelling

1 Introduction

Oil and gas revenues play strategic roles in the structure of the Iranian economy. Holding 10% of the world's total proven oil reserves and as the second largest producer (after Saudi Arabia) within the Organization of Petroleum Exporting Countries (see OPEC (2005)), Iran both affects the international oil market and is broadly affected by it. Iran's economy relies heavily on crude oil export revenues, representing about 90% of total export earnings and, on average, 60% of government revenues in annual budgets (Central Bank of Iran (2008)). The share of oil value added in the GDP of Iran averaged about 20% between 1970 and 2006. In this situation, any shock to global oil markets can have a tremendous effect on the government budget and the structure of the economy. Figure 1 (source: Central Bank of Iran (2008) and IFS-Database) illustrates the co-movement of the Iranian GDP per capita with fluctuations of real oil prices since 1970. We can observe that the former variable is linked to trend of the latter.

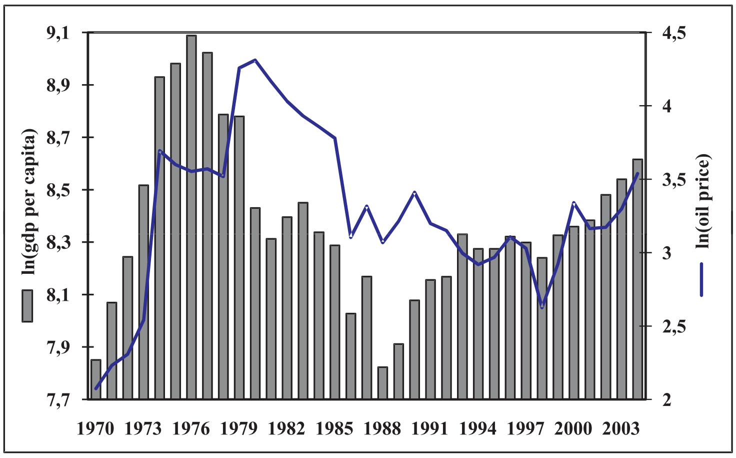

Fig. 1. The co-movement between GDP per capita and oil price

The unique role of oil revenues in the structure of government budgets and social security programs distinguishes the Iranian economy from others. Despite higher oil prices and revenues in recent years, the Iranian government budget deficits are still a challenging issue, in part due to the large scale of state subsidies on energy and comestible goods. Possible sources of financing the annual budget deficits include issuing state bonds, foreign borrowing, privatization, and withdrawals from the Oil Stabilization Fund (OSF). The shares of various sources of financing the budget deficits in Iran over 2005 to 2007 are presented in table 1. As is evident from this table, more than 90% of annual budget deficits in Iran is financed through withdrawals from OSF. This is like spending oil revenues directly and has strong inflationary effects through increasing money supply in the economy. Considering the high rigidity of current government expenditures in Iran, any significant negative oil price shocks will worsen the budget deficit of the government and create inflationary pressures for the whole economy.

Table 1
Financing budget deficit

	2005		2006		2007	
	budget	actual	budget	actual	budget	actual
State bond	3.2%	3.3%	5.4%	0%	6.2%	0%
Foreign borrowing	2.1%	0%	3.2%	0%	2.8%	0.4%
Privatization	30.9%	0.4%	4.8%	0.2%	26.4%	1.7%
Oil Stabilization Fund	**57.5%**	**87.2%**	**82.7%**	**96.3%**	**62.0%**	**94.0%**
Others	6.2%	9.1%	3.9%	3.5%	2.6%	3.9%
Total	100%	100%	100%	100%	100%	100%

Source: Survey of the Iranian Economy, Karafarin Bank, Online E-library

Thus, it appears that oil price changes highly influence the welfare and subsidization programs of the government. Subsidies on gasoline and other essential products are part of income redistribution programs.[1] In recent years, the average share of total subsidies in annual state budgets reached about 10%. Figure 2 shows the share of subsidies in the annual budgets of Iran since 1973 (Shirkavand (2004)).

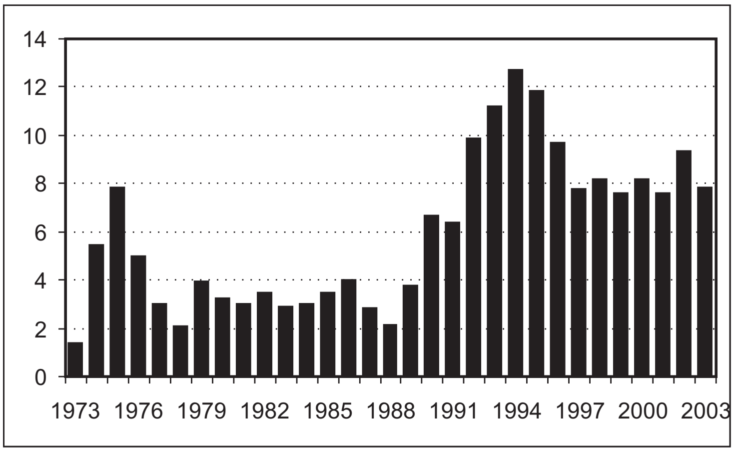

Fig. 2. Share of subsidies in state budget

Besides the effects of oil price fluctuations on state welfare programs, the other important aspect of vulnerability of the Iranian economy can be observed in the appreciation of the exchange rate during oil price booms, leading to a contraction

[1] Subsidies on gasoline are defined as the difference between import prices of gasoline and domestic prices. It is important to note that some kinds of subsidies, such as subsidies on gasoline, are implicit subsides and are not transparent within annual budgets.

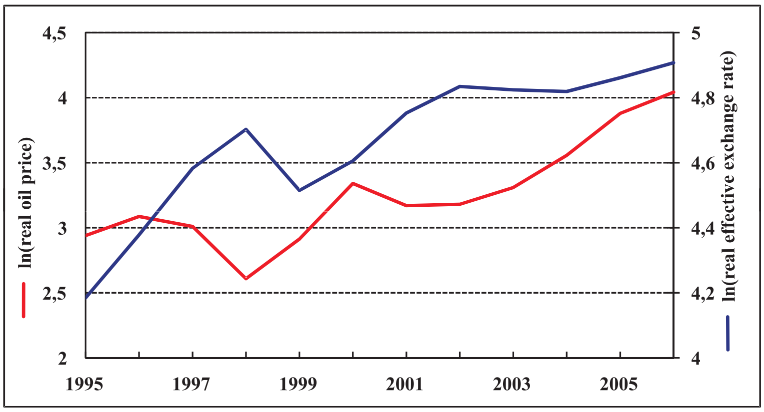

Fig. 3. Co-movement of real oil price and real effective exchange rate

of the tradable sector. Figure 3 (source: IFS-Database) shows the co-movement of the real oil price and the real effective exchange rates since 1995. This phenomenon is known as ”Dutch disease” [2] (see, e.g., Corden and Neary (1982), Corden (1984) or van Wijnbergen (1984)). This effect, combined with the proposition that the tradable sector (usually manufacturing) generates lager growth effects. This leads to the conclusion that natural resource ownership exerts a drag on long run growth. This phenomenon is not limited to Iran, but has also affected other main oil exporters. Table 2 illustrates the overall economic performance of key oil rich countries in comparison with control groups.

Given the high degree of dependence on oil revenues, a comprehensive analysis that considers the main transmission channels of oil price shocks on the Iranian economy is vital. This paper is one of only a handful of studies on a developing, net oil exporting economy. The effects of oil price shocks are analyzed in three different channels: the supply side, the demand side, and the terms of trade.

Our main results for the period 1989:I–2006:IV on the supply side of economy reveal that positive oil price shocks stimulate Iranian industrial production [3] and real imports. On the other hand, negative shocks on oil prices undermine the process of real industrial production and play a significant role in lowering the real level of imports.

[2] Dutch disease is the standard example of the Paradox of Plenty. In the 1970s, large revenues to the Dutch state from the extraction of natural gas led to the temptation to build a welfare state that was unsustainable in the long run. The competitive ability of the private sector was reduced and the industrial sector experienced a setback from which it took many years to recover. In the case of oil exporting countries, this is even more likely because abundant petroleum revenues change the calculations of even the most prudent rulers, thus making learning more difficult, not only between countries but also within them.

[3] The same results were obtained in the case of using real GDP per capita instead of real industry value added GDP per capita.

Table 2
Comparative economic performance of selected oil exporters (1975-2004)

	gdp per capita in*		growth rate**	*gdp* per capita	
	1975	2004	1975-2004	highest value	year of highest value
MENA oil exporters					
Iran	6984	6916	-0.03%	7976	1976
Kuwait	27760	17815	-1.52%	27760	1975
Saudi Arabia	21591	12706	-1.81%	23265	1977
Out of MENA oil exporters					
Nigeria	922	1061	0.48%	1061	2004
Mexico	6298	9010	1.75%	9046	2000
Venezuela	7103	5544	-0.84%	7587	1977
Comparators					
East Asia & Pacific	806	4920	6.44%	4920	2004
South Asia	1101	2635	3.06%	2635	2004
World	4835	8187	1.83%	8187	2004

Source: World Bank (2006) and own calculations, Note: * in US Dollar (PPP, 2000), ** compounding geometric growth rate, MENA is the abbreviation for Middle East and North Africa countries

On the demand side, both positive and negative oil price shocks have inflationary effects and drive up the general level of prices, which translate into lower real disposable incomes and a reduction in the real effective demand of Iranian consumers. Another unexpected finding is the response of government expenditures to oil price changes. We can identify only a marginal impact of oil price fluctuation on real government expenditures. The third main result of our paper is on terms of trade. Increasing oil prices improves the terms of trade and appreciates the real effective exchange rate. The response of the exchange rate to positive shocks is significantly positive, and increasing in the short and midterm. At the same time, negative shocks cause significantly negative responses in the real effective exchange rate, increasing competitiveness of the tradable Iranian goods in international markets. In addition to the evaluation of impulse response analyses, we have carried out variance decomposition analyses to illustrate the contribution of oil price shocks to fluctuations of major macroeconomic variables in Iran. Studying the effects of asymmetric changes in real oil prices can be a step forward in understanding the Achilles' heel of the Iranian economy and in filling the existing gap in the empirical literature regarding the macroeconomics of oil in developing and net oil exporting countries.

In the next section, we briefly review the existing literature covering the oil price macroeconomic relationship. In the third section, the data and the VAR methodology will be discussed. In section four, the empirical findings, the discussion of results and robustness tests are presented. Finally, section five summarizes the main findings.

2 Previous literature

The important role of crude oil in the global economy has attracted a great deal of attention among politicians and economists. Researchers have focused on studying the impacts of crude oil price shocks mainly within developed, net oil-importing economies. However, explicit studies on net oil exporters have been rare so far. In an international context, oil price shocks may have a different impact depending on countries' sectoral compositions, their institutional structures and their economic development.[4] Researchers have focused on analyzing the relationship between oil price changes and macroeconomic variables such as output growth, employment, wages and inflation. As we will see, the literature is still far from reaching a consensus. In the following section, we will review some selected studies on industrial and developing economies.

2.1 Industrial economies

There are several studies addressing the question of whether there is a relationship between oil price shocks and macroeconomic key variables. Pioneering work on oil price effects carried out by Darby (1982) and Hamilton (1983) focused on the US economy. While Darby was not able to identify a significant relationship between oil prices and macroeconomic variables, Hamilton found that oil price shocks were an important factor in almost all US recessions from 1949 to 1973. He concludes that changes in oil prices Granger-caused changes in unemployment and GNP in the US economy.

Following Hamilton (1983) the literature for net oil importing countries raises two fundamental questions. First, is the relationship between oil prices and economic output stable over time? Second, does an asymmetric relationship exist between oil price changes and economic activity?

In considering the first question, studies e.g. Burbidge and Harrison (1984), Gisser and Goodwin (1986), Hooker (1996), Rotemberg and Woodford (1996) and Schmidt and Zimmermann (2007) have shown that for several industrial countries, oil price shocks have a significant negative impact on industrial production. However, they all concluded that oil price changes have different impacts on economies over time. It seems evident that the effects of oil price movements have weakened during the eighties.

[4] See Cunado and de Garcia (2004) for a similar view.

Recently, Blanchard and Gali (2007) examined and compared the current response of inflation and output in a group of industrialized economies to those of the 1970s. They concluded that the main reasons behind the weak response of economies in recent years is smaller energy intensity, a more flexible labor market, and improvements in monetary policies.

In considering the second question, Mork (1989) proposes an asymmetric definition of oil prices and distinguishes between positive and negative oil price changes. He defines oil price changes as follows: [5]

$$roilp_t+ = max(0, (roilp_t - roilp_{t-1})) \tag{1}$$

$$roilp_t- = min(0, (roilp_t - roilp_{t-1})) \tag{2}$$

where $roilp_t$ is the log of real oil price in time t. Mork showed that there is an asymmetry in the responses of macroeconomic variables to oil price increases and decreases. He concluded that positive oil price changes have a strongly negative and significant relationship with changes in real GNP while negative oil price changes exhibit no significant effects. For more comprehensive details on asymmetric effects of oil prices see Mork (1994).

Hamilton (1996) suggested another form of asymmetric transformation of real oil prices. Hamilton stated that most of the oil price increases are simply corrections of earlier declines. He argued that if researchers want to measure how unsettling an increase in the prices of oil is likely to be for the spending decision of consumers and firms, it seems more appropriate to compare the current price of oil with that during the previous year rather than during the previous quarter alone (see Hamilton (1996), p. 216). Hamilton thus proposed using the percentage change over the previous year's maximum if the oil price of the current quarter exceeds the value of the preceding four quarters' maximum. If the price of oil in t is lower than in the previous year, the $noilp+$ is defined to be zero in quarter t. In this case no positive oil price shocks have occurred.

$$noilp_t+ = max[0, ((roilp_t) - max((roilp_{t-1}), ..., (roilp_{t-4}))] \tag{3}$$

$$noilp_t- = min[0, ((roilp_t) - min((roilp_{t-1}), ..., (roilp_{t-4}))] \tag{4}$$

In his study, net nominal oil price increases are significant in explaining growth in the real GDP of the US. Hamilton (2003) asserted that "Oil price increases are

[5] Mork does not use real oil prices in absolute terms. Instead he uses several producer price indices for crude oil. For a more detail description see Mork (1989), p. 741.

much more important than oil price decreases, and increases have significantly less predictive content if they simply correct earlier decreases" (Hamilton (2003), p. 363).

Lee, Ni and Raati (1995) pointed to the volatile nature of oil prices since the big decline in 1986 and concluded that Mork's (1989) method of separating positive and negative effects does not reveal a strong effect of oil price shock on real GNP growth for the sample up to 1992. If oil prices are volatile in nature, economic agents will expect an increase in prices to be reversed in a short time. They used a GARCH-model in order to extract conditional variance from real oil price changes. They concluded that positive oil price shocks are significantly negatively correlated with real GNP growth, but negative oil price shocks are not. In the same vein, Elder and Serletis (2006) showed that uncertainty about oil prices has a negative and significant effect on industrial production.

Recently, Jimenez-Rodriguez and Sanchez (2005) assessed empirically the effects of oil price shocks on real economic activities in a sample of seven OECD countries, Norway and the Euro area as a whole. They carried out a multivariate VAR analysis using both symmetric and asymmetric models. Jimenez-Rodrigez and Sanchez concluded that oil price increases have a larger impact on GDP growth than oil price declines. They emphasized the difference between oil importing and oil exporting countries. Among oil importers, oil price increases have a significant negative impact on economic activity, but for oil exporting countries, the effect is ambiguous.

For a comprehensive survey of recent developments on the relationship between oil price shocks and the macroeconomy in industrial countries, see Jones et al. (2004).

2.2 Developing economies

Despite the main focus of research directed towards net oil importers and developed economies, some recent studies have examined the effects of oil price changes on the macroeconomy of developing economies. In this literature, net oil exporting countries are the center of interest.

Eltony and Al-Awadi (2001) found evidence that symmetric oil price shocks are important in explaining fluctuations in macroeconomic variables in Kuwait. Their results showed the importance of oil price shocks on government expenditures, which are the major determinant for the level of economic activity in Kuwait.

Raguindin and Reyes (2005) examined the effects of oil price shocks on the Philippine economy over the period of 1981 to 2003. Their impulse response functions for the symmetric transformation of oil prices showed that an oil price shock leads to a prolonged reduction in the real GDP of the Philippines. Conversely, in their asymmetric VAR model, oil price decreases play a greater role in each variable's fluctuations than oil price increases.

Anshasy et al. (2005) examined the effects of oil price shocks on Venezuela's economic performance over 1950 to2001. They investigated the relationship between oil prices, governmental revenues, government consumption spending, GDP and investment by employing a general to specific modeling (VAR and VECM). They found two long run relations consistent with economic growth and fiscal balance. Furthermore, they found that this relationship is important not only for the long run performance but also for short-term fluctuations.

Berument and Ceylan (2005) studied the effects of symmetric oil price shocks on output (proxied by industrial production) for a group of Middle East and North African countries, including Iran. They estimate several VAR models for each of these countries by using annual data over the period of 1960 to 2003. Their impulse response analysis suggest that the effects of world oil price on GDP of Algeria, Iraq, Jordan, Kuwait, Oman, Qatar, Syria, Tunisia and UAE are positive and statistically significant. For Bahrain, Egypt, Lebanon, Morocco and Yemen they found in majority positive but not significant results. For Iran, the estimated impulse response of output to a shock in oil prices is contemporaneously significant and positive. We extent this analysis by using higher frequency data, using a higher dimension VAR models and considering possible asymmetric effects of oil price changes.

Olomola and Adejumo (2006) examined the effects of oil price shocks on output, inflation, real exchange rate and money supply in Nigeria using quarterly data from 1970 to 2003. Using VAR methodology they found that oil price shocks do not have any substantial effect on output and inflation. Oil price shocks significantly determine the real exchange rate and significantly affect the money supply in the long run. Olomola and Adejumo conclude that this may squeeze the tradable sector, giving rise to the Dutch disease.

Our analysis aims not only to examine the symmetric and asymmetric effects of oil price shocks on the Iranian economy, but also to trace their effects over different time periods.

3 Data and methodology

3.1 Data

In our analysis, we make use of six macroeconomic variables: real industrial GDP per capita (*rgdpi*), real public consumption expenditures (*rgex*), real imports (*rimp*), real effective exchange rate (*reex*), inflation (*inf*) and real oil prices changes (*roilp*).[6]

The full sample comprises quarterly observations for the 1975:II–2006:IV period. Our main results examine the post-war period (1989:I–2006:IV) and for the robustness check, we compare these results with the pre-war period (1975:II–1988:IV). Furthermore, to take into account the effects of the Iranian revolution (1979), the Iraq-Iran war (1980–1988), the Iraq-Kuwait war (1990), the financial crisis of South East Asia (1998), the terrorist attacks on the USA (2001) and the Iraq war (2003), we have employed five dummy variables. For more details on the dummy variables, refer to appendix B. Seasonal dummies are used in all specifications of VARs to control for probable seasonalities in our variables. All variables except for inflation are in logarithmic form.

The proper definition of applicable oil prices is a challenging task. We use oil prices in real terms, taking the ratio of the average world nominal oil price in US dollars to the US Consumer Price Index extracted from IFS online database. In our analysis, we make use of symmetric oil price growth rates as well as of Mork's asymmetric definition of oil price changes. In the second specification, we distinguish between the positive rate of quarterly changes (*roilp+*) and the negative rate of quarterly changes (*roilp-*).[7]

3.2 Empirical methodology

To investigate the response of macroeconomic variables to symmetric and asymmetric innovations in oil prices, we use an unrestricted vector autoregressive model (VAR). The VAR model provides a multivariate framework where changes in a particular variable (oil price) are related to changes in its own lags and to changes in other variables and the lags of those variables. The VAR treats all variables as jointly endogenous and does not impose a priori restrictions on structural relationships. Be-

[6] The definitions of the variables and the data sources are presented in the appendix A.
[7] Cf. equation (1) and (2) for a technical description. Hamilton's asymmetric specification cf. equation (3) and equation (4) is used for robustness tests in section 4.3.

cause the VAR expresses the dependent variables in terms of predetermined lagged variables, it is a reduced-form model. Once the VAR has been estimated, the relative importance of a variable in generating variations in its own value and in the value of other variables can be assessed (Forecast Error Variance Decomposition (VDC)). VDC assesses the relative importance of oil price shocks in the volatility of other variables in the system. The dynamic response of macroeconomic variables to innovations in a particular variable (e.g., here oil prices and oil market) can also be traced out using the simulated responses of the estimated VAR system (Impulse Response Functions (IRF)). Thus, the IRF allows us to examine the dynamic effects of oil price shocks on the Iranian macroeconomy. Our unrestricted vector autoregressive model of order p is presented in equation (5):

$$y_t = A_1 y_t + ... + A_p y_{t-p} + B z_t + \varepsilon_t \tag{5}$$

where y_t is a vector of endogenous variables, z_t is a vector of exogenous variables, A_i and B are coefficient matrices and p is the lag length. In this study, we have selected lag 4 for the pre-1989 and for the post-1989 sample and lag 8 for the full sample. The innovation process ε_t is an unobservable zero-mean white noise process with a time invariant positive-definite variance-covariance matrix. In our unrestricted VAR models, the vector of endogenous variables, according to our first Cholesky ordering, consists of real oil price (*roilp*, *roilp+*, *roilp-*), real government expenditures (*rgex*), real industrial GDP per capita (*rgdpi*), inflation (*inf*), real effective exchange rate (*reex*), and real import (*rimp*):

$$y_t = [roilp, rgex, rgdpi, inf, reex, rimp]. \tag{6}$$

The innovations of current and past one-step ahead forecast errors are orthogonalised using Cholesky decomposition so that the resulting covariance matrix is diagonal. This assumes that the first variable in a pre-specified ordering has an immediate impact on all variables in the system, excluding the first variable and so on. In fact, pre-specified ordering of variables is important and can change the dynamics of a VAR system. The vector of exogenous variables is given by:

$$z_t = [constant, Q1, Q2, Q3, D1, D2, D3, D4, D5]. \tag{7}$$

where $Q1$-$Q3$ refers to seasonal dummies and $D1$-$D5$ refers to all other important exogenous events during 1975–2006. The details behind the coding of dummies are given in appendix B.

In the first set of ordering, the real oil price changes are ranked as a largely exogenous variable, especially for the case of Iranian economy. Although Iran is one of the key suppliers of crude oil to global markets, its production and export quota are predetermined by the OPEC criteria, domestic consumption and investment in oil fields. Furthermore, demand for crude oil is largely determined by global economic growth, energy intensity within industrialized economies, speculator operations in oil markets, expectations of other key oil producers about current and future developments of the market, international oil companies' decisions on liquidation of their stocks and finally, the policy of key oil consumers on strategic petroleum reserves. Therefore, oil prices are an exogenous factor for the Iranian economy. We expect that significant shocks in oil markets affect contemporaneously the other key macroeconomic variables in the system.

The second variable in the ordering is government expenditures. Government expenditures can be broadly defined as current and capital consumptions. Current expenditures cover recurrent expenditures (e.g., payments of governmental employees, subsidies, and so on.), whereas capital expenditures aim to add, rather than maintain, the physical and material assets of an economy. A pattern that has been observed since 1970 in Iran is the large and growing wage bill, which reflects the trend and magnitude of current expenditures of state. The dominant role of the government in the economy, especially since the Islamic Revolution in 1979 and the large initial nationalization caused a great over-employment in the government sector. Subsidies also play an important role in the size and inflexibility of current expenditures in Iran. The government, as a main recipient of oil rents, tries to distribute some part of rent through different kinds of subsidies. The magnitude of explicit budgetary subsidies is not large by international standards, but there are substantial implicit subsidies in the form of free or blow-cost provision of government services such as utilities, education, health, transport and inputs for specific sectors. These implicit subsidies cover consumption of petroleum products and long-term loans. Most of these expenditures reflect themselves in current payments. The average share of current expenditures for the period of 1970–2006 is 71%, whereas the average of capital expenditures over the same period is 29%. The inflexible structure of government expenditure ranks it largely as an exogenous variable in our first ordering.

Industrial production is also affected instantly by the level of government demand. The industry production per capita as a proxy for real income per capita [8] feeds into changes in inflation. The positive development in oil prices, which results in higher levels of government expenditures and income per capita, pushes the effective demand

[8] Selecting industrial output per capita designed to analyze the effects of oil price shocks on real economic activity. The literature also uses industrial production as suggested by Bernanke and Mihov (1995), Kim and Roubini (2000), Wong (2000) and Papapetrou (2001) for analyzing the effects of oil shocks.

upward. Furthermore, the limited capacity of domestic supply and inefficiencies as well as time lags in response to increased demand may push the general consumer prices upward, fueling inflation.

Increasing inflation appreciates the real effective exchange rate. The real exchange rate measures the relative price of non-tradable goods to tradable ones and is a measure of the competitiveness of an economy. The real effective exchange rate is a weighted real exchange rate index, with the weights assigned to trading partners of the local economy. If domestic prices increase, while prices abroad remain unchanged, this would increase the relative prices of non-tradeables and the competitiveness of an economy will fall. Finally, we have allowed that a shock in real effective exchange rate contemporaneously affects real imports in Iran. As explained earlier, any significant developments in exchange rate markets affect the competitiveness of Iranian products and foreign trade, as well. [9]

Another debatable point concerns use of VAR model in levels or in first differences. If all used variables follow a I(0) process, the specification in levels is appropriate. However, as most time-series variables have the problem of non-stationarity, the question of differencing arises. According to Hamilton (1994), one option is to ignore the non-stationarity altogether and simply estimate the VAR in levels, relying on standard t- and F- distribution for testing any hypotheses. In Hamilton's words, this strategy has three commendable features: "(1) The parameters that describe the system's dynamics are estimated consistently. (2) Even if the true model is a VAR in differences, certain functions of the parameters and hypothesis tests based on a VAR in levels have the same asymptotic distribution as would estimates based on differenced data. (3) A Bayesian motivation can be given for the usual t- or F-distributions for test statistics even when the classical asymptotic theory for these statistics is non-standard." (Hamilton (1994), p. 652). The other option is to difference any apparently non-stationary variables before estimating the VAR. If the true process is a VAR in differences, then differencing should improve the small sample performance. The drawback to this approach is that the true process may not be a VAR in differences. Some of the series may in fact have been stationary, or perhaps some linear combinations of the series are stationary, as in a cointegrated VAR. According to Hamilton (1994), in such circumstances, a VAR in differenced form is mis-specified. The case of losing useful information by differencing, while there are cointegration vectors in the system, is also argued by Sims (1980) and Doan (1992).

[9] As robustness tests, we have carried out VAR Granger Causality Block Exogeneity Wald Tests (see Granger (1969)) for alternative ordering of variables. The three alternative Cholesky orderings on the base of mentioned test are as follow: A.[*roilp*, *reex*, *inf*, *rimp*, *rgdpi*, *rgex*], B.[*roilp+*, *reex inf*, *rgdpi*, *rimp*, *reex*, *rgex*] and C.[*reex*, *rimp*, *roilp-*, *inf*, *rgdpi*, *rgex*].

The other area of debate is whether an unrestricted VAR should be used where the variables in the VAR are cointegrated. There is a body of literature that supports the use of a vector error correction model (VECM), or cointegrating VAR, in this situation. It has been argued, however, that in the short term, unrestricted VAR perform better than a cointegrated VAR or VECM. Naka and Tufte (1997) demonstrated the advantages of unrestricted VAR by examining impulse response functions in cointegrated systems. According to their analysis, a system of cointegrated variables is estimated either as a VAR in levels or as a VECM model, where the latter is a restricted version of the former. If there is cointegration, imposing this restriction will yield more efficient estimates. However, in the short run, VEC estimates are less accurate than those from a VAR. Their Monte Carlo analysis shows that the loss of efficiency from VAR estimation is not critical for the commonly used short horizon. Besides Naka and Tufte (1997), other researchers like Engle and Yoo (1987), Clements and Hendry (1995), and Hoffman and Rasche (1996) showed that an unrestricted VAR is superior (in terms of forecast variance) to a restricted VEC model on short horizons when the restriction is true.

As a first step we check the properties of the used variables in order to determine the appropriate specification for VAR estimation. The order of integration for each variable is determined using Augmented Dickey and Fuller (1979) and Phillips and Perron (1988) tests. The results of these tests are reported in table C.1 in the appendix C. The ADF-tests and PP-tests indicate that the variables expressed in logs are non-stationary. When all variables are first differenced, we find evidence that all variables are stationary. Considering that the variables of the model follow a I(1) process, we analyze in a second step whether there is a long run relationship among these variables. To test this, we employ Johansen cointegration tests (see Johansen (1991, 1995)). In formulating the dynamic model for the test, the question of whether an intercept and trend should enter the short- and/or long-run model is raised (Harris (1995), p. 95). We used all five deterministic trend models considered by Johansen (1995). The number of cointegrating relations from all five models, on the basis of trace statistics and the maximal eigenvalue statistics using critical values from Osterwald-Lenum (1992) at 5% level, are summarized in tables C.2 and C.3 in the appendix C.

Considering the existence of long-term equilibrium relationships among non-stationary variables in the system and the mentioned debates about advantages and drawbacks of different VAR specifications, we decide to employ an unrestricted VAR system in levels. The optimal lag length is 4. The selected lag length is based on different criteria.[10] The results of IRFs and VDC analyses for symmetric and asym-

[10] For details see table C.4 and table C.5 in appendix C.

metric formations of real oil prices within the Iranian macroeconomy are presented below.

4 Empirical results

4.1 Impulse response functions

To identify orthogonalised innovations in each of the variables and the dynamic responses to such innovations, the variance-covariance matrix of the VAR was factorized using the Cholesky decomposition method suggested by Doan (1992). This method imposes an ordering of the variables in the VAR and attributes all of the effects of any common components to the first variable in the VAR system. An impulse response function (IRF) traces the effects of a one-time shock to one of the innovations on current and future values of the endogenous variables. If the innovations ε_t are contemporaneously uncorrelated, the interpretation of the impulse response is straightforward. The i^{th} innovation $\varepsilon_{i,t}$ is simply a shock to the i^{th} endogenous variable $y_{i,t}$.

According to Runkle (1987), reporting impulse response functions without standard error bars is equivalent to reporting regression coefficients without t-statistics. As an indication of significance, we have estimated 68% confidence intervals for the IRF's (see Sims and Zha (1999)). These confidence bands are obtained from 1,000 Monte Carlo simulations. The middle lines in the figures represent the impulse response function while the bars represent confidence intervals. In this regard, when the horizontal line falls into the confidence interval, the null hypothesis - that there is no effect of oil price shocks on other macroeconomic variables - cannot be rejected. Thus, including the horizontal line for the particular time period obtained in this manner is interpreted as evidence of statistical insignificance (Berument and Ceylan (2005)). To investigate the response of the Iranian macroeconomic variables, symmetric and asymmetric real oil prices as shock variables have been utilized. Additionally we include dummy variables to capture exogenous shocks and seasonal effects.

Figure 4 shows IRFs for one standard innovation in real oil price growth (in symmetric definition) for the period of 1989:I–2006:IV. The shocks in real oil price growth significantly increase both real industrial GDP per capita and CPI inflation for the first two quarters after the initial shock. Real government expenditures rise rapidly and reached their maximum positive response to the initial oil price shock after the 5^{th} quarter. This strong increase in government consumption increases aggregate demand in the economy and, consequently, the general level of prices. The real im-

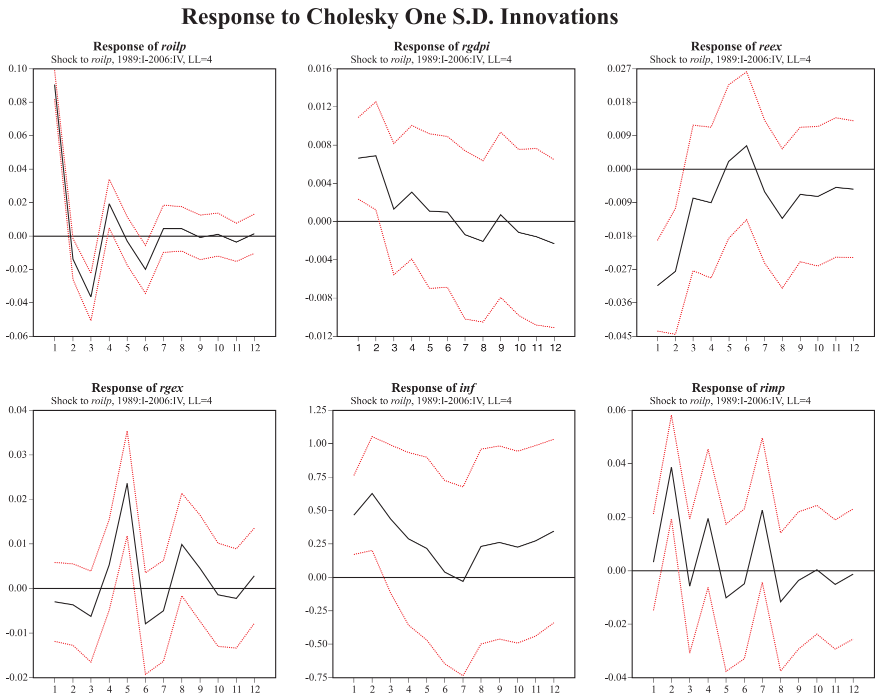

Fig. 4. Impulse Response Functions for *roilp*

port responds significantly and reached its peak two quarters after the initial shock. Considering the composite of imports in Iran since 1959, which include on average 60% for raw and intermediary materials, it would be natural to expect a significant response of industrial output to oil price shocks. The impulse response of the real effective exchange rate suggests that, in the long-run, this variable reacts to a symmetric shock in real oil price by appreciating. However, this appreciation is not statistically significant. The significant real effective depreciation in the short run (two quarters) could be explained by the fact that rising oil prices lead directly to higher inflation in the major trading partners of Iran via higher import prices, while domestic prices of energy products are highly subsidized in Iran and are below global market prices. However, in the medium- and long-run, the second round effects of higher inflation in Iran because of increasing nominal wages and wealth of citizens appear to surpass the inflation in trading partners, leading to a real appreciation of the Iranian rial.

Figure 5 shows IRFs based on one standard deviation shock to positive changes in real oil price for the period of 1989:I–2006:IV. The response of industrial output per capita is clearly positive and lasted till the end of the period. Based on Monte Carlo confidence bands, we can judge that its response is significant, especially for the first six quarters after the shock. This confirms the stimulus effect of positive oil price shocks on domestic industrial output. Using real GDP per capita instead of industrial GDP per capita does not change the results. The real GDP per capita

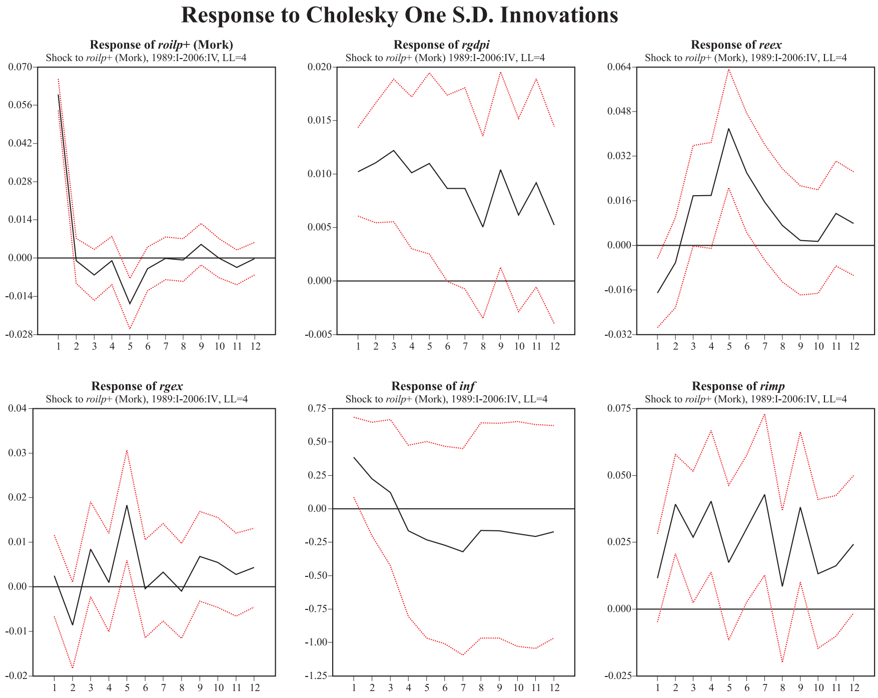

Fig. 5. IRF *roilp+*

also reacts positively and significantly, especially three to six quarters after the initial shock.[11] However, some of the stimulus effect of positive oil price shocks on domestic production is offset by appreciation of domestic currency. The response of real effective exchange rate to asymmetric positive shocks on oil price is increasing and statistically significant between the 4^{th} and 7^{th} quarters after initial shock. This supports the presence of a Dutch disease syndrome. Inflation reacts positively to oil price increases in the short run (two quarters).

The inflationary effects of positive oil price shocks on the Iranian economy can be explained through the AD-AS model. Increasing oil revenues contribute to higher levels of government expenditures. Considering the dominant role of the government in the domestic economy, which is beyond the budgetary expenditures[12] and includes great implicit expenditures (e.g., various energy subsidies, offsetting the state companies' annual losses, etc.), current and capital expenditures of the government will rise as oil revenues increase. Also, because of increased net foreign reserves of the central bank, the money supply will increase. The increased money supply and government expenditures will shift demand curve upward.

[11] The results are available upon request.
[12] The response of real government expenditures to positive oil price shocks is not statistically significant. However, this response does not reflect all expenditures by the government in Iran, but rather reflects only the budgetary consumption. Part of this insignificant response may be explained by a new institutional design of OSF in 2000.

At the same time, increasing oil prices and foreign exchange revenues lead to higher volumes of imports. As the Iranian industrial output is highly dependent on imported raw and capital intermediaries, the volume of domestic production will rise, shifting the supply curve to the right. However, limited capacity of domestic industries and inefficiency of production technology impede the rapid adjustment of supply section to increased demand. Furthermore, the international trade sanctions during the Iran-Iraq war and the US trade sanctions in the most years after the war have increased extra burden on limited production capacity. This circumstance restricts the shift of the AS curve. Thus, the combination of movements of supply and demand curves will increase the level of production and prices in the economy.

The other explanation for inflationary effects of positive oil price changes in Iran is through the Dutch disease phenomenon and within the "spending effects" as suggested by Corden (1984). The "spending effect" happens because higher oil prices lead to higher wages or profits in the oil related sectors, thus increasing aggregate effective purchasing power and demand in the economy. While the price of the tradeable sector (oil and manufacturing) is exogenously determined in international markets, the price of the non-tradeable sector, which includes services, is determined within the domestic market. A component of increased demand is shifted to the non-tradeable sector, causing push-demand inflation in these sectors. In this case, we have assumed the immobility between tradeable and non-tradeable sections. Therefore, we will not face a transfer of workers toward the booming service section from the oil and manufacturing section. However, if we assume the mobility of labor forces in the economy, the booming non-tradable section absorbs workers from oil industry and manufacturing sections, leading to an increase in wages in the tradable section as well. Since prices in the tradable section are determined from outside of the domestic market, their profit margin will fall and they will be forced to downsize their operations. This phenomenon is described by Corden (1984) as "indirect de-industrialization".

Real import response to a shock on positive changes in real oil prices is positive and lasts until the end of period. The increasing response of real import for the first quarters after initial shock is significantly different from zero. The positive response of real imports to positive oil price shocks act as a built-in stabilizer, mitigating the inflationary effects of increased money supply after positive oil price shocks. The long-run decreasing trend, albeit not statistically significant, of CPI inflation may be due to increased import volumes.

Finally, the response of real government expenditure to a one standard deviation shock to positive oil price changes is not significantly different from zero. At first glance, this might seem counter-intuitive. However, the Iranian policy of saving a large part of the windfall oil revenues in an oil stabilization fund since 2000, and using them in part to finance the capital expenditures and payment of external debts, has been an effective mechanism for oil wealth management.

In figure 6, we demonstrate the responses of variables to negative changes in real oil prices. The response of the real effective exchange rate to a decreasing real oil price is negative, reaching its minimum in the 4^{th} quarter after the shock. This negative response remains significantly different from zero for the first nine quarters. The significant reduction of the real effective exchange rate, which results in strong depreciation of the rial, can be interpreted as a warning sign of currency crisis. Following significant negative oil price shocks, government foreign exchange revenues fall considerably. Thus, it will not be able to allocate enough resources to clear the domestic exchange market and defend the fixed exchange rate. The depreciation of the domestic currency makes foreign products more expensive by increasing import prices. More expensive raw, intermediary, and capital imports will reduce real imports and dampen the domestic industrial production.

As expected, the response of industrial output to a negative shock of real oil price is negative and permanent. The response of this variable reached its minimum, on average, after three quarters of initial shock. [13] Due to the fall of real effective exchange rate and foreign exchange reserves, the response of real imports to a shock in negative oil price changes is also negative and lasts until the end of the period. This negative response is significant for the first 10 quarters after the shock and reaches to its minimum level, on average, in the 6^{th} quarter. The response of inflation to decreasing oil prices is also interesting. Inflation responds again positively to a negative oil price shock. After a shock in negative oil prices, inflation reaches its maximum in the second quarter and gradually decreases over the period of forecasting. However, it remains above the base line until the end of the period. This positive response is statistically significant for the first four quarters after the shock. When oil revenues fall because of negative oil price shocks, the level of imported raw and capital intermediaries, which is mainly financed through oil revenues, will decrease. Thus, domestic production will decrease. This means a shift of the supply curve to the left. Because of deficit spending through borrowing of the government from the central bank (or recently withdrawals from oil stabilization accounts), which raise the base money and money supply, the demand curve shifts to the right. A combination of these two shifts in demand and supply curves leads to increased prices and to a reduction of the production level in the economy. The economy suffers from inflationary pressures with both positive and negative oil price shocks.

[13] The same negative response to negative oil price shocks is considered by using real GDP per capita. Again, on average, after three quarters from initial shock, this variable experienced the largest fall and remained negative for the long-run with some adjustment upward.

Pressures due to a significant reduction in government oil revenues cause a short run reduction of its real consumption, reaching its minimum, on average, in the third quarter after a shock. This negative fall is statistically significant. However, rigidities in the structure of current government expenditures and the high level of involvement of the state within the domestic economy will adjust this fall in state consumptions in the mid-run. Again, the establishment of the OSF has facilitated the financing of budget deficits and government expenditures during negative developments of oil market.

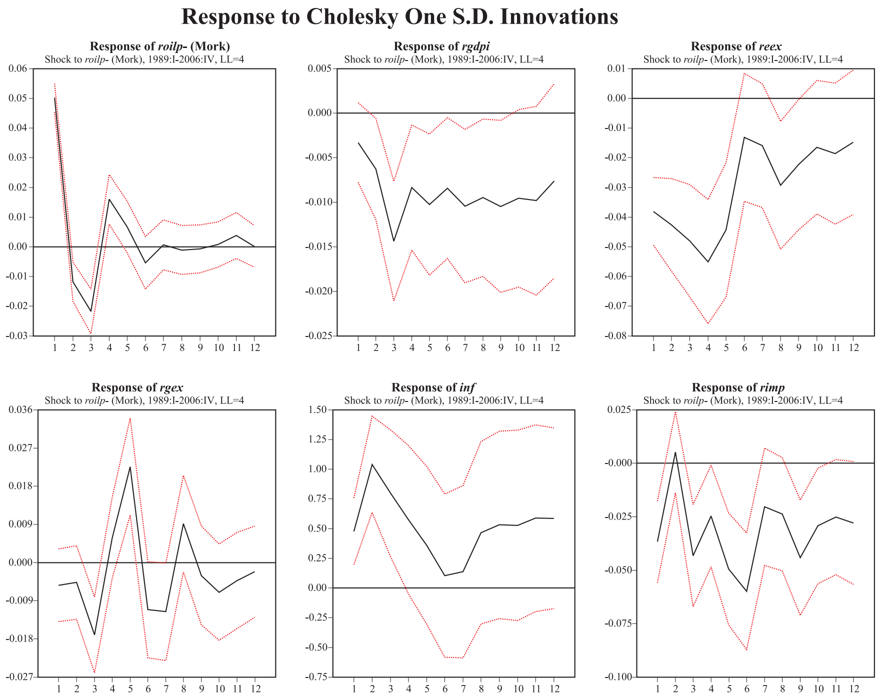

Fig. 6. IRF *roilp-*

4.2 Variance decomposition analysis (VDC)

The impulse response functions illustrate the qualitative response of the variables in the system to shocks in real oil prices. We can also examine the forecasting error variance decomposition to determine the proportion of the movements in the time series that are due to shocks in their own series as opposed to shocks in other variables, including oil prices.

Table 3 demonstrates the variance decompositions of the VAR models. Both oil price increases and decreases affect the volatility of the other variables in the model to varying degrees. For fluctuations of inflation, negative oil price shocks have a stronger short and long run role compared to positive oil price shocks. While positive oil price shocks account for just 2% and 1% of variances of inflation in the 1^{th} and 12^{th} quarters, respectively, negative oil price shocks explain about 5-8% of inflation fluctuations for the same period. This confirms again the high inflationary pressures of financing budget deficits during negative oil markets. The past innovations in inflation in both positive and negative oil price shocks explain more than 90% of the variance of inflation in the short-run (one quarter after shock). In both scenarios of positive and negative oil price shocks, in the long-run (after 12 quarters from initial shock), the real industrial GDP per capita accounts for much of the variance in inflation (about 20-24%). In both scenarios, real effective exchange rate fluctuations also play a relative important role for inflation variances (about 12% in the long-run).

Table 3
Variance decomposition of *roilp+* and *roilp-*

Quarter	*inf+*	*inf-*	*reex+*	*reex-*	*rgex+*	*rgex-*	*rimp+*	*rimp-*	*roilp+*	*roilp-*	*rgpdi+*	*rgpdi-*
Variance decompositions of *inf*												
1	95.37	91.87	0.00	0.00	2.47	3.03	0.00	0.00	2.10	5.09	0.07	0.01
4	86.67	73.51	1.19	0.87	6.19	8.32	0.78	0.88	1.13	11.84	4.04	4.56
8	55.56	49.43	8.03	7.75	11.44	13.51	1.90	4.22	1.12	7.78	21.95	17.51
12	49.71	44.03	11.61	11.93	10.32	11.70	3.35	4.69	1.01	7.61	23.99	20.04
Variance decompositions of *reex*												
1	1.08	0.17	94.13	81.30	2.93	4.17	0.00	0.00	0.00	10.04	1.87	4.34
4	7.46	3.70	79.47	59.13	4.75	3.98	5.51	7.54	1.80	23.49	1.02	2.17
8	9.07	5.34	73.27	56.12	4.19	3.90	4.60	6.35	5.87	24.53	2.99	3.76
12	8.66	4.87	72.91	56.10	3.89	3.67	4.90	6.05	5.55	24.18	4.09	5.11
Variance decompositions of *rgpdi*												
1	0.00	0.00	0.00	0.00	6.11	4.13	0.00	0.00	0.92	2.91	92.97	92.96
4	1.43	0.83	7.05	5.16	6.05	5.01	5.85	5.43	8.01	7.32	71.61	76.25
8	1.21	0.66	5.61	3.79	4.45	3.78	3.25	3.21	6.45	7.67	79.24	80.88
12	1.01	0.63	4.92	3.38	3.37	3.09	2.62	2.74	5.76	7.63	82.31	82.52
Variance decompositions of *rimp*												
1	3.80	4.53	1.47	3.53	1.57	2.15	77.32	70.66	0.23	4.99	15.60	14.14
4	2.83	4.21	8.47	5.62	2.38	2.35	60.07	58.07	8.04	6.63	18.02	21.14
8	2.38	3.28	13.79	7.72	2.95	3.34	50.87	45.30	8.86	11.99	21.14	25.90
12	2.05	2.85	14.57	7.87	2.95	3.20	45.08	39.71	9.45	13.73	25.90	32.63
Variance decompositions of *rgex*												
1	0.00	0.00	0.00	0.00	99.79	99.35	0.00	0.00	0.21	0.65	0.00	0.00
4	2.69	2.61	5.82	9.09	78.14	73.11	3.39	6.26	2.04	5.47	7.92	3.45
8	2.38	2.15	10.68	12.31	61.41	58.95	10.55	11.62	2.79	7.66	12.20	7.31
12	2.74	2.78	10.80	12.54	56.55	52.87	10.60	12.23	3.24	6.96	16.06	12.62

Note: The column (+) shows the VDC for positive oil price shocks and the column (-) shows the VDC for negative oil price shocks.

The other important aspect of asymmetric oil shocks can be seen in its effects on real effective exchange rate fluctuation. While positive oil shocks play almost no role on variations in this variable immediately after the initial shock, negative oil shocks have the largest effect in both the short- and long-term. Negative oil price shocks explain for about 10% of fluctuations in the real effective exchange rate for the first quarter after shock, increasing to about 24% in the third year after the shock. This confirms the detrimental role of negative oil price shocks on the real effective exchange rate. When we examine the VDC of real effective exchange rate by including a positive oil price shock, the direct role of oil price shocks transfers to inflation. In fact, in the positive scenario of oil price shocks, the total magnitude of inflation over all periods is doubled compared to the total inflation due to negative shocks.

Again negative oil price shocks are stronger than positive shocks for explaining the variances of real industrial GDP per capita in the short- and long-run. However most of the fluctuations in industrial output per capita are explained by their own past shocks. Negative oil price shocks compared to positive oil shocks have larger explanatory effects for real imports fluctuations. This role increased gradually from 5% in the first quarter after shock to about 14% at the end of period.

The explanation for the majority of real import variances however, after its own innovations, is fluctuations in the real industrial GDP per capita. This demonstrates the close connection between domestic production and foreign trade section as a provider of necessary inputs.

In both scenarios of positive and negative oil markets, real government expenditure variances in the short run can be only explained by its own past innovation. This illustrates the inflexible structure of state expenditures, which is due to the vast role of the state in different aspects of economy. Even in the long run, more than half of the variance in government expenditures is explained by itself. However, once again, the role of negative oil price shocks on the long-run fluctuations of government expenditures are stronger than positive oil price shocks and account for about 7%.

4.3 Robustness tests

Alternative orderings

A debatable point in VAR analyses is the ordering of variables in the system. In order to check the stability of our results, we reestimate IRFs with alternative orderings based on VAR Granger causality tests for asymmetric definitions of oil prices shocks. [14] The impulse responses obtained by innovation in positive oil price growth in alternative ordering *roilp+*, *reex*, *inf*, *rgdpi*, *rimp*, *rgex* is comparable to the responses obtained using the first ordering. The only difference in this latter case is

[14] The results for the IRFs with alternative ordering are reported in figure D.1 and figure D.2 in appendix D.1.

the significance of real government expenditures positive response in the five quarters after initial positive oil price shocks. The magnitude of this response is slightly larger than the one that was obtained in the first ordering. The impulse responses estimated by innovations in negative changes of oil prices in alternative ordering *reex*, *rimp*, *roilp-*, *inf*, *rgdpi* is qualitatively and quantitatively similar to the first ordering. The only exception is the response of real industrial output per capita, which is not significant in the latter ordering.

Alternative oil price definitions

A second debatable point is the proper definition of oil price changes. For our robustness test we use the oil price definition as suggest by Hamilton (1996) (compare equations (3) and (4)). The use of this less volatile oil price shock definition only slightly changes the results. For positive oil price changes, the significance of the responses is similar to the responses obtained by using Mork's (1989) definition. The negative definition of oil price changes, which we have constructed on the basis of Hamilton (1996) formulation of positive changes, leads to different results. The response of inflation to negative changes of oil prices is still positive for two quarters after the shock. However, in this alternative negative oil price shock definition, the negative response of inflation for the period between the 6^{th} and the 12^{th} quarter is statistically significant. Besides that, we have not found significant responses from real effective exchange rate and real import in this case. This is contrary to the expected responses that we observed on the basis of Mork's definition of negative oil price shocks. The results for the alternative definition of oil price shocks are reported in figure D.3 and D.4 in the appendix D.2.

The pre-1989 period

In order to compare the structural differences of the Iranian economy before and after the first Persian Gulf (Iran-Iraq) war, we take the year 1988 (the end of the war) as a breakpoint. It is important to note that estimating the pre-1988 VAR model is challenging due to the lack of quarterly data for industrial GDP, imports, and government expenditures. The quarterly data of mentioned variables are interpolated from annual observations (for details see Karimi (2005)). Because of data quality issues, the interpretation of the pre-1988 results should be carried out with cautious.

We examine the effects of oil price shocks for the period of 1975:II–1988:IV. The symmetric oil price shocks do not show a significantly different pattern of affects on variables compared with the post-1989 period.

Regarding the response of other variables to a one standard deviation shock to positive oil price innovations, we observe some similarities and differences between the two sub-periods. The response of real industrial GDP per capita is positive and reached its maximum, on average, in the 4^{th} quarter after the shock, while this maximum happened in the 3^{rd} quarter during the post-1989 period. The second difference is the magnitude of real output response. The size of the response in the pre-1989 period is smaller than in the post-1989 period. This may indicate increased dependency of industrial production on shocks in global oil markets through fluctuations in imported inputs and intermediaries for the post-1988 period. The qualitative and quantitative responses of real imports are similar in the post- and pre-1988 period. It is positive and significant for the five quarters after shock. The third difference is the response of real government expenditures, which is increasing and statistically significant for the first four quarters after the initial positive oil shock. We did not identify such a positive response for the post-1988 period. Positive oil price shocks demonstrate their inflationary nature for pre-1988 period. This positive response is only significant in the short run. When we use real GDP per capita instead of real industry GDP per capita for the pre-1988 period, the response of this variable to positive oil price shocks is effectively zero.

The full sample

In this section, we estimate the VAR model for the full sample (1975: II–2006: IV). [15] Innovations in positive oil price growth cause significant and positive responses in real effective exchange rates and real imports. The real effective exchange rate reaches its maximum in the 6^{th} quarter after the shock. Contrary to the post-1989 period, during which positive oil price shocks increased real industrial output, the response is not significant for the full sample. The inflation response is only significant in the long run (12 quarters) and negative. Increased real imports may act as a built-in stabilizer in the long run, reducing inflationary pressures. The response of government expenditures to positive oil price shocks is also slightly significant in the long run.

In considering the negative oil price shocks, we observe that in the long run (12 quarters) the trend of decreasing real output reverses and is a significantly positive response by the end of the period. The depreciation of real effective exchange rate might benefit the real output of the economy in the long run by increasing competitiveness of Iranian non-oil products in the global markets.

Another different result for the full sample can be observed in the response of inflation to negative oil price shocks. It is negative and significant in the short- and medium-term, which is also statistically significant. The reduction of real effective exchange rate, while assuming the foreign prices of major trading partners are constant, can

[15] The IRFs for the full sample are reported in figure D.5 and figure D.6 in the appendix D.3.

happen by depreciation of nominal exchange rate or reduction of inflation by implementing concretionary monetary policies. The Iranian government tried to support the over-valued domestic currency for almost the entire duration of the study. The unification of exchange rates that followed a considerable depreciation of the rial against the US dollar in 2002 was a breakpoint. Thus, the remaining channel for decreasing real effective exchange rate can be through the reduction the domestic inflation.

Rolling bivariate VARs

An alternative approach to analyzing possible changes in the macroeconomic effects of oil price shocks over time is the use of rolling bivariate VARs. This approach allows for a gradual change in the estimated effects of oil price shocks, without imposing a discrete break in a single period. [16] The estimation of bivariate IRFs is based on a series of dynamic equations and examines a variable of interest by looking at its own past lags as well as the current and lagged values of oil price changes. We use this approach by applying a moving window of 41 quarters, with the first moving window centered in 1982. After estimating the first IRF we shift the sample period four quarters forward and iterate the VAR estimation. The outcome of this is a series of 22 bivariate IRFs over the full sample. The formulation of the rolling VARs is as follows (for more details see Blanchard and Gali (2007)):

$$y_t = \alpha + \sum_{p=1}^{4} \beta_p y_{t-p} + \sum_{p=0}^{4} \beta_j roilp_{t-p} + \varepsilon_t \tag{8}$$

where y_t is the variable of interest and $roilp_t$ describes the oil price variable in different definitions. In comparison to our multivariable approach in the previous section, the proper identification of oil price shocks is less confident in the bivariate model, given the low dimension specification of the economy's dynamics. The advantage of the bivariate VAR specification is the possibility of using shorter samples and, hence, being able to obtain rolling IRFs (see Blanchard and Gali (2007)).

In the following, we focus on the dynamic rolling responses of real effective exchange rate, inflation, and real industrial GDP per capita to positive and negative oil price shocks. The similar dummy variables in pervious analyses of multivariate VARs are used here too.

Figure 7 displays the rolling IRFs for the real effective exchange rate. The *reex* appears to be much more sensitive to positive oil price shocks in recent years (especially

[16] We would like to thank the referrers for suggesting this point.

in the late 1990s and early 2000s). Real effective exchange rate appreciated two to four quarters after shock by 0.05 percentage point after one positive standard deviation shock to oil prices in the early 2000s. This reflects the higher risk of Dutch disease in recent years for the Iranian economy. Negative oil price shocks also caused domestic currency to fall over the total period under study. However, this negative decrease of domestic currency was much stronger pre-1989 than post-1989.

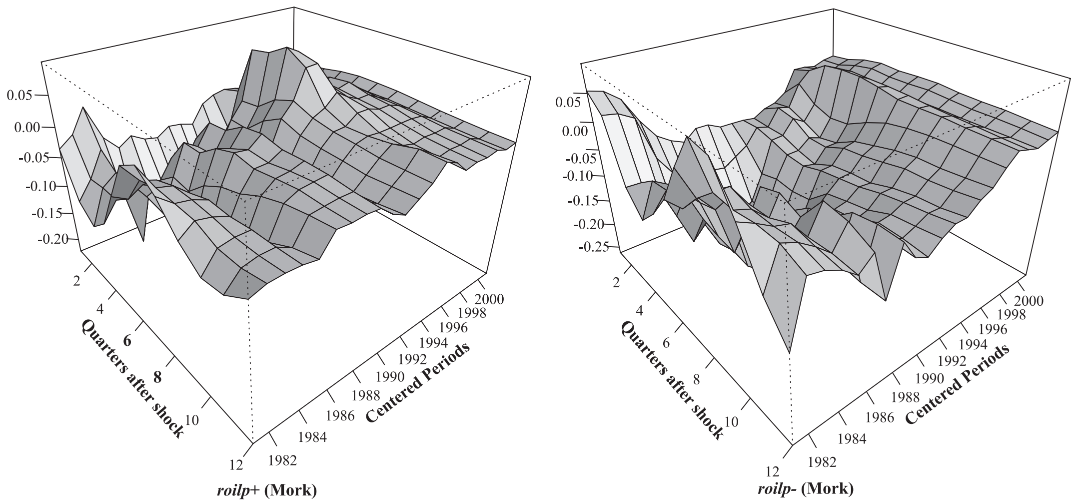

Fig. 7. Bivariate responses of real effective exchange rate

The positive response of real industrial output per capita to positive oil price shocks increased gradually over the total period (see figure 8). This rise is more obvious in recent years. It reached its maximum in the late 1990s. However, the long- run responses of this variable became weaker in recent years.

The negative response of real industrial GDP per capita to negative oil price shocks is stronger in the late 1980s. It seems that before the 1980s, decreasing oil prices by reducing government revenues and increasing the import prices through exchange rates was an extra burden on domestic production, especially during the eight years war with Iraq. In recent years, decreasing oil prices by reducing effective exchange rate and improving terms of trade (through increased non-oil exports) offset, to some extent, the increased import prices of required inputs for industrial production.

Figure 9 shows the rolling responses of the Iranian inflation rate to asymmetric oil price shocks. The response of inflation to positive oil price shocks over the period is positive, at least for the short- and medium-run. This response, however, seems to be stronger in the late 1980s. In particular, in the period centered in 1988, the response of inflation to one standard deviation positive shock to oil prices is three percentage points. The inflationary effects of positive oil price shocks in recent years have become weaker compared to the late 1980s. In recent years, considerable volumes of imports

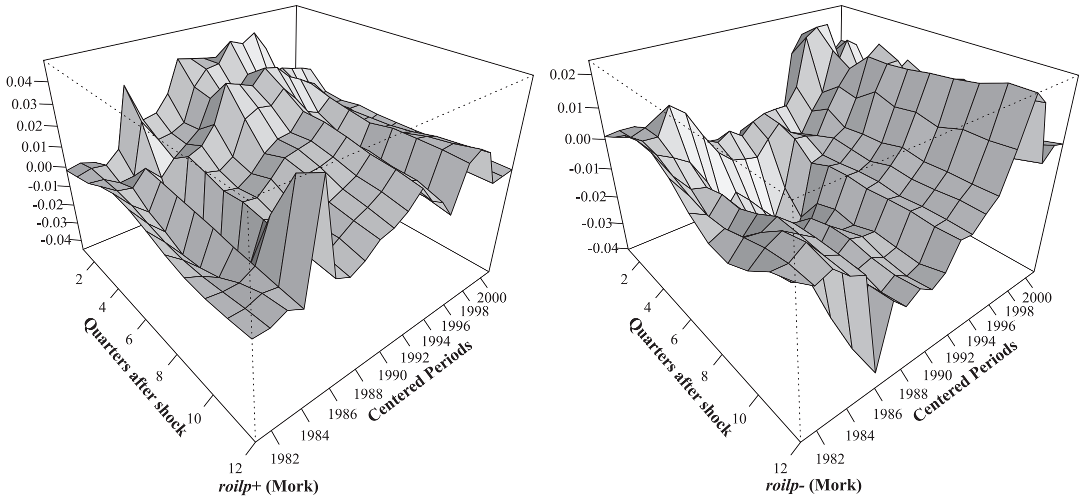

Fig. 8. Bivariate responses of industrial GDP per capita

have had a role as built-in stabilizers for containing the inflationary pressures of petro dollars in the economy. The response of inflation to negative oil price shocks, however, shows us another side of coin. The inflationary effects of reduced oil revenues, and consequently huge budget deficits for which the solution often involves asking the state to cover these deficits, have led to much stronger responses in the recent years than in the late 1970s.

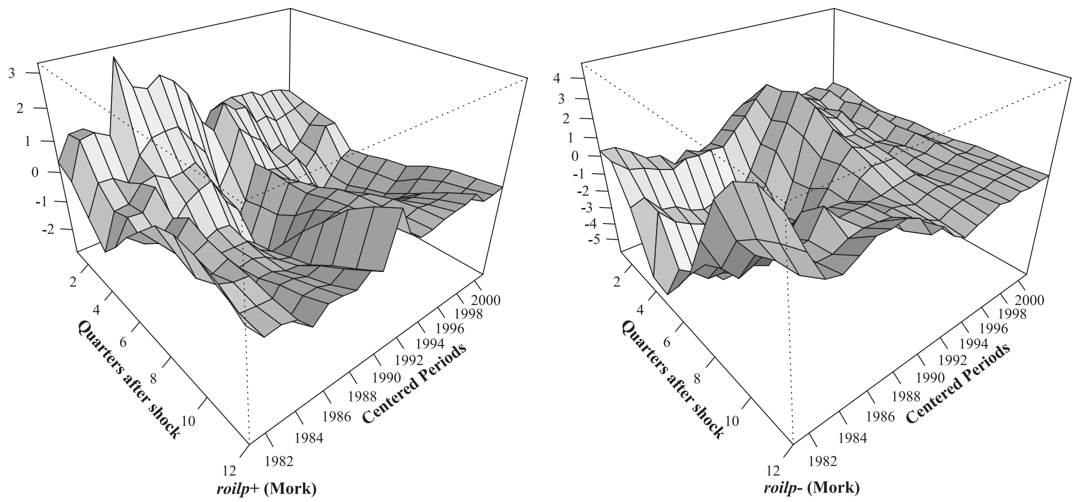

Fig. 9. Bivariate responses of Inflation

5 Conclusions

Much of the research on the *oil–gdp* relationship has concentrated on developed oil importing economies. A formal study on the impact of oil price shocks on macroeconomic variables in an oil exporting country such as Iran is still lacking. One of the main challenges of such studies is the lack of reliable high frequency data on aggregate macroeconomic variables. In this study, we mainly focused on the post Iran-Iraq war period. We also tried to compare the main results from the post-war period with those from the pre-war period, which spanned from 1975 to 1988. Moreover, we estimated rolling bivariate VARs for inflation, output, and real effective exchange rates.

The empirical findings of this study suggest that positive oil price shocks increase the real effective exchange rate and appreciate domestic currency in mid run, which is one of the syndromes of a Dutch disease. This reduces the price of imports and increases the price of exports. Real imports and domestic output per capita increase significantly and we are only able to observe the initial inflationary effects of positive oil shocks. Real government expenditures also only increase in the mid-run and are marginally significant. The effects of the oil stabilization fund for mitigating inflationary effects of a positive shock and protecting the annual state budgets from external shocks should be important.

The Iranian economy is much more vulnerable to the negative shocks of oil prices. The real effective exchange rate falls significantly (domestic currency depreciates) until the end of the period (12 quarters). This is a warning sign of a potential currency crisis after negative price shocks in oil markets. This depreciation increases the price of imports, and despite the traditional approach, which welcomes this event because of improving non-oil exports, our analysis for the case of Iran shows the opposite effects. The real output, which depends heavily on imported raw and intermediary materials, will be forced to downsize. Inflationary effects are much more pronounced during negative shocks. This is mainly because of increased import prices and the mechanism of financing budget deficits in Iran. Government expenditures initially fall significantly but increase beyond the base line after five quarters of initial shock. This demonstrates the sticky structure of government expenditures in Iran. The reduction of government expenditures following negative oil shocks cannot be permanent.

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A Data sources and description

We use quarterly data for the period of 1975:II to 2006:IV. The variables considered in this paper are as follow:

- Real industrial production per capita (*rgdpi*)

The variable measures industrial value added in GDP per capita. This variable is before seasonal adjustment and is at constant prices of 1997. The source of this variable is the online portal of time series at the Central Bank of Iran.

- Real effective exchange rate (*reex*)

This variable is the nominal effective exchange rate index of the Rial adjusted for inflation rate differentials with the countries whose currencies comprise the trade basket. Real effective exchange rate is defined such that an increase means a real appreciation of the currency considered. An appreciation of the real exchange rate is expected to hurt the country's external competitiveness and vice versa for decreasing it. The (*reex*) series has extracted from the IFS online database.

- Inflation (*inf*)

This variable is the yearly changes in the Iranian consumer prices and has been extracted from IMF via Datastream.

- Real public consumption expenditure (*rgex*)

This variable is non-seasonally adjusted of public consumptions of Iran on the base of constant prices of 1997, extracted from the Central Bank of Iran online database.

- Real imports (*rimp*)

This variable is non-seasonally adjusted data of the Iranian imports on the base of constant prices of 1997, extracted from the Central Bank of Iran online database.

- Real oil price (*roilp*)

This variable is the quarterly nominal average of world oil prices deflated by the US consumer price index. The price series is extracted from the IFS online database.

B Coding of the dummy variables $D1$-$D5$

- $D1$–Iranian revolution and the Iraq-Iran war, 1979:I–1988:III

This period cover a military conflict and therefore a strong presence of state in the economy. Nearly all the key markets and price mechanism were administered by the government.

- $D2$–Iraq-Kuwait war, 1990:I-1990:IV

This conflict, known as the first Gulf war, started in 1990 and ended in 1991. The movement of oil prices in 1990/1991 was erratic, with crude price increasing by 160.1% over the war period.

- $D3$–South East Asian financial crisis, 1997:III-1998:IV

The severe economic collapse after mid-1997 greatly reduced growth in energy consumption. Gas demand growth was 2.3%, compared to the pre-crisis rates of more than 5%. The impact on oil demand was even more dramatic –rather than growing by the pre-crisis expectation of 1.0 MMbpd/yr, demand in 1998 declined by 0.5 MMbpd/yr– the first decline since 1985. The powerful negative shock also sharply reduced the price of oil, which reached a low of US$8 per barrel towards the end of 1998, causing a financial shock in OPEC nations, including Iran and other oil exporters.

- $D4$–September 11, 2001:III–2002:II

In the month following the terrorist attacks of September 11, 2001, oil prices declined to a two year low of US$17.50 per barrel due market concerns regarding a possible slowdown in the United States and the global economy. The decision by OPEC to cut crude oil exports and signs of a more robust global recovery contributed to oil price quickly returning to pre-September 11 levels in early 2002.

- $D5$–Iraq-US war, 2003:I–2003:IV

Prices spike on Iraq war due to rapid demand increases, constrained OPEC capacity, low inventories, and so on.

C Stationarity, cointegration, and optimal lag length tests

C.1 Stationarity tests

Table C.1 reports the ADF tests and the Philips-Perron tests for the stationary of each variable, over sample period 1989:I to 2006:IV. We applied models with and without trend. For the log-level series, the ADF test (Dickey and Fuller (1979)) does not reject the null hypothesis of a unit root at 95% confidence level. However, the Phillips-Perron tests (Phillips and Perron (1988)) reject the null hypothesis of a unit root (nonstationary) at the 99% confidence level for the case of *rgex* and *rimp*. After first differencing, each series rejects the null hypothesis of nonstationary at the 99 or 95% levels. Relying on ADF tests, all variables have unit root in levels and are stationary after first differencing. Since all the series are nonstationary at the levels and integrated of the same order, this suggests a possibility of the presence of cointegrating relationship between oil prices and the Iranian economic variables.

C.2 Johansen cointegration tests

The Johansen cointegration test is carried out to test for cointegrating relationships among real oil prices and the five Iranian macroeconomic variables. The exogenous dummy variables are also included. Prior to performing the Johansen cointegration test, variables are entered as levels into a VAR to determine the optimal number of lags needed in the cointegration analysis. Three criterions, the Akaike information

Table C.1
Tests for unit roots (with non seasonal adjusted data)

	ADF				PP			
	without trend		with trend		without trend		with trend	
variables	level	first diff.	level	first diff.	level	first diff.	level	first diff.
$rgdpi$	-0.66	-4.60***	-3.00	-5.14***	$-.91$	-15.4***	-2.07	-16.0***
$rgdp$	$-2,85$*	-4.01***	-2.18	-5.38***	-3.06**	-15.2***	-3.03	-16.93***
$reex$	-1.33	-10.7***	-2.01	-10.6***	-1.36	-10.7***	-2.04	-10.6***
inf	-3.05**	-7.30***	-3.05	-7.26***	-3.18**	-7.52***	-3.17*	-7.49***
$rgex$	-1.04	-17.1***	-0.36	-17.5***	-6.91***	-36.8***	-7.13***	-39.5***
$rgexs$	-0.58	-6.58***	-3.71**	-6.59***	-6.16***	-26.6***	-9.39***	-26.4***
$rimp$	-2.01	-13.0***	-1.60	-13.2***	-3.76***	-21.7***	-3.76**	-21.8***
$roilp$	-8.99***	-9.03***	-8.98***	-8.98***	-8.99***	-27.6***	-9.02***	-27.4***
$roilp^{+}$	-7.94***	-8.73***	-7.95***	-8.69***	-7.86***	-50.9***	-7.86***	-50.3***
$roilp^{-}$	-9.81***	-15.2***	-9.76***	-15.2***	-9.82***	-29.6***	-9.78***	-29.4***

Notes: Sample is 1975:II-2006:IV for the variables in levels, and starts one quarter later for variables in first differences. We use the Schwarz Info Criterion for lag length selection. The maximal allowed number of lags was 12. We denote with */**/*** the rejection of the null hypothesis of an unit root at a 10/5/1 percent significance level.

criterion (AIC), Final Prediction Error (FPE) and the likelihood ratio (LR) test are applied to determine the optimal lag length.

Table C.2
Cointegrating 1

Data Trend	None	None	Linear	Linear	Quadratic
Test type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	3	3	2	2	3
Maximum eigenvalue	2	2	2	2	3

Notes: Selected number of cointegrating vectors (*roilp+*, (Mork), 1989:I–2006:IV, number of lags: 4, exogenous variables: *Q1*, *Q2*, *Q3*, *D2*, *D3*, *D4*, *D5*)

Table C.3
Cointegrating 2

Data Trend	None	None	Linear	Linear	Quadratic
Test type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	3	4	4	5	4
Maximum eigenvalue	3	3	3	3	3

Notes: Selected number of cointegrating vectors (*roilp-*, (Mork), 1989:I–2006:IV, number of lags: 4, exogenous variables: *Q1*, *Q2*, *Q3*, *D2*, *D3*, *D4*, *D5*)

C.3 Optimal lag length

Table C.4 and C.5 reports the results for the optimal lag length test.

Table C.4
VAR Lag order selection criteria, *roilp+*

Lag	LogL	LR	FPE	AIC
0	-132.66	NA	6.12e-06	5.02
1	127.95	419.88	1.22e-08	-1.22
2	172.50	64.35	1.03e-08	-1.46
3	222.21	63.51	7.86e-09	-1.84
4	276.32	60.12*	5.78e-09*	-2.34*

* indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion

Table C.5
VAR Lag order selection criteria, *roilp-*

Lag	LogL	LR	FPE	AIC
0	-132.57	NA	6.11e-06	5.02
1	129.39	422.05	1.18e-08	-1.26
2	180.77.41	74.21	8.15e-09	-1.69
3	236.51	71.22	5.28e-09	-2.24
4	296.99	67.20*	3.25e-09*	-2.92*

* indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion

D Robustness tests

D.1 Alternative VAR orderings

Fig. D.1. IRF *roilp+*, alternative ordering

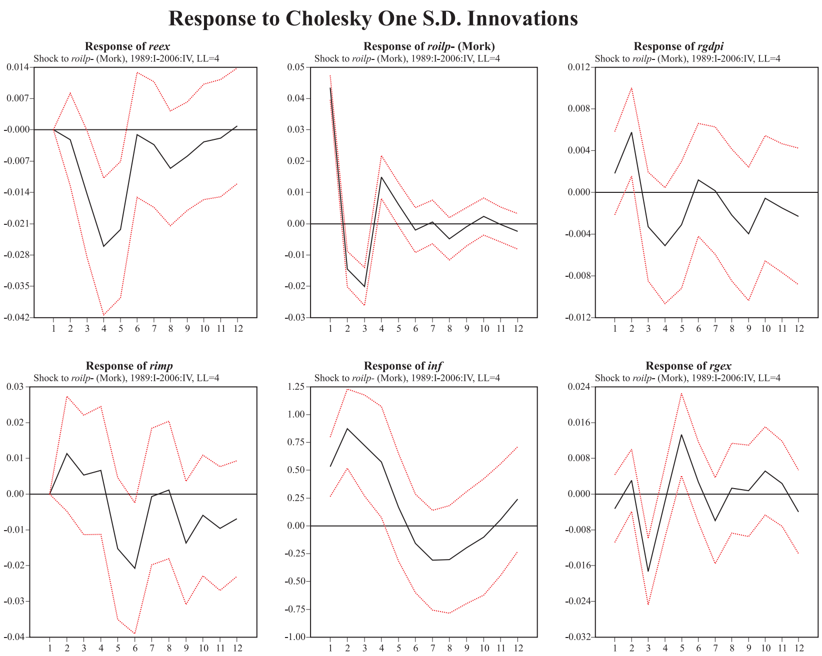

Fig. D.2. IRF *roilp-*, alternative ordering

D.2 Hamilton's oil prices

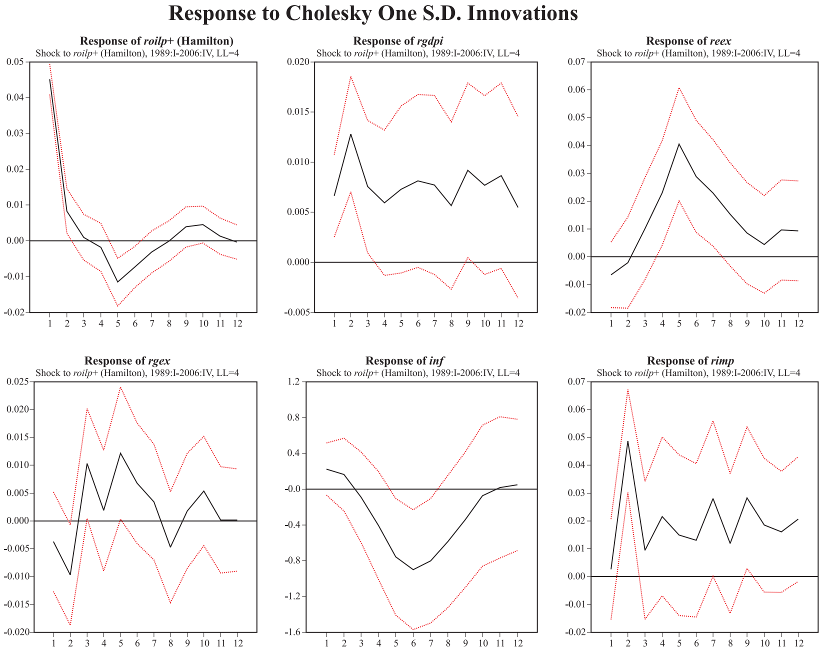

Fig. D.3. IRF *roilp+*, in Hamiltons definition

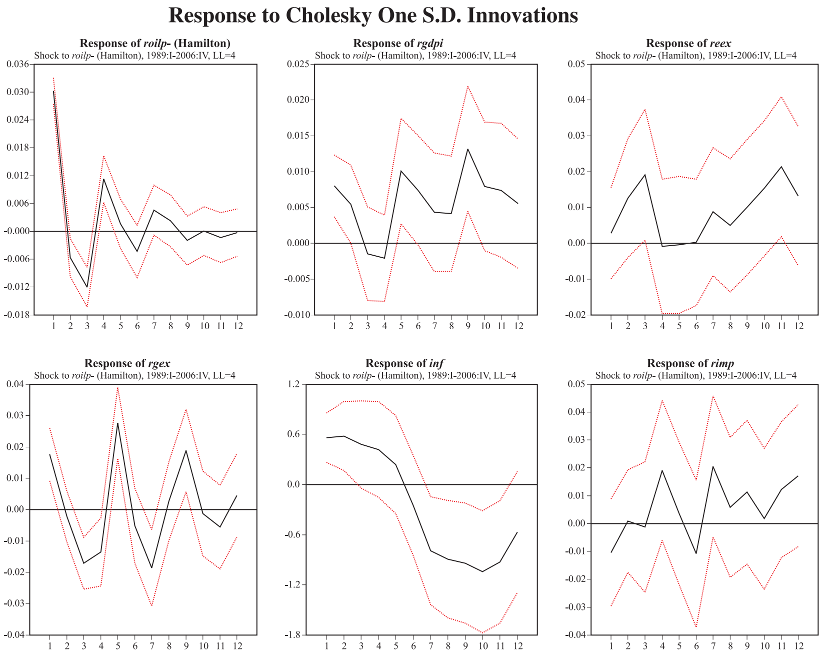

Fig. D.4. IRF *roilp-*, in Hamiltons definition

D.3 The full sample

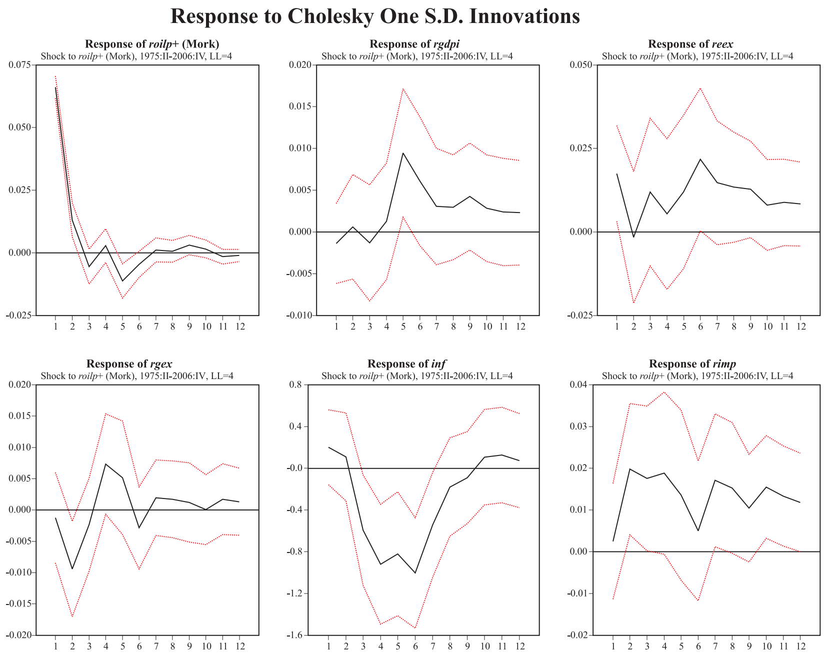

Fig. D.5. IRF *roilp+*, full sample

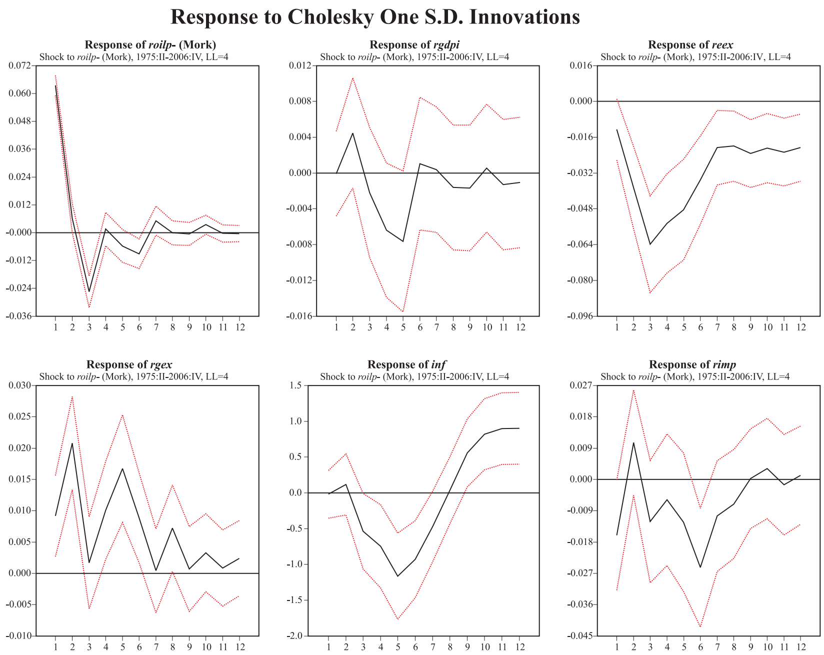

Fig. D.6. IRF *roilp-*, full sample

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