The Effects of Oil Price Shocks on the Iranian Economy

Mohammad Reza Farzanegan[a], Gunther Markwardt[b,*]

[a]*Faculty of Business and Economics, Dresden University of Technology, D-01062 Dresden, Germany*

[b]*Faculty of Business and Economics, Dresden University of Technology, D-01062 Dresden, Germany*

Abstract

Due to the high dependence on oil revenues, oil price fluctuations have a special impact on the Iranian economy. By applying a VAR approach, this paper analyzes the dynamic relationship between asymmetric oil price shocks and major macroeconomic variables in Iran. Contrary to previous empirical findings for oil net importing developed countries, oil price increases (decreases) have a significant positive (negative) impact on industrial output. Unexpectedly, we can not identify an significant impact of oil price fluctuation on real government expenditures. The response of real imports and the real effective exchange rate to asymmetric oil price shocks are significant. Furthermore, the response of inflation to any kind of oil price shocks is significant and positive.

Key words: macroeconomic fluctuations; oil price shocks; developing economies, Iran
JEL classification: E32; E37; Q32

* Corresponding author.
Email address: gunther.markwardt@tu-dresden.de (Gunther Markwardt).

[1] The authors are grateful for useful comments from Peren Arin, Marcus Dittrich, Christian Lessmann, Annabel Payne and Marcel Thum. We also thank the participants of the 11^{th} IIES International Oil and Gas Forum in Tehran and would like to acknowledge the German Academic Exchange Service (DAAD) for financial support. The usual disclaimer applies.

27 August 2007

1 Introduction

Oil and gas incomes have an strategic role in the structure of the Iranian economy. Holding 11 percent of the world's oil reserves and being the second largest producer 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 80-90 percent of total export earnings and 40-50 percent of the government annual budgets. Figure 1 shows the share of resource rents in the total state budget (Tadbir Eghtesad Research Institute (2003)). The sale of oil amounts to about 20 percent of the GDP of Iran. In this situation any shock to global oil markets can have a tremendous effect on

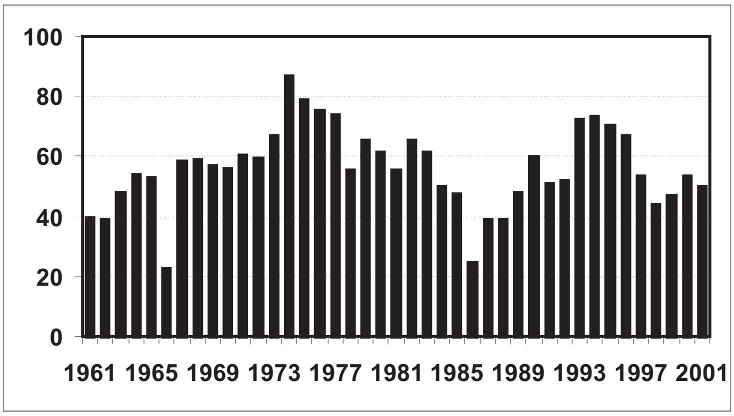

Fig. 1. Share of resource rents in total state income

the structure of the economy. The unique role of oil revenues in the structure of government budgets and social security programs distinguishes the Iranian Economy from other economies. 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. The main source of financing subsidies is oil revenues which are directly under the control of the government. Thus it appears that oil price changes highly influence the welfare and subsidisation programs of the state. Subsidies on gasoline and other essential products are one of these welfare programs. In recent years, the average share of subsidies in annual state budgets reaches about 10 per cent. Figure 2 shows the share of subsidies in the annual budgets of Iran since 1973. During the period 1990-2001, the average of total subsidies per year amounted to 9.5 billion dollars of which electricity, gas oil and gasoline with the annual average of 2.3, 2.4 and 1.7 billion dollars are the most important items in the energy subsidy basket. Meanwhile, the share of subsidies on energy products in GDP has increased from about 5.5 percent to about 9.0 percent in 2001 (Shirkavand (2004)).

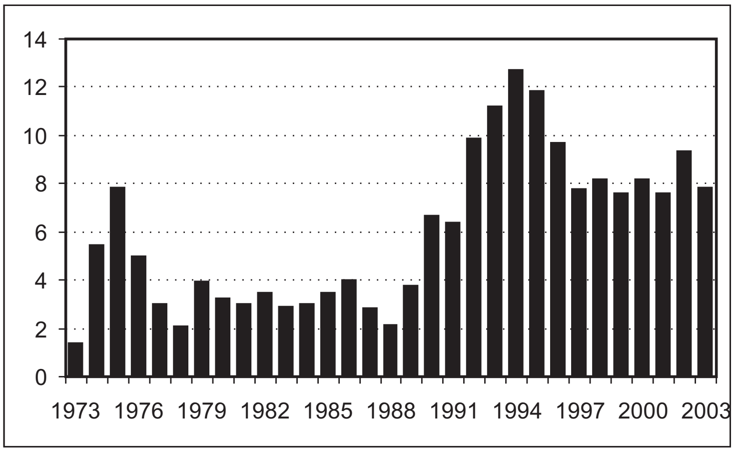

Fig. 2. Share of subsidies in Iran state budget

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 exchange rate during oil booms, leading to a contraction of the tradable sector. This phenomenon is known as "Dutch Disease" [2] (Corden and Neary (1982), Corden (1984) and van Wijnbergen (1984)). This effect, combined with the proposition that tradable sectors (usually manufacturing) are superior because of learning-by-doing and other positive externalities, leads to the conclusion that natural resource ownership exerts a drag on long run growth. State as a sole receiver of petro-dollars in Iran is in itself the largest supplier and demander of foreign exchange in the market. This situation enables the government to control the official exchange rate. This artificial control of exchange market created the considerable gap between the official exchange rate (subsidized rates) and market rates, providing another channel of rent-seeking and unproductive activities in this section of the economy (Figure 3 (Shirkavand (2004)).

This paper is one of the rare studies of a developing net oil exporting economy with a high dependence on oil revenues. Given the degree of dependence on oil as illustrated by figures, a comprehensive analysis which considers the main transmission channels of oil price shocks on the Iranian economy is vital. The effects of oil price shocks have been analyzed in three different channels: the supply side, the demand side, and the terms of trade.

[2] The 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 prudent rulers, thus making learning more difficult, not only between countries but also within them.

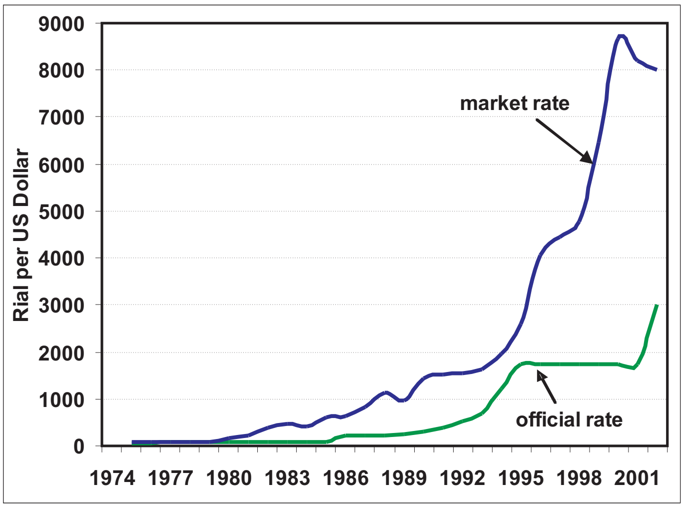

Fig. 3. Average market and average official exchange rate

Our results on the supply side of economy reveal that positive oil price shocks stimulate the Iranian industrial production and real imports. On the other hand, the negative shocks on oil prices undermine the process of real industrial production and play a significant role in lowering the real level of imports. 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. The third main result of our paper is in the area of terms of trade. The proxy indicator for this channel is the real effective exchange rate. The response of this variable to positive shocks is positive and increasing in the short and mid term. At the same time, negative shocks cause negative significant responses in the real effective exchange rate, leading to a more favorable situation in terms of trade and the 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 analysis to illustrate the contribution of oil price shocks in explaining the fluctuations of major macroeconomic variables in Iran. Studying the effects of non-linear changes in real oil prices can be one step forward to evaluating and understanding the Achilles' heel of the Iranian economy and to filling the existing gap in 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, data and the VAR methodology will be discussed. In section four, econometric analysis and results 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, particular studies on net oil exporters have so far been very rare. In an international context, oil price shocks may have a different impact depending on countries' sectoral compositions, their institutional structures and their economic development. [3] 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 a consensus. In the following, 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. One of the pioneer works on oil price effects was carried out by Hamilton (1983) who focused on the US economy. He finds that oil price shocks (in a linear definition) were an important factor in almost all US recessions over 1949-1973. Hamilton concludes that changes in oil prices Granger-caused changes in unemployment and GNP in the US economy.

By using VAR models for Canada, Germany, Japan, the United Kingdom and the United States, Burbidge and Harrison (1984) show that oil price shocks have a significant negative impact on industrial production. However, they conclude that oil price changes have different impacts on the macroeconomy before 1973 than after. Similar results are produced by Gisser and Goodwin (1986) for the US.

Following Hamilton (1983), Mork (1989) proposed an asymmetric definition of oil prices and distinguished between positive and negative oil price changes. He defined oil price changes as follows: [4]

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

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

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

[4] Mork does not use the real oil prices in absolute terms, instead of this he used several producer price indices for crude oil. Fore a more detail description see Mork (1989), p.741.

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. Mork (1994) argued that this happened because of the important role of oil as a means of production. Changes in its prices lead to the reallocation of resources in the economy. This reallocation of resources may lead to slower GDP growth.

Again in the case of the US economy, Lee, Ni and Raati (1995) studied oil price shocks and real US GNP growth over the period 1949-1992. They point to the volatile nature of oil prices since the big decline in 1986 and conclude that Morks'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 generalized autoregressive conditional heteroscedasticity (GARCH) model in order to extract conditional variance from real oil price changes. They concluded that the 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) show that uncertainty about oil prices has a negative and significant effect on industrial production.

Hooker (1996) criticized Hamilton (1983), in finding evidence that oil prices do not seem to be more endogenous to the US macroeconomy. He pointed out that oil prices (in linear as well as non-linear specifications) do not Granger-cause most macroeconomic indicators in quarterly data from 1973 up to 1994.

In response to Hooker (1996), Hamilton (1996) suggested another form of non-linear transformation of real oil prices. Hamilton states that most of the oil price increases are simply corrections of earlier declines. He argues 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 proposes 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.

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

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

In his study, net nominal oil price increases are significant in explaining growth in the US real GDP.

Hamilton (2003) returned to the issue of the linear versus non-linear relationship between oil price changes and GNP growth. He asserts that "Oil price increases are much more important than oil price decreases, and increases have significantly less predictive content if they simply correct earlier decreases" (Hamilton (2003), p. 363).

Recently, Jimenez-Rodrguez and Sanchez (2004) 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 linear and non-linear models. Jimenez-Rodrigez and Sanchez conclude that oil price increases have a larger impact on GDP growth than oil price declines. They emphasize 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.

2.2 Developing economies

Despite the main focus of research being on net oil importers and developed economies, recently some limited studies have been done on the effects of oil price changes on the macroeconomy of developing economies. In this literature in particular, net oil exporting countries are in the center of interest.

Eltony and Al-Awadi (2001) find evidence that linear oil price shocks are important in explaining fluctuations in macroeconomic variables in Kuwait. Their results show the importance of oil price shocks in 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 linear transformation of oil prices show that an oil price shock leads to a prolonged reduction in the real GDP of the Philippines. Conversely, in the non-linear 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 1950-2001. They investigated the relationship between oil prices, governmental revenues, government consumption spending, GDP and investment by employing a general to specific modelling (VAR and VECM). They found two long run relations consistent with economic growth and fiscal balance and that this relationship is important not only for the long run performance but also for short term fluctuations.

Berument and Ceylan (2005) examined how oil price shocks affect the output growth of selected Middle East and North African countries that are either exporters or net importers of oil commodities. In this respect, they used a structural vectorautoregressive (SVAR) model, focusing explicitly on world oil prices and the real GDP over the period of 1960-2003. Their impulse response analysis suggests that the effects of the world oil price on GDP of Algeria, Iran, Iraq, Jordan, Kuwait, Oman, Qatar, Syria, Tunisia and UAE are positive and statistically significant. However, for Bahrain, Egypt, Lebanon, Morocco and Yemen they did not find a significant impact on oil price shocks.

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 find that oil price shocks do not have any substantial effect on output and inflation. Oil price shocks only significantly determine the real exchange rate and in the long run money supply. Olomola and Adejumo conclude that this may squeeze the tradable sector, giving rise to the "Dutch Disease".

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*) and inflation (*inf*) and data on real oil prices (*roilp*). The sample comprised quarterly observations for the 1988:I–2004:IV period. [5] Furthermore, in order to take the effects of Iraq-Kuwait war in 1990, the financial crisis of South East Asia in 1998, the terrorist attacks to USA in 2001 and Iraq war in 2003 into account, we have employed a dummy variable (*war*). [6] All in all a mixture

[5] The definition of the variables and the data sources are presented in the Appendix A.
[6] The dummy variable *war* is defined as one in the period 1990:I-1990:IV, 1998:I-1998:IV, 2001:III-2002:III, 2003:I-2003:IV and zero else. For a more details on the dummy variable

of financial and fundamental macroeconomic variables will show a bigger picture of the role of oil price shocks in Iran.

The proper definition of applicable oil prices is a challenging task. We use oil prices in real terms, taking the ratio of the nominal oil price in US dollars to the US Consumer Price Index (see Jimenez-Rodrguez and Sanchez (2004)). In our analysis we make use of Mork's non-linear definition of oil prices. In this specification we distinguish between the positive rate of quarterly changes ($\triangle roilp^{+}$) and its negative rate of quarterly changes ($\triangle roilp^{-}$).[7] All oil price transformations are used both for the real price of Iran light oil as well for the real price of Iran heavy oil.

3.2 Empirical Methodology

To investigate the response of macroeconomic variables to positive and negative 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 the structural relationships. Because the VAR expresses the dependent variables in terms of only predetermined lagged variables, the VAR model is a reduced form model. Once the VAR has been estimated, the relative importance of an individual market in generating variations in its own value and in the value of other markets can be assessed (Forecast Error Variance Decomposition (VDC)). In fact, VDC assesses the relative importance of oil price shocks in the volatility of other variables in the system. The dynamic response of the markets or macroeconomic variables to innovations in a particular variable or market (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 macroeconomic activity, inflation and prices. Our unrestricted vector autoregressive model in reduced form of order p is presented in equation 5:

$$y_t = c + \sum_{i=1}^{p} A_i y_{t-i} + \varepsilon_t \tag{5}$$

where $c = (c_1, ..., c_6)'$ is the (6×1) intercept vector of the VAR, A_i is the i^{th} (6×6)

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war refer to B

[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.

matrix of autoregressive coefficients for $i = 1, 2, ..., p$, and $\varepsilon_t = (\varepsilon_{1,t}, ..., \varepsilon_{6,t})'$ is the (6×1) generalization of a white noise process.

The vector autoregressive model is estimated in levels of the variables in natural logarithms (except inflation). As described in the data section, we use six endogenous macroeconomic variables in our system: *roilp*, *rgex*, *rgdpi*, *inf*, *reex*, and *rimp*. The form of unrestricted VAR system in this study is thus given by:

$$\begin{bmatrix} roilp \\ rgex \\ rgdp_i \\ inf \\ reex \\ rimp \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \\ c_6 \end{bmatrix} + A(l) \begin{bmatrix} roilp_{t-1} \\ rgex_{t-1} \\ rgdpi_{t-1} \\ inf_{t-1} \\ reex_{t-1} \\ rimp_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix} \tag{6}$$

where $A(l)$ is the lag polynomial operators, the error vectors are assumed to be mean zero, contemporaneously correlated, but not autocorrelated.

The unrestricted VAR system can be transformed into a moving average representation in order to analyze the system's response to a shock on real oil prices, which is:

$$y_t = \mu + \sum_{i=0}^{\infty} \Psi_i \varepsilon_{t-i} \tag{7}$$

with Ψ_0 is the identity matrix and μ is the mean of process:

$$\mu = (I_p - \sum_{i=1}^{p} A_i)^{-1} c. \tag{8}$$

The application of moving average representation is to obtain the forecast error variance decomposition (VDC) and the impulse response functions (IRF). In our study, 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 per-specified ordering has an immediate impact on all markets and variables in the system, excluding the first variable and so on. In fact, pre-specified ordering of markets and variables is important and can change the dynamics of a VAR system. In this analysis, we have used two different orderings. The first one is as follows: *roilp*, *rgex*, *rgdpi*, *inf*, *reex* and *rimp*. For robustness test we make use of an alternative ordering which is based on VAR Granger Causality test is as follow: *roilp*, *reex*, *inf*, *rgex*, *rimp*, and *rgdpi*.[8]

The alternative approach related to studies of the macroeconomics of oil price shocks is applying structural vector autoregressive models (SVAR). Essentially, the SVAR attempts to identify the variance decomposition and impulse response functions by imposing a priori restrictions on the covariance matrix of the structural errors and the contemporaneous and/or long-run impulse responses themselves. But the SVAR approach has also some drawbacks, one of them is validity of this a priori restrictions. In the case of linkages between macroeconomic variables in the system, it would be very difficult to impose a priori assumptions. In order to overcome the problems of the dependence of the orthogonalised impulse responses on the ordering of the variables in the VAR and the SVAR approach, the generalised VAR was developed by Pesaran and Shin (1998). This approach is invariant to the ordering of the variables in the VAR and therefore results in one unique solution. In this paper, we have also employed Generalized VAR models; however, we did not find special changes in our results obtained by applying unrestricted VAR models with Cholesky ordering.

One other debatable point concerns the context of using a VAR model in levels or in first differences. Obviously, if all used variables follow a I(0) process, this discussion is unnecessary. However, as the most time-series variables have the problem of non-stationarity, the question of whether to difference or not 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 worthy 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 routinely 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

[8] The results of Granger-Causality tests are available upon request.

series are stationary, as in a cointegrated VAR. According to Hamilton (1994), in such circumstances a VAR in differenced form is misspecified. The case of losing useful information by differencing, while there are cointegration vectors in the system argued by Sims (1980) and Doan (1992), too.

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 known to perform poorly relative to 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), the other researchers like Engle and Yoo (1987), Clements and Hendry (1995), and Hoffman and Rasche (1996) show 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 [9] considered

[9] Johansen (1991) suggests the need to test the joint hypothesis of both the rank order and the deterministic components, based on the so-called Pantula principle. That is, all models are estimated and the results are presented from the most restrictive alternative (i.e., $r = 0$ and model 1) through to the least restrictive alternative (i.e., $r = n - 1$ and model 4). The test procedure is then to move through from the most restrictive model and at each stage to compare the trace (or max eigenvalue) test statistic to its critical value and only stop the first time the null hypothesis is not rejected.

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 percent level, are summarized in table C.2 in the Appendix C. There is evidence of a minimum of five and a maximum of six cointegrating relations among the six mentioned variables. Thus, they exhibit long-run stability.

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] Following the results of IRFs and VDC analyses for asymmetric formations of real oil prices within the Iranian macroeconomy are presented.

4 Empirical results

4.1 Impulse Response Functions

To identify orthogonalised innovations in each of the variables and the dynamic responses to such innovations, variance-covariance matrix of the VAR was factorized using the Choleski 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 variable that comes first 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) impulse response functions without standard error bands is like to report regression coefficients without t-statistics. As an indication of significance, we have estimated 68% confidence intervals for the IRF's. These confidence bands are obtained from 1.000 draw Monte Carlo simulations. The middle lines in the figures represent the impulse response function while the bands stand for the confidence intervals. In this regard, when the horizontal line falls into the confidence interval, then the null hypothesis that there is no effect of oil price shocks on other macroeconomic variables cannot be rejected. Thus, including the horizon-

[10] For details see table C.3 and table C.4 in Appendix C.

tal line for the particular time period obtained in this manner is interpreted as the evidence of statistical insignificance (Berument and Ceylan (2005)). To investigate the response of Iranian macroeconomic variables, namely inflation (*inf*), real governmental expenditures (*rgex*), real effective exchange rate (*reex*), real imports (*rimp*) and the real industrial output per capita (*rgdpi*) asymmetric specifications ($\triangle roilp^{+}$, $\triangle roilp^{-}$, for light and heavy oil) as shock variables have been utilized. Additionally we include a dummy variable (*war*) to capture exogenous shocks.

Figure 4 shows IRFs base on one standard deviation shock to positive changes in light oil price. The response of industrial output per capita (*rgdpi*) 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 5 quarters after shock. Real light oil price increases initially reduce the real effective exchange rate (*reex*) till three quarters, but after that we observe a positive response and increasing trend of this variable. This could be a sign of the "Dutch Disease" in the long run after a shock to positive changes in oil price, implying the reduction of competitiveness in the tradable sector of the Iranian economy. The response of this variable, however, is not significant. Inflation (*inf*) response to innovations in light oil prices is significantly positive. This response is significant above its initial level in the first 3 quarters. In the long-run inflation experiences a decrease to its initial level, though this decrease does not remain significant in the long-run. This shows the short-run inflationary effects of increasing oil prices on the Iranian economy as a main exporter of these products in the world. This response can be defined within the "resource movement" and "spending effects" explained by Corden (1984). The resource movement only happens when the production factors like labor have the highest mobility between oil and non-oil sectors. In that case, increasing oil prices and booming oil industry absorb labor from the other sections of the economy which is well-known as "resource movement". However, considering the different level of labor qualifications between oil and non-oil industries and high capital intensity of oil industries, "resource movement" can not be a case in Iran. The alternative scenario of "spending effect" may define the response of inflation in our study. The "spending effect" happens because higher oil prices lead to higher wages or profits in the oil related sectors, thus increasing aggregate effective power of purchase and demand in the economy. While the price of tradeable sections (oil and manufacturing) may assume exogenous and determined in international markets, the price of non-tradeable sections like services determine within the domestic market. Some part of increased demand shift to non-tradeable section, causing the push-demand inflation in this section. In this case, we have assumed the immobility between tradeable and non-tradeable sections. Therefore, we will not face a transfer of workers toward booming service section from oil and manufacturing section.

That is, while the price of services increases, the supply of services remains constant. However, if we assume the mobility of labor forces in the economy, booming non-tradable section absorb workforces from oil industry and manufacturing sections, leading to increase in wages in tradable section, too. Since tradable section gets the prices from outside of the domestic market, their profit margin will reduce and they force to downsize their operations. This phenomenon described by Corden (1984) as "indirect de-industrialization". Real import (*rimp*) response to a shock on positive changes in real light oil prices is positive and lasting till the end of period. The increasing response of real import for the first 5 quarters is significantly different from zero. The similar significant response can be observed for this variable over 6-7 and 9 quarters.

Finally, the response of real government expenditure (*rgex*) to a one standard shock to positive oil price changes is not significantly different from zero. At a first glance, it might seem against the initial expectation. However, the Iranian authority 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 than spending for current expenditures, has therefore probably an effective mechanism for oil wealth management. The establishment of oil fund may have contributed to the response of real effective exchange rate to positive oil price shocks. The response of real effective exchange rate till mid-term is increasing but not significant. This is against the a priori expectation of facing "Dutch Disease" in the case of positive oil price shocks. In fact, financial discipline originated of establishment of oil stabilization fund in Iran and controlling government consumption has partly absorbed the unexpected oil revenue increases and possible appreciation in effective exchange rate.

In Figure 5, we demonstrate the responses of variables to negative changes in real light oil prices. The main difference in comparison with the former case can be seen in the responses of the real effective exchange rate (*reex*), industrial output per capita (*rgdpi*) and real import (*rimp*). The response of the real effective exchange rate to a decreasing real light oil price is negative, reaching to its minimum level in the 5^{th} quarter after the shock. This negative response remains significant different from zero for the first 10 quarters. The reduction in *reex* demonstrates an increase in competitiveness in non-oil export sections and implying implementation of the export-friendly policies by government in the case of the dropping of crude oil prices. The response of industrial output to a shock in negative changes of real light oil price is negative and permanent, implying the high sensitivity of industry structure to changes in oil prices and dependency of this section to petro-dollars. This response is statistically significant over 1-3, 5-7, and 9-11 quarters. As we expected, the response of imports to a shock in negative oil price changes is also

Fig. 4. IRF $\triangle roilp^{+}$ (light oil)

negative and lasting till the end of period. This negative response is instantly significant and reaches to its minimum level in the 5^{th} quarter after the initial shock. The response of real imports between the 4^{th} and 10^{th} quarters is significant different from zero. 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 reached its maximum in the 4^{th} quarter and gradually decrease over the period of forecasting. However, it remains significantly above the base line for the first 7 quarters. In a country like Iran which is highly dependent on oil revenues, consumption patterns of consumers are accompanied by higher oil prices. They cannot adjust their consumption level instantly to negative changes in oil price. Therefore, extra demand and shortage of supply that is obvious in response to industrial output push the price level upward. Another reason for increasing in inflation during negative changes of oil price in Iran can be found in increasing government budget deficit effects. In order to cover its budget deficit, the government may increase money supply or issuing governmental bonds. All in all, these policies can lead to a stagflation situation in the economy which is highly dependent on oil dollars.

The results of responses of variables using real heavy oil prices and alternative orderings are almost identical (in a qualitative as well as quantitative respect) to

Response to Cholesky One S.D. Innovations

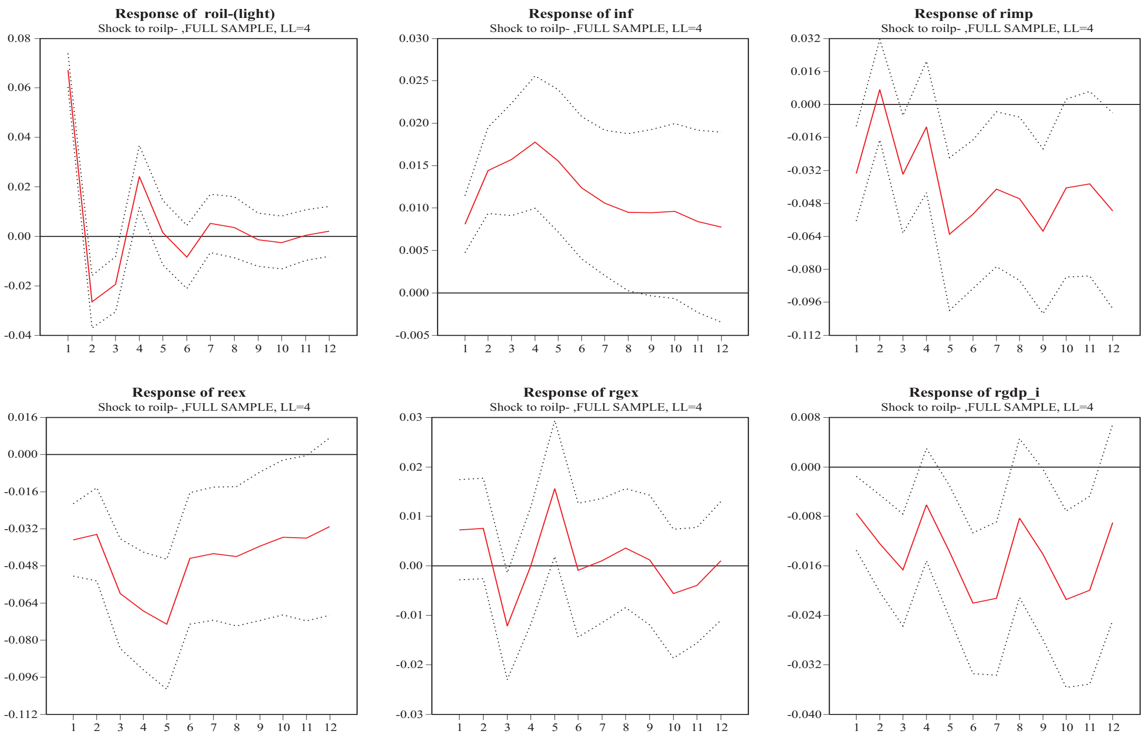

Fig. 5. IRF $\triangle roilp^{-}$ (light oil)

impacts of positive and negative shocks of real light oil price. [11]

4.2 Variance decomposition analysis

The impulse response functions illustrate the qualitative response of the variables in the system to shocks to real oil prices. To indicate the relative importance of these shocks requires a variance decomposition. It shows us how many unforeseen changes or variations of the variables in the model are explained by different shocks. In order to achieve this, consider the n-step ahead forecast of a variable based on information at time t. Similar to impulse response function, here we apply two sets of variance decompositions for positive and negative formations of oil prices.

Tables 1 and 2 demonstrate the variance decomposition of the VAR model. Both oil price increases and decreases affect the volatility of the other variables in the model to varying degrees. For inflation (inf), positive oil price shocks initially account for about 13 percent of its variation, decreasing to a share of 6 percent in the four years after shock, while the negative oil price shocks account for about 26 percent

[11] The results are presented in Appendix D.

of changes in inflation in the long run. However, the instant (first quarter) impacts of negative oil shocks are a little lesser than the impact of positive shocks. Also, the other important aspect of the nonlinear oil shock can be seen in the effects on real effective exchange (*reex*) rate fluctuation. While the positive oil shocks play a marginal role on variations in this variable, the negative oil shocks have a largest share both in the short and long term. The negative oil price change explains for about 11 percent of fluctuations in the real effective exchange rate in the first quarter after shock, increasing to about 39 percent in the third year after the shock. This confirms the detrimental role of negative oil price shocks on changes in real effective exchange rate in the Iranian economy. Despite the larger share of positive oil price shocks on the variations of industrial output (*rgdpi*) in the first quarter (about 8 percent), this share of impacts remains marginal till the end of the period (about 11 percent). However, the negative oil price shocks increase their share from about 3 percent in the first quarter to nearly 22 percent in the 12 quarter after shocks. This fact also shows us the important role of negative oil price shocks in the long term on variations of output in the industry of Iran. The effects of positive oil price shocks in the short term variation of real imports (*rimp*) is larger than negative oil shocks but in the longer period the negative shocks play a greater role. However, in both specifications of oil prices, we cannot ignore the important role of real effective exchange rates in explaining variations of real imports. The both positive and negative oil price shocks, however, have a marginal share on the fluctuation of real government expenditures (*rgex*). Of course the size of negative oil shocks still has a greater but limited share (about 5 percent). For this variable, the effective exchange rate has the largest effects, especially during a longer period (about 20 percent in the negative specification of oil price and 17 percent in positive definitions of oil shocks).

5 Conclusions

This paper investigates the dynamic response of the Iranian industry output, inflation, real effective change, real government expenditures and real import to asymmetric specifications of real light and heavy crude oil prices innovations, using unrestricted VAR models for the period 1988-2004. Impulse response functions and variance decomposition are obtained from each set of model specifications to evaluate how oil price shocks move through major channels of the Iranian economy and how much such shocks contribute to the fluctuations of the variables in the model.

Impulse response functions indicate that a one standard innovation in real oil price positive changes have a significant and positive impact on inflation, industry output

Table 1
Variance decomposition $\triangle roilp^{+}$ (light oil)

Quarter	*inf*	*reex*	$rgpd_i$	*rgex*	*rimp*	$\triangle roilp^{+}$
Variance decompositions of *rgex*						
1	0.00	0.00	0.00	99.96	0.00	0.04
4	2.90	11.85	0.83	71.25	12.80	0.35
8	2.61	18.98	3.19	59.64	12.66	2.19
12	2.64	17.46	6.38	56.91	13.75	2.84
Variance decompositions of *rgpdi*						
1	0.00	0.00	77.39	14.86	0.00	7.74
4	4.64	19.34	38.08	10.08	7.58	19.54
8	3.44	26.27	40.21	10.51	6.12	13.44
12	3.14	28.25	40.10	11.37	5.85	11.29
Variance decompositions of *inf*						
1	79.65	0.00	3.43	4.08	0.00	12.84
4	70.09	0.29	10.16	7.99	0.87	10.60
8	47.28	15.18	14.56	11.30	4.70	6.98
12	38.91	25.89	14.13	9.71	5.70	5.67
Variance decompositions of *reex*						
1	0.12	96.77	1.03	0.16	0.00	1.91
4	4.08	87.21	4.28	1.01	2.10	1.32
8	8.03	76.67	8.36	1.58	1.65	3.69
12	6.34	77.57	9.71	1.41	1.69	3.26
Variance decompositions of *rimp*						
1	3.88	0.00	9.13	0.78	76.66	9.55
4	2.11	23.20	12.90	2.80	38.35	20.64
8	2.03	38.25	11.23	3.28	26.36	18.85
12	1.52	42.27	12.10	4.02	21.28	18.81

and real import. As have discussed earlier in this study, the response of inflation can be explained by the "spending effect" caused by increasing oil prices and effective demand for non-tradeable section. Meanwhile, the positive response of real import to shocks of positive oil price changes illustrates the main financing source of import in Iran, e.g. petro-dollars. Considering the high share of oil revenues in foreign exchange revenues of the government, it is natural to expect a high sensitivity of imports to fluctuation in oil prices. Also the response of the real effective exchange rate to a shock in increasing oil prices in the middle and long term is positive. The same responses have been observed for a shock in real heavy oil price positive changes. The response to a shock in negative light oil prices is positive and significant. This indicates that both positive and negative shocks to oil prices have inflationary effects in the economy. The responses of industry output, real effective exchange rate and real import to a shock in negative oil price are negative and significant. The negative response of *reex* shows that the government tries to implement non-oil export-oriented policies in order to offset some part of reductions in oil revenues.

Our results are in contrast to recent studies for developed economies. For example Hamilton (2003) and Jimenez-Rodrguez and Sanchez (2004) find that positive oil

Table 2
Variance decomposition $\triangle roilp^{-}$ (light oil)

Quarter	*inf*	*reex*	$rgpd_i$	*rgex*	*rimp*	$\triangle roilp^{-}$
Variance decompositions of *rgex*						
1	0.00	0.00	0.00	98.78	0.00	1.22
4	3.65	13.57	0.33	64.20	14.52	3.73
8	3.39	21.26	3.73	51.09	15.52	5.01
12	3.92	20.59	6.17	48.58	16.10	4.63
Variance decompositions of *rgdpi*						
1	0.00	0.00	84.73	11.87	0.00	3.39
4	3.92	9.97	48.92	8.91	15.04	12.86
8	2.43	16.62	41.72	8.61	10.99	19.61
12	2.12	19.14	38.11	8.97	9.91	21.74
Variance decompositions of *inf*						
1	85.90	0.00	0.64	1.61	0.00	11.85
4	65.75	17.31	0.70	2.81	2.90	27.68
8	42.16	14.11	2.84	4.94	8.71	27.24
12	34.58	22.53	3.22	4.46	8.85	26.36
Variance decompositions of *reex*						
1	0.67	88.27	0.25	0.02	0.00	10.78
4	1.79	60.07	2.47	0.65	6.21	28.80
8	2.19	50.43	3.65	1.14	4.10	38.47
12	1.94	50.37	4.28	0.99	3.57	38.83
Variance decompositions of *rimp*						
1	6.37	0.97	21.18	0.02	66.97	4.48
4	8.19	13.09	22.55	1.82	49.54	4.79
8	7.28	23.26	18.31	1.75	34.64	14.75
12	6.06	26.29	18.10	1.76	28.46	19.32

price shocks have a larger impact on gross domestic product than negative shocks. While increasing oil prices mostly cause a significant decline in domestic output, decreasing oil prices evolve only marginal impact in industrial countries. However, Iran as a developing economy and net oil exporter shows that both positive and negative oil price changes significantly affect the output of the economy. We find evidence that oil price fluctuations are the Achilles' heel of the Iranian economy. The oil revenues are at same time a great opportunity and treat for current and future generations of Iran. The design of best practices for windfall oil funds management must be taken into account by the policymakers of the Iran.

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A Data sources and description

In our research, we use quarterly data for the period of 1988:I to 2004:IV. The variables considered in this paper are as follow:

- Real gross domestic product per capita in industrial sector (*rgdpi*)

is a measure of total output within the geographic limits of the Iran, regardless of the nationality of the producers of industrial output per capita, before seasonal adjustment (at constant prices of 1997-98). The (*rgdpi*)series has extracted from Central Bank of Iran.

- real effective exchange rate (*reex*)

is the nominal effective exchange rate index of the Rial adjusted for inflation rate differentials with the countries whose currencies comprise the trade basket. The (*reex*) series has extracted from the International Monetary Fund (IMF) via Datastream.

- inflation (*inf*)

is the yearly changes in Iranian Consumer Prices and has been extracted from IMF via Datastream.

- real public consumption expenditure (*rgex*) is non-seasonally adjusted of public consumptions of Iran on the base of current prices of 1997-98, extracted from Central Bank of Iran.

- real imports (*rimp*)

is non-seasonally adjusted data of Iranian Imports on the base of constant prices of 1997-98, extracted from Central Bank of Iran.

- real oil price (*roilp*)

is the quarterly average of monthly world market prices for Iranian light/heavy crude oil deflated by US Consumer Price Index. The prices of Iranian light/heavy oil prices has extracted from the OPEC databank and the CPI of the United States from IMF via Datastream.

B Reasoning for the coding of the dummy variable *war*

- South East Asian financial crisis (1998)

The serve economic collapse since mid-1997 greatly reduced growth in energy consumption. Gas demand growth was 2.3 percentage, compared to the pre-crisis rates of more than 5 percentage. 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 decline 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.

- Iraq-Kuwait war (1990)

This conflict well-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 percentage over the war period.

- Terrorists attack (2001)

In the month following the terrorist attacks of September 11 2001, oil prices declined to a 2 year low of US$17.50 per barrel due the 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.

- Iraq-US war (2003)

Price spike on Iraq war, rapid demand increases, constrained OPEC capacity, low inventories, etc.

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 1988:I to 2004: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 percent confidence level. However, the Phillips-Perron tests (Phillips and Perron (1988)) reject the null hypothesis of a unit root (nonstationary) at the 99 percent 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 percent 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.

Table C.1
Tests for unit roots

	ADF				PP			
	without trend		with trend		without trend		with trend	
variables	level	first diff.	level	first diff.	level	first diff.	level	first diff.
rgdpi	−0.39	−3.32**	−1.99	−3.29*	−1.35	−21.8***	−5.18***	−23.9***
reex	−2.61*	−7.94***	−1.54	−8.64***	−2.68*	−7.94***	−1.25	−9.92***
inf	−2.20	−5.08***	−2.65	−5.19***	−2.12	−5.95***	−2.25	−5.88***
rgex	−1.34	−13.9***	−2.54	−13.8***	−7.48***	−45.2***	−11.1***	−45.0***
rimp	−0.83	−11.0***	−0.86	−11.0***	−4.22***	−18.5***	−4.30***	−18.4***
$roilp^l$	−2.24	−8.02***	−2.49	−8.07***	−2.16	−8.35***	−2.41	−8.42***
$roilp^h$	−2.53	−8.23***	−2.79	−8.25***	−2.45	−8.54***	−2.72	−8.57***

Notes: Sample is 1988:I-2004: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 10. $roilp^l$ is the real price for Iran light oil; $roilp^h$ is the real price for Iran heavy oil. We denote with */**/*** the rejection of the null hypothesis at a 10/5/1 percent significance level.

C.2 Johansen cointegration tests

The Johansen cointegration test is carried out to test for cointegrating relationships among light and heavy real oil prices and the five Iranian macroeconomic variables. The exogenous war dummy variable is 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 criterion (AIC), Schwarz criterion (SC) and the likelihood ratio (LR) test are applied to determine the optimal lag length needed. In this test a lag length of six has applied.

Table C.2
Selected number of cointegrating relations by model

Test type	Model 1	Model 2	Model 3	Model 4	Model 5
Trace	5	6	6	6	5
Maximum eigenvalue	5	6	6	6	5

Notes: The table show the cointegration tests including the five macroeconomic key variables, the $roilp^l$ variable and the exogenous *war* dummy. The results including $roilp^h$ are qualitatively unchanged. In this tests a lag length of six has been applied.

C.3 Optimal lag length

Table C.3 and C.4 reports the results for the optimal lag length test.

Table C.3
VAR Lag order selection criteria with positive oil price changes

Lag	LogL	LR	FPE	AIC	SC	HQ
0	153.26	NA	3.63e-10	-4.71	-4.29	-4.55
1	317.85	285.28	5.05e-12	-8.99	-7.32*	-8.34
2	356.78	59.70	4.78e-12	-9.09	-6.16	-7.95
3	433.78	102.67	1.35e-12	-10.46	-6.27	-8.82
4	495.11	69.50*	7.18e-13*	-11.30*	-5.86	-9.17*

* 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, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Table C.4
VAR Lag order selection criteria with negative oil price changes

Lag	LogL	LR	FPE	AIC	SC	HQ
0	153.43	NA	3.61e-10	-4.71	-4.29	-4.55
1	316.67	282.93	5.25e-12	-8.96	-7.28*	-8.30
2	355.41	59.41	5.00e-12	-9.05	-6.11	-7.90
3	423.48	90.76	1.19e-12	-10.12	-5.93	-8.48
4	498.74	85.30*	6.36e-13*	-11.42*	-5.97	9.29*

* 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, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

D Robustness tests

D.1 Heavy oil prices

Figures D.1and D.2 shows the response of variables to Cholesky one standard deviation innovation in oil prices for heavy Iranian oil. The results are qualitative and quantitative unchanged in comparison the results for Iranian light oil.

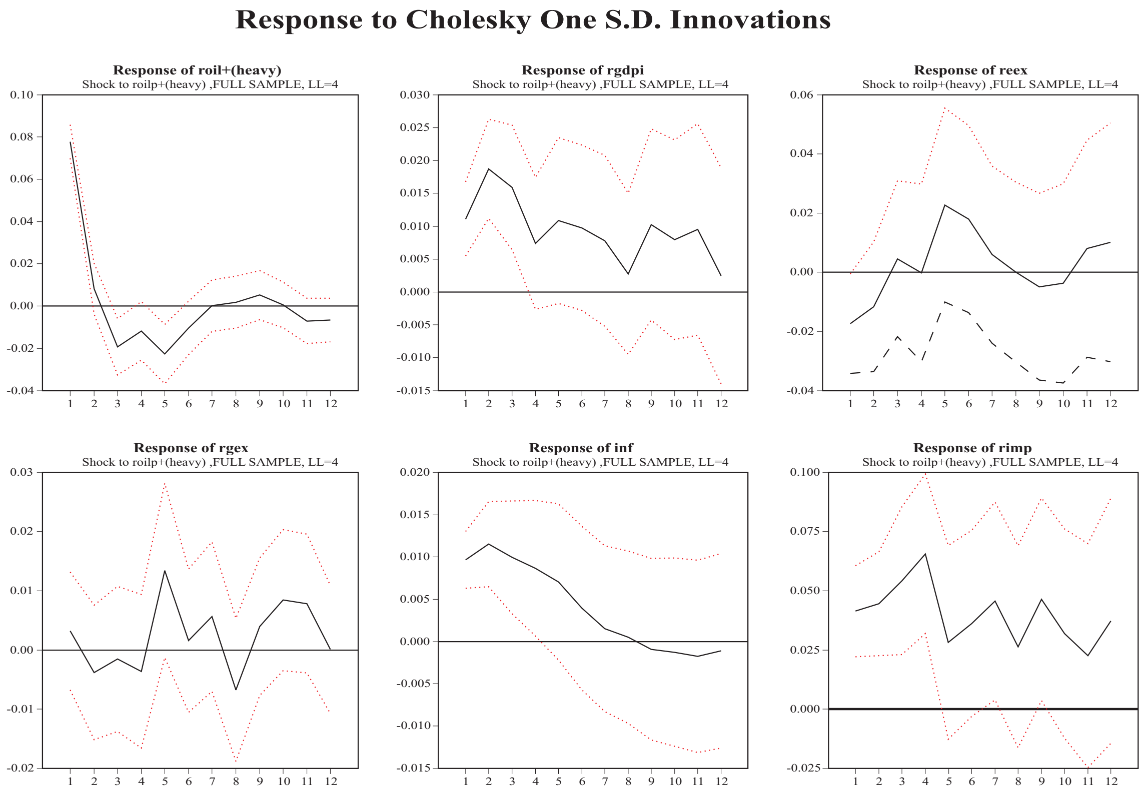

Fig. D.1. IRF $\triangle roilp^{+}$ (heavy oil)

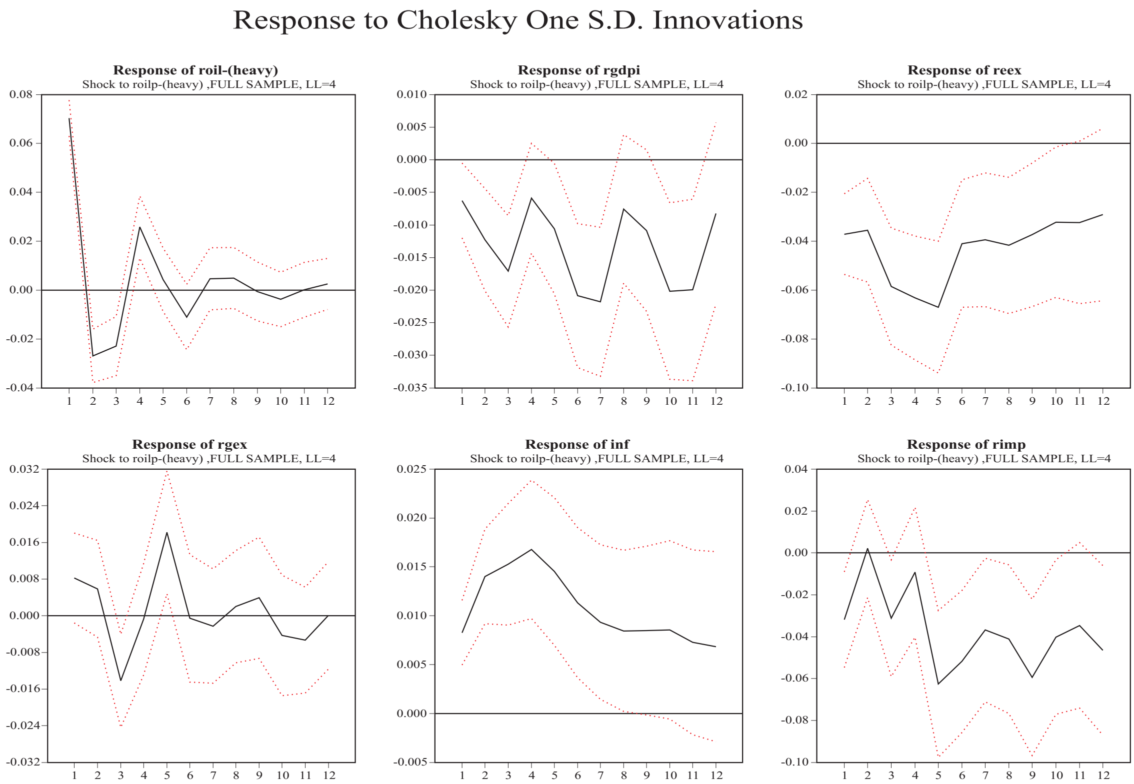

Fig. D.2. IRF $\triangle roilp^{-}$ (heavy oil)

D.2 Hamilton's oil prices

Figure D.3 illustrate the IFRs on the base of Hamilton's positive oil price shock definition (c.f. chapter 2.1 quod vide equation (7)). The general qualitative and quantitative responses of system variables to one standard deviation to asymmetric oil prices are similar to Mork definition. The excepted case is the response of inflation to positive oil price shock. Thought still is positive, but not significant. On the case of Hamilton negative oil price definition (c.f. chapter 2.1 quod vide equation (8)), we can not identified significant responses in the variables in the system (see figure D.4). The only exception is the response of inflation which is again positive an significant.

D.3 Other VAR orderings

Figures D.5 and D.6 shows the results for the alternative Cholesky ordering as described in chapter 3.2. The results are qualitative and quantitative unchanged.

Response to Cholesky One S.D. Innovations

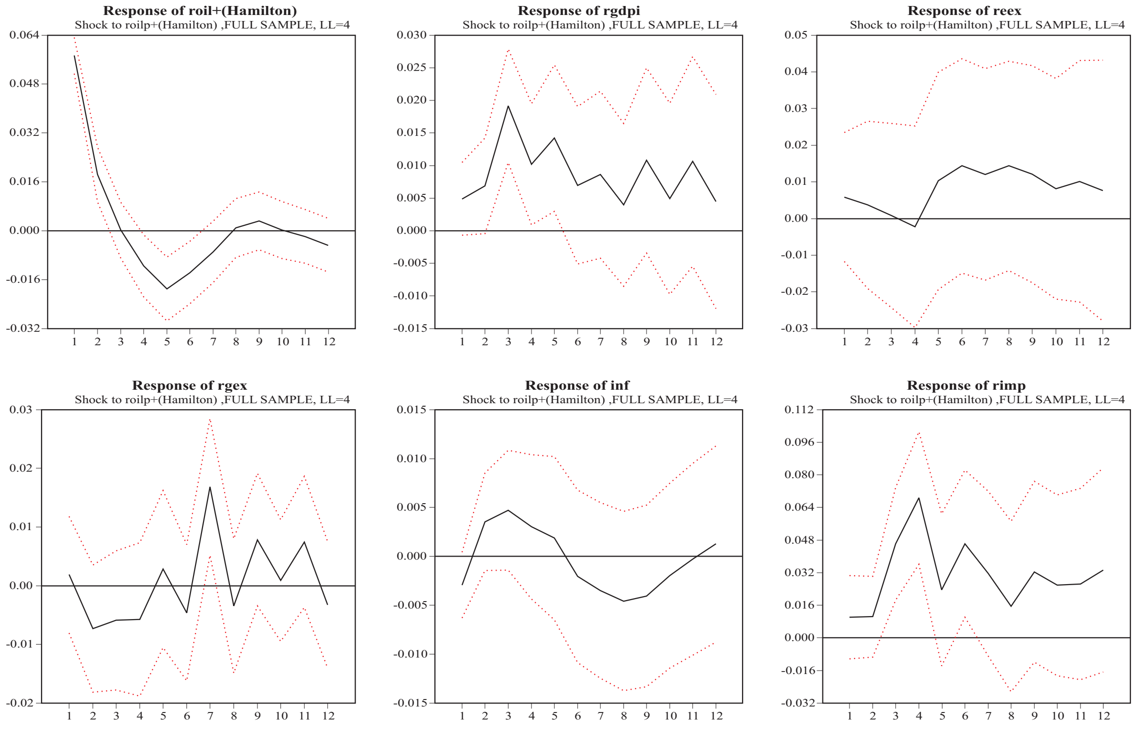

Fig. D.3. IRF $noilp^{+}$ (light oil)

Response to Cholesky One S.D. Innovations

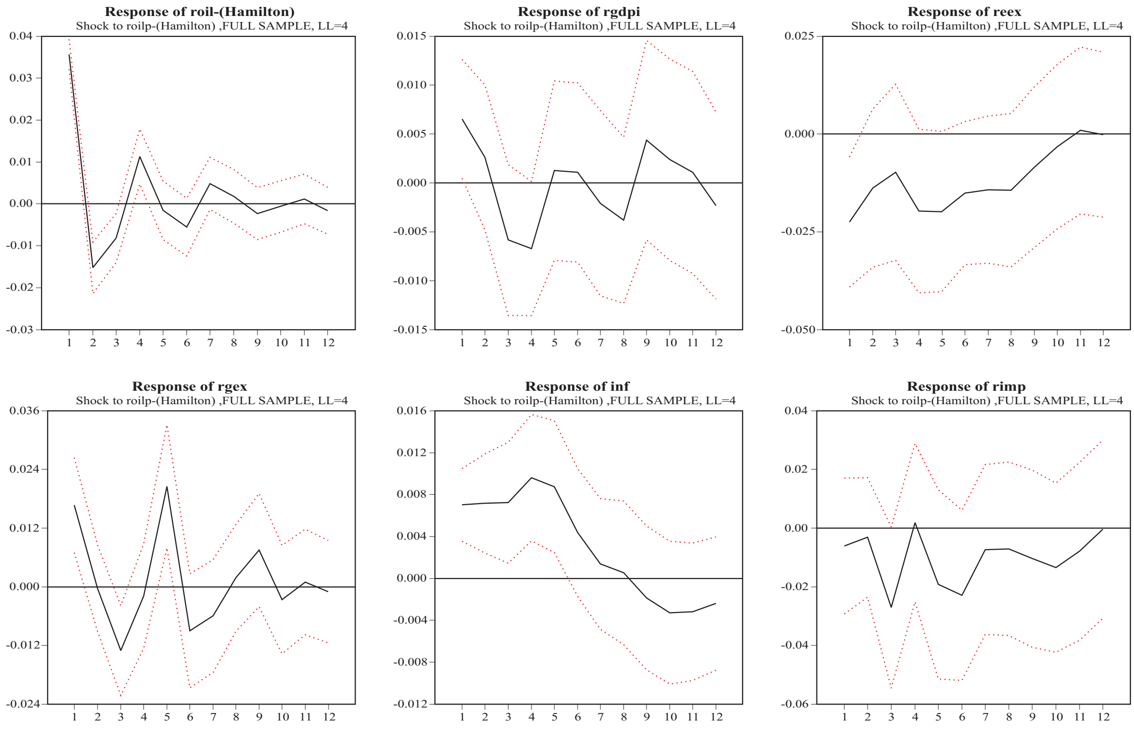

Fig. D.4. IRF $noilp^{-}$ (light oil)

Response to Cholesky One S.D. Innovations

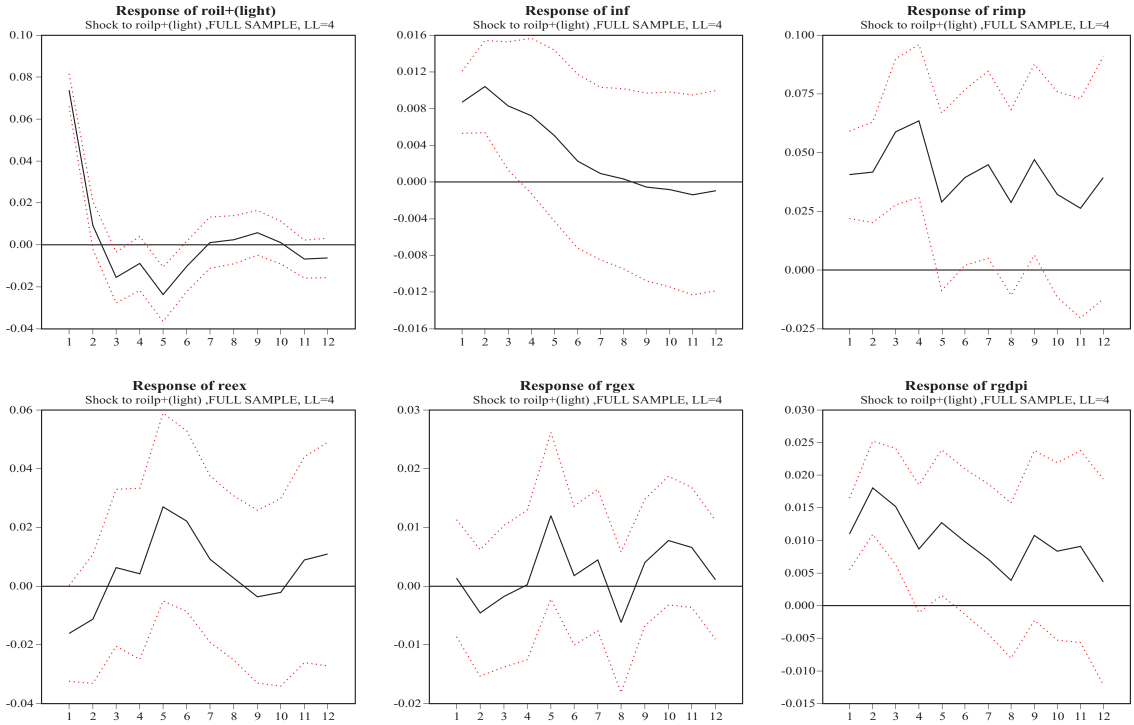

Fig. D.5. IRF $\triangle roilp^{+}$ (light oil)

Response to Cholesky One S.D. Innovations

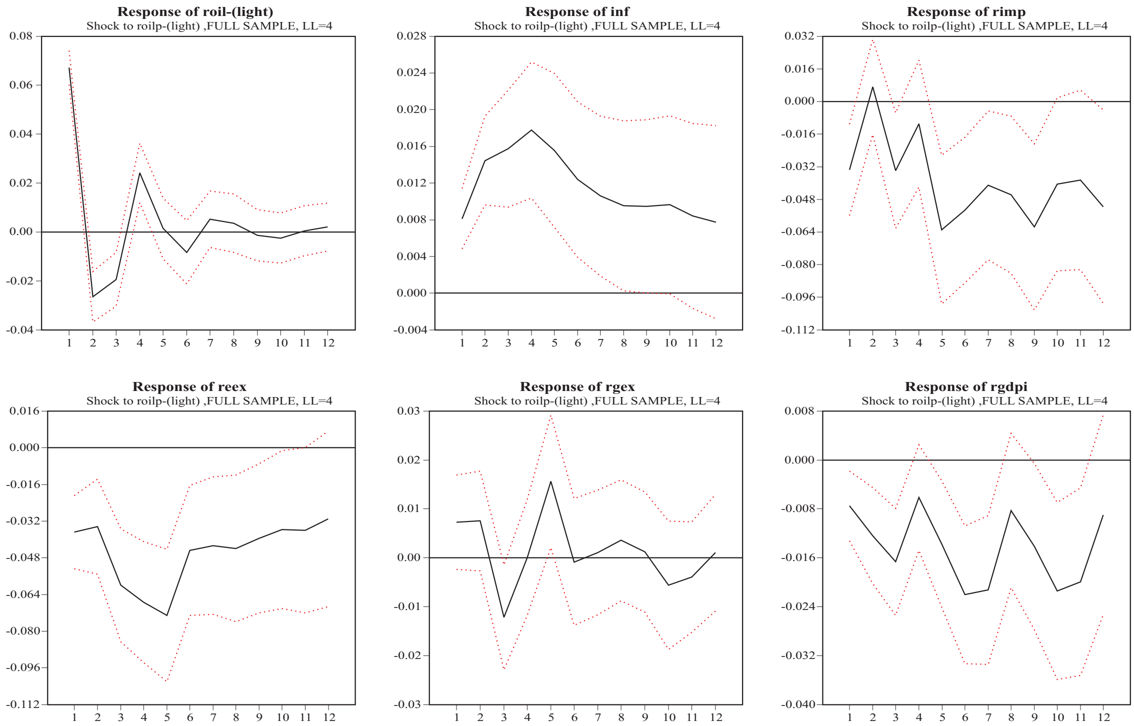

Fig. D.6. IRF $\triangle roilp^{-}$ (light oil)