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A Nonlinear Approach to the Effect of Oil Shocks on Iran's Economy

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ABSTRACT

This paper aims to show the asymmetric effect of oil shocks on Iran's economy. It uses nonlinear time series models to investigate the asymmetric effect of oil shocks on resource allocation in Iran's economy. The results show that adverse oil shocks have been more persistent during the last decades and severely negatively affect resource allocation in Iran's economy. Different oil shocks have different implications for importing and exporting countries, and the rigidity of state fiscal systems in exporting countries causes adverse oil shocks to be more persistent. The oil economy's response to positive and negative oil shocks depends on the structure of the economy. The government budget and trade balance have significant implications for the effects of oil shocks on oil-exporting economies. The government budget is highly dependent on oil revenues, so in the case of adverse oil shocks, the pass-through exchange rate will cause high inflation because of foreign exchange shortage and overshoot in the exchange rate.

1. Introduction

Oil prices have been fluctuating during the last decades. Since the first oil shock in 1973, in which oil prices quadrupled until now, the world oil market witnessed three significant shocks and high fluctuations, which are not considered shocks but have significant impacts on both importing and exporting economies. A series of empirical studies investigated the relationship between oil price changes and the macro-economy for oil-importing countries to explore the asymmetric effect of positive and negative oil shocks. Ju et al. (2016), Hamilton (2000), Gordon (1998), Raymond and Rich (1997), Hamilton (1996), Hooker (1996), Filardo (1994), Diebold and Rudebusch (1996), Mork (1989), Hamilton (1989), and Hamilton (1983) are the most cited among others. It assumed that oil price changes have different effects on oil-importing and exporting economies. An increase in oil prices is considered cost-push inflation for importing countries while bringing foreign exchanges into the exporting countries. Since the 1970s, most research has been allocated to investigating the negative effect of oil price increase on inflation and unemployment within importing oil economies. Some seminal research studies investigated positive oil shocks on exporting economies from a political economy point of view and resource allocation and sectoral capital accumulation via the price mechanism. Dutch disease models, which roots in the leading works of Corden and Neary (1982) and Gelb (1981), focus on how a change in relative prices resulting from positive oil shocks will deteriorate industries and agriculture in oil-exporting countries. In this approach, the economy is disaggregated into the booming sector (i.e., oil and gas) and the tradable

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and untradable sectors. The income effect or expenditure effect shows that the increase in booming sector export causes an increase in aggregate demand in the economy; thus, untradable prices increase with respect to the tradable sector, which is expressed in actual exchange rate deterioration. On the other side, the factor movement effect explains how an increase in productivity of factors in the untradable sector forces factors of production from tradable sectors in the untradable sector. These models conclude that positive oil shocks led to de-industrialization and de-agriculturalization in oil-exporting countries.

Resource thesis by Auty (1995) explains structural changes in resource-based economies. These studies consider the adverse effects of positive oil shocks and ignore the harmful effects of adverse oil shocks. It seems that negative oil shocks have more effects on these economies. Further, these researches consider oil price shocks rather than oil income. A decrease in oil revenues as a form of foreign saving has different implications for oil-exporting economies. Lack of foreign exchanges will increase the value of foreign currencies and cause import inflation. According to the economic literature, exchange pass-through explains high inflation, especially in oil-exporting economies. Oil price shocks affect exporting economies by changing oil income, government budget, and exchange rate fluctuations. Similar to oil price shocks, sanctions limit access to foreign exchanges and significantly impact the government budget. Any deficit in the government budget forces the government to use inflationary financing methods, resulting in a high inflation rate. An increase in the inflation rate pushes the exchange rate upward, and although it has a positive effect on export in the short run, it decreases the power of competitiveness of domestic industries and resource allocation in general. In the case of Iran, oil sanctions caused significant effects on economic growth during lad decades. A decrease in oil income in 2012–2014 and 2017–2019 pushed up the exchange rate and caused double-digit inflation. Rates of economic growth decreased such that for the first time Iran's economy witnessed negative gross capital accumulation growth. The government budget deficit and its debt to the central bank caused unprecedented growth in liquidity and inflation. Therefore, it is essential to study the effect of the positive and negative oil shocks on oil-exporting countries.

Pesaran et al. (2012) developed a model to investigate the role of oil from a macroeconomic point of view. The model covers previous models' shortcomings and allows distinguishing between short-term and long-term effects of oil on macroeconomic variables. In this model, oil income is considered a long-term source of income. In this model, oil income is connected to the technical change, real exchange rate, and other factors related to the aggregate supply. The result of the model shows that there is a long-run relationship between oil income and production. Inflation was attributed to weakness in institutional and policy infrastructures, which banned optimal usage of oil income and investment efficiency. Since financial markets are immature and not integrated into international financial markets, they cannot buffer external shocks. Therefore, financial markets are the main reason behind the vulnerability of Iran's economy to external shocks and caused positive and negative oil shocks to affect macroeconomic variables directly.

Mehrara et al.(2015) studied the role of oil shocks on the value added of four economic sectors using a vector-autoregressive (VAR) model and showed service and industry, and mine sectors respond to positive oil shocks with lag while agriculture and oil and gas sector response is not significant. Mohammadi Pour et al. (2020) developed a DSGE model to investigate the effect of oil income shock alongside monetary shocks on Iran's economy. The results show that although an increase in oil revenues increases government expenditures, intermediary goods, and household consumption in the first period, it harms private sector investment expenditures. In the long-run, employment and output level decrease. Esmaeil Nia et al. (2012) investigated the effect of oil shocks on government expenditures in Iran. The results show that positive oil shocks significantly affect government military and social security expenditures. Other expenditures are not sensitive to oil shocks. Ghaffari and Mozaffari (2010) studied the asymmetric effect of the oil shock on economic growth in Iran. They applied a VAR approach and showed that adverse oil shocks negatively affect economic growth, but the positive shock does not necessarily have positive effects. Nonlinear models allow investigating different shocks. In economic literature, these models are applied to test the nonlinear effect of good and bad news on the financial market. This research aims to analyze the asymmetric effect of positive and negative shocks. Therefore, nonlinear models are more appropriate ones.

This paper uses nonlinear time series models to investigate the asymmetric effect of oil shocks on relative prices and resource allocation in Iran's economy. Both GAR and TARCH models show that adverse oil shocks affect the economy more than positive shocks and support our assumption. The rest of the paper is constructed as follows. The following section has a brief look at the effect of the oil shock on exporting countries. Section three reviews oil shocks implications for Iran's economy. Section four tests the asymmetric effect of oil shocks on Iran's economy. The last section concludes the results.

2. Oil shocks: symmetric and asymmetric effects

The role of oil in Iran's economy has been controversial discussions. On the one hand, it is argued that oil income provides a significant financial source of investment, and Iran's economy can experience more rapid economic growth than other developing economies. On the other hand, it is asserted that because of structural and institutional shortcomings, oil income is not optimally used, and the abundance of oil income harmed the performance of the economy. Although oil income increased consumption, it lagged the economy from growth in some directions. In general, the lack of efficient institutions caused oil shocks to affect Iran's economy in different directions.

In general, three oil shocks can be identified since the 1970s. The first oil shock occurred in 1973, caused by the Arab–Israeli war. The 1979 Islamic revolution in Iran and a sharp decrease in Iran's oil production were the sources of the second oil shock, and the third shock occurred in 1986. After that, Saudi Arabia increased its production. Afterward, the oil market witnessed fluctuations in oil prices, but none was considered a shock.

Benchmark oil prices such as Brent and West Texas Intermediate increased from $30 in early 2004 to more than $100 per barrel in early 2008. The market witnessed a temporary decline in mid-2008 due to the world financial and economic crisis. Then, the average prices fell below 60 dollars and were expected not to back to their historical level.

A series of studies consider the implications of oil shocks for exporting countries. Gelb (1982) and Hablutzel (1981) focused on the first oil shock. These studies consider the fiscal response to positive oil shocks and show how increasing oil prices affect different economic sectors within oil-exporting countries.

Theoretically, a rigid fiscal system and the inability of the government to adjust its expenditures to the different oil shocks cause oil shocks to have asymmetric effects on oil-exporting countries. In other words, different fiscal responses to positive and negative oil shocks have different implications for relative prices and resource allocation. Thus, a rigid fiscal system of the state in exporting economies causes positive and negative oil shocks to have an asymmetric effect on exporting economies.

Symmetric and asymmetric effects of oil shocks on development and recurrent expenditures appear to have existed in all oil-exporting countries. However, these effects depend on macroeconomic policies during shocks and after that. The first positive oil shock was associated with a rapid increase in oil exporters' recurrent, and development expenditures is well documented. In addition, the association of adverse oil shocks such as the third shock in 1981 with a sharp decline in oil exporters' development expenditures is evident. In Indonesia, following the downturn of oil export in 1984 and 1985 and the negative oil shock in 1986, the government's development expenditures rapidly declined. Government actual development expenditures in Indonesia declined to 6.7% of GDP in 1985 relative to 10.2% and 12.4% in 1981 and 1982, respectively. In the face of the third oil shock (a negative oil shock), government recurrent expenditures remained relatively high, reaching 11.6% of GDP in 1986 compared to 12% of GDP in 1981, the period of the second oil shock.

Regarding the effect of oil shocks on the economy, Iran had many characteristics similar to other oil economies in the first and third oil shocks. Like other oil-exporting countries, the first shock accelerated the process of industrialization and growth. The third oil shock harmed all oil economies. A significant difference between Iran and other oil-exporting countries was the nature of the second oil shock which the total export of all oil economies increased except for Iran because of a sharp reduction in Iran's oil production. While total exports of Saudi Arabia doubled in 1980 and 1981 compared with 1979, Iran's total exports decreased by 24% and 46% in the same years.

3. Oil income and Iran's economy

Oil revenues were the primary source of foreign exchanges and government budget financing during the last decades. Investigations show that the share of oil sector value added in GDP has been significant. The share of oil income in GDP increased since 1952, and it was 12.3 percent out of GDP in 1962, which increased to 18 percent in 1967. It amounted to 50.6 percent in 1972 (Katouzian, 2004, p.202). On average, oil income stands for 50 percent of GDP and more than 80 percent of export (Salehi Isfahani, 2010:7). Farzanegan (2008:2) showed that oil income contributed to 20 percent of economic growth between 1960–2006. The main problem is that a high share of oil value added in GDP means that the share of other tradable sectors has been decreased. Studies showed a strong relationship between oil export and GDP growth in Iran's economy, and economic progress in 1981–82 and 1989–1991 is highly supported by oil income (Karshenas and Hakimian, P.68). As indicated in Figure 1, oil rents share in GDP during the last decades was significant. In 1971, the share of oil rent out of GDP was 50 percent. After the revolution and in consequence of the revolution and decrease in oil production and export, the share of oil rents in GDP declined below 10 percent. In the 1990s, it was 21 percent on average and increased to 25 percent in the 2000s, showing more dependency on oil rents. Although the share of oil rents decreased in recent years primarily because of sanctions, high inflation and recession showed how much the economy depends on oil rents.

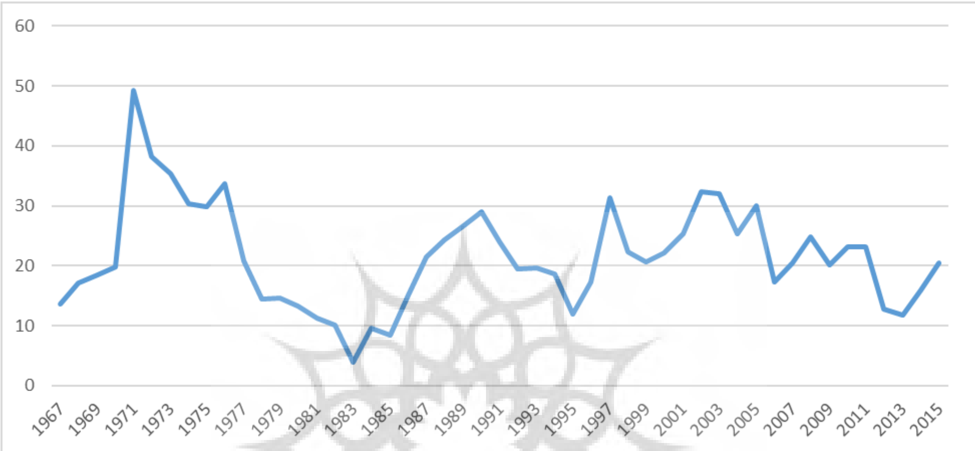

Figure 1. Oil rents (percentage of GDP); Source: World Bank.

The share of oil exports in total goods and services shows how much the economy depends on oil revenues. Figure 2 indicates that oil income has been the primary source of foreign exchanges during the last decades. Share of oil export in total export of goods and services was 91 percent between 1960–1074 on average and reached its maximum level of 99 percent in 1974. After the revolution and because of the decrease in oil production and recently because of oil sanctions by the US, the share of oil revenues decreased, but it was 71 percent on average during the whole period. It shows that Iran's economy is highly dependent on oil revenues and fluctuations in oil prices, and consequently, oil income will affect macroeconomic variables.

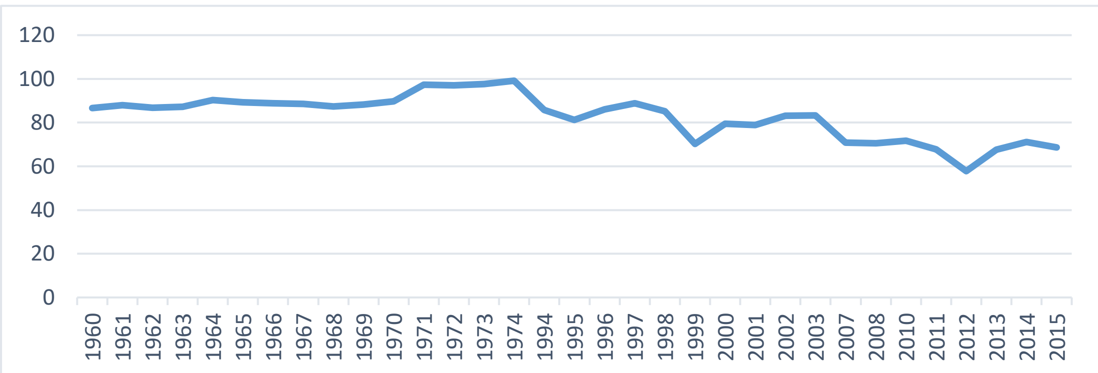

Figure 2. Share of oil revenues in total export of goods and services; Source: World Bank.

To capture the effect of oil shocks on Iran's economy, we analyze per-capita GDP trends during three oil shocks in this session. Oil entered into the government budget in the 1960s, and the government was enabled to implement seven-year development plans. Per-capita GDP also increased by increasing the rate during this period. In the 1970s, because of the sharp increase in oil prices (first oil shock), the government had to revise the budget in 1977. The second oil shock was caused by a reduction in Iran's oil production and coincided with the Islamic revolution in Iran. Although oil prices increased, Iran's oil income declined. Figure 3 shows that immediately after the revolution, oil production decreased and per-capita GDP dropped to half of its pre-revolution level. A decrease in per capita income would be attributed to a decline in oil income and never backed to its pre-revolution level. Therefore, the second oil shock had no positive effect on Iran's economy. The third oil shock occurred in 1985 when Saudi Arabia increased its production, which caused oil prices to decrease sharply. This shock had a negative effect on per-capita GDP.

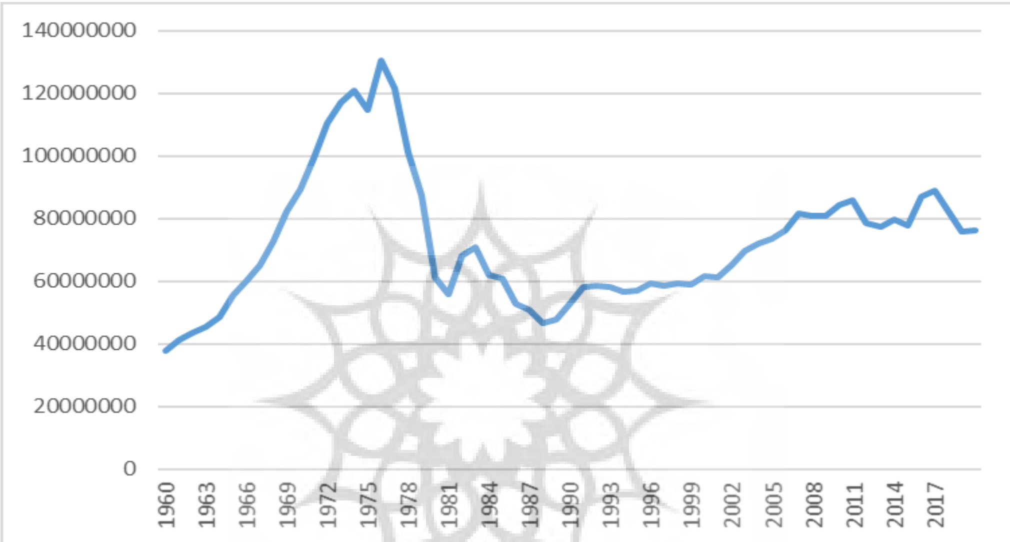

Figure 3. Per-capita GDP at constant price 1960–2019; Source: World Bank.

The fiscal response to oil shocks in Iran is of particular interest. First, none of the cross-countries and country-specific studies includes a rigorous analysis of fiscal response to the second shock for the case of Iran. Second and more important, Iran's economy differs from all other exporting countries in terms of the second oil shock. While the second oil shock brought a huge oil windfall into the economies of all exporting countries, Iran's economy faced an unprecedented reduction in foreign exchange inflow.

After the economic recession of 1960–1963, the actual GDP share of total public real revenue increased to 11.8% in 1965. This share was almost stable until 1973. As a result of the first oil shock, the actual GDP share of real public revenue significantly increased, reaching 39% in 1974. At the second oil shock, this amount started declining to 19.5 % in 1980 but slightly increased when oil export recovered. At the third shock in 1986, it decreased again to 8.4% of real GDP in 1988. The actual GDP share of total public real revenue started increasing again, reaching 13.3 % in 1992 (Baky-Haskuee, 2003).

While recurrent public expenditures share of real GDP averaged 3.9% during 1960–64, public actual development expenditures started increasing, in parallel with an increase in actual public revenue, reaching 6.5% of real GDP in 1972. The first oil shock enabled the government to increase its development expenditures. The actual GDP share of real public development expenditures reached 12.4% at the end of the first shock period in 1977. This share decreased to 7.5% in 1980 during revolution-induced capital outflow and the flight of the second oil shock. After a mild increase during the 1981–83 period, actual public development expenditures declined sharply due to war, which absorbed a significant proportion of foreign exchange, and third oil shock in

1986, falling below 3% of real GDP in 1988 and 1989. This share increased slightly to 3.4% on average during the 1990–1992 period but was still lower than the average level during 1960–63. Although different from actual development expenditures, recurrent public expenditures were affected by oil revenue shocks. A significant positive oil revenue shock usually boots all types of public expenditures, although to a different degree. In the face of significantly negative oil shocks, the government may be unable to cut recurrent expenditures. In Iran's economy, after a relatively stable average actual GDP share of 6.8% during the 1960s, recurrent public expenditures tripled in 1974, reaching 20.9% of real GDP, twice the actual GDP share of real development expenditures in the same year.

Despite the revolution-induced capital outflow in 1979 and the significant negative oil shock in 1980, which significantly reduced total public real revenue, the actual GDP share of recurrent expenditures remained 22%, even higher than the post-first oil shock level. This share reached 25.7%.

The sustained shortage of foreign exchange, insufficient source of public non-oil revenue, government unwillingness or inability to borrow from abroad, and the heavy burden of war, coupled with the third oil shock in 1986, eventually required a decrease in the actual GDP share of recurrent expenditures, to 13.8% in 1986 larger than its pre-first oil shock level. The relatively high level of recurrent public expenditures at the time of adverse oil shocks was associated with a high budget deficit, high inflation, and excessive money supply.

Table 1 presents the oil income and poverty population. It is argued that oil income availability could be a source of poverty reduction. Investigations show that in the first period of the 1970s, poverty level declined (Mahmoudi, 2007:48), while it was 48 and 37 percent in 1972 respectively, and per-capita income at constant prices increased 50 percent from 1972 to 1977 (Azimi, 1994:203–205). In 1975 only 39 percent of rural households and 13 percent of urban households were under the poverty line.

In 1986, around 22.7 million population were undernutrition (Azimi, 1994:92). Although war affected households' level of welfare, the main reason was a sharp decrease in oil revenues. Oil income in 1986 was one-fourth of its level in 1982. In the 1990s, which imposed war has been finished and oil revenues were allocated to economic development plans, and oil revenues tripled between 1987 and 1999, but there was no significant improvement in the level of welfare and reduction in poverty. Findings are consistent with the result of studies that show economies dependent the oil income experienced a higher level of poverty and consequently fertility, low life expectancy, and heath (Terry et al., 2009:664). Although positive oil shocks had moderate effects on poverty reduction, the negative oil shocks effect was not compensated by positive shocks. Per-capita income at constant prices decreased after the Islamic revolution. Gross domestic product increased from 11939 billion Rials in 1977 to 17455 billion Rials in 1999 at constant prices. It shows that the average economic growth was 1.2 percent. The population grew from 36.8 million in 1977 to 64.6 million in 1999, which shows that per-capita income decreased by 30 percent during that period (Rashidi, 2002:173).

Table 1. Result for TARCH (1, 1).

Oil income and poverty population		
Year	**Oil revenues (billion Rials)**	**Poverty (Percentage of population)**
1971	155.3	47.7
1975	1246.8	26
1986	434.7	43
1993	14683.2	24
2005	181881.2	33.3
2007	173519.1	35
Source: Mosallanejad and Sheikhzadeh (2013:49)		

The government has conducted subsidy reform since 2010 and planned to support low-income families. The policy goal was to redistribute energy subsidies by direct cash payment to households to increase income and welfare. Investigations showed that because of fiscal rigidity in the government budget, the government applied a series of inflationary financing methods of its budget. Therefore, high inflation rate deteriorated the effect of policy such that between 2017 and 2019 more than 30 percent of the population have been under the poverty line. Accordingly, oil income improved the welfare level and increased the percentage of the population under the poverty line.

The European Union banned oil imports to the member countries in response to oil sanctions against Iran's oil sector (Kortewege, 2013:12), significantly decreasing oil income. Oil sanction against Iran is considered an action led by the USA to limit Iran's nuclear program. Sanctions are imposed to limit the access of Iran to oil revenues in order to put pressure on Iran to negotiate with western countries. Other sanctions, including shipment and banking sanctions, have the same effects on the access of Iran to oil export revenues. Although sanctions shock the domestic economy, but cannot be considered an oil shock at the international level. The impact of oil sanctions on Iran's economy was overshooting in the exchange rate and decreased fixed capital formation, which led to a decrease in economic growth. During the last decade, Iran's economy experienced unprecedented recession and stagflation.

4. Test for asymmetry in resource allocation

We showed that rigidity in the state financial system is the primary channel for the asymmetric effect of oil revenues on resource allocation in oil-exporting countries. We show RER that determines resource allocation movement has an asymmetric behavior to test this. Purchasing power parity theory defines the real exchange rate as follow:

$$RER = \frac{P}{P^f e} \quad (1)$$

where P and P^f are domestic and foreign price indexes, and e is the nominal exchange rate, defined as the domestic value of a unit of foreign currency. Alternatively, the real exchange rate can be defined as the relative price of untradable in terms of tradable goods. Although these two definitions differ, the former is used as the proxy for later in most empirical studies (Edwards, 1989, pp. 1–8)[2].

Following Edwards (1989), an alternative real exchange rate is defined as the relative price of untradable in terms of tradable goods $RER = \frac{P_N}{P_T}$ where P_N and P_T are untradable and tradable price indexes respectively defined as the ratio of value added of each sector in current prices to the value added in real (constant) prices[3] . Both tradable and untradable sectors are decomposed into consumption and capital goods to construct RER. Tradable capital goods include machinery and equipment, and untradable capital goods include construction. Value added in the service sector is treated as untradable consumption goods. Services include public, social, professional, monetary, and financial services, transportation and communication, hotels, restaurants, and commercial activities. They include governmental services as well. This concept shows the change in relative prices and competitiveness of domestic tradable goods against importable foreign goods. Although the two definitions differ, the former is used as a proxy for later empirical studies[4].

In its simplest form, the purchasing-power-parity hypothesis suggests that the real exchange rate is constant at the level reached at a time of macroeconomic balance and that reversions to the mean from any observed deviations are rapid. However, empirical evidence in support of this hypothesis is limited. To explain this discrepancy, several recent studies have examined time-varying sources of fluctuation in equilibrium actual exchange rates as an alternative to the purchasing-power-parity hypothesis[5].

MacDonald and Ricci (2003; South Africa) and Koranchelian (2005; Algeria) studied the effect of resource endowments (e.g., oil discoveries), terms of trade (e.g., oil prices), actual interest rates, and labor productivity differentials relative to a country's trading partners and changes that arise as a result of economic policies and other factors; however, they did not examine the effects of parallel market rates on the equilibrium actual exchange rates. When prices are flexible, and the nominal exchange rate is frequently floating, the RER depends on the real fundamentals of the economy. Changes in real fundamentals such as log-term productivity growth, underlying capital flow, term of trade, and world economic conditions cause a change in the underlying demand and supply in the real sector and consequently lead to a change in the real exchange rate. Against purchasing power parity hypothesis, which expresses equilibrium real exchange rate is constant, it depends upon fundamentals that may change over time.

[2] For alternative definition of equilibrium real exchange rate see Williamson, 1985, pp. 13–20.
[3] The base year for construction of real prices is 2000.
[4] For detail on relation between two definition see Edwards (1989), p. 1–8
[5] See Hinkle and Montiel (1999) for a survey of the challenges in assessing a country's equilibrium real exchange rate.

5. Methodology

Economic theory suggests that several important time series variables should exhibit nonlinear behavior (Enders: 2004, p. 387). The cycle in many economic series is widely believed to be asymmetric because the expansions and contractions do not coincide[6].

Hamilton (1989) analyzed the post-war US GNP series in an influential article using a nonlinear parametric model, specifically, an ARIMA model augmented with a latent Markov switching trend process. Clements and Krolzig (2003) developed rigorous tests for asymmetry in the Markov switching framework, analyzing the US's GNP, investment, and consumption growth data.

In empirical macroeconomics and finance, nonlinear time series models are frequently considered to describe and forecast the relevant time series variables[7]. A key feature of many nonlinear time series models is that they allow for the possibility that the model structure (lag length, parameters, and variance) experiences changes, depending on the state of the economy (expansions or recessions) or of the financial market (for example, high or low volatility). Threshold autoregressive (TAR) model (Tong, 1990), smooth transition autoregression (STAR) model (Ter¨asvirta, 1994; 1998), Markov-switching model (Hamilton, 1989), and the artificial neural network (ANN) model advocated by Kuan and White (1994) are most commonly nonlinear models.

Since the seminal paper of Engle (1982), autoregressive moving average (ARMA) models have been extended to essentially equivalent models for the variance. Autoregressive conditional heteroscedasticity (ARCH) models have been extensively used in the literature. The asymmetric power ARCH (APARCH) model of Ding, Granger, and Engle (1993) is undoubtedly one of the most promising ARCH-type models. Indeed, this model nests at least seven ARCH-type models and is particularly relevant in many recent applications[8].

The common point of all the applications dealing with the APARCH model (and most of the ARCH-type models) is that they are estimated by maximum likelihood methods and use numerical techniques to approximate the derivatives of the likelihood function with respect to the parameter vector (the score or gradient vector). However, as shown by Fiorentini, Calzolari, and Panattoni (1996), Gable, Van Norden, and Vigfusson (1997) (for Markov switching models), and McCullough and Vinod (1999), using analytical scores in the estimation procedure should improve the numerical accuracy of the resulting estimates and speed-up maximum-likelihood estimation.

5.1. APARCH specification

The $APARCH(p,q)$ model of Ding, Granger, and Engle (1993) can be defined as follow:

$$y_t = \acute{X}_{1,t}\mu + \varepsilon_t \quad (2)$$

$$\varepsilon_t = \sigma_t z_t \quad (3)$$

$$\sigma_t^\delta = x'_{2t}\omega + \sum_{i=1}^{q} \alpha_i k(k_{t-i})^\delta + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^\delta \quad (4)$$

$$k(\varepsilon_{t-i}) = |\varepsilon_{t-i}| - \gamma_i \varepsilon_{t-i} \quad (5)$$

where x_{1t} and x_{2t} are two vectors of respectively n_1 and n_2 weakly exogenous variables (including the intercept); $\mu, \omega, \alpha_i's, \gamma_i's, \beta_j's$ and δ are parameters (or vectors of parameters) to be estimated. Assumption of δ ($\delta > 0$) plays the role of Box-Cox transformation of conditional standard deviation δ_t, while the $\gamma_i's$ reflect the so-called leverage effect. A positive (or negative) value of the $\gamma_i's$ means that past negative (positive) shocks have a more profound impact on current conditional volatility than past positive shocks.

The properties of the APARCH model have been studied by He and Terasvirta (1999a,199b). The APARCH includes seven other ARCH extensions as exceptional cases:

Putting $\delta = 2, \gamma_i = 0$; $(i = 1, \dots, p)$ and $\beta_j = 0$; $(j = 1, \dots, p)$ results in ARCH of Engle (1982).

- If $\delta = 2$ and $\gamma_i = 0$; $(i = 1, \dots, p)$, the result will be GARCH of Bollerslev (1986).
- If $\delta = 1$ and $\gamma_i = 0$; $(i = 1, \dots, p)$, we get Taylor's (1986)–Schwart's (1990) GARCH model.
- The TARCH of Zakoian (1994) was attained by setting $\delta = 1$.
- The GJR of Golsten, Jagannathan, and Runkle (1993) when $\delta = 2$.
- The NARCH of Higgins and Bera (1992) when $\gamma_i = 0$; $(i = 1, \dots, p)$ and $\beta_j = 0$; $(j = 1, \dots, p)$.

[6] An early widely quoted quantitative study on the asymmetry in economic cycles was published by Neftci (1984).

[7] See Granger and Ter¨asvirta (1993) and Franses and van Dijk (2000) for reviews.

[8] See Giot and Laurent, 2001 and Mittnik and Paolella, 2000 among others.

The log-ARCH of Geweke (1986) and Pentula (1986), when $\delta \to 0$. Sebastien Laurent (2003) analytically derived APARCH model properties.

This paper uses the TARCH model to investigate asymmetric oil shocks on resource allocation in Iran's economy. In the next section, we discuss TARCH model specification further and then estimate the model's parameters. The results support our assumption of the asymmetric effect of oil shocks in Iran's economy.

5.2. TARCH model

For most economic phenomena, especially equities, it is often observed that downward movements in the market are followed by higher volatilities than upward movements of the same magnitude. The threshold ARCH (TARCH) model, introduced by Zakoian (1990) and Glosten, Jaganathan, and Runkle (1993), can explain this asymmetric effect. The specification for the conditional variance is as follows:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 d_{t-1} + \beta\sigma_{t-1}^2 \qquad (6)$$

where d_{t-1} if $\varepsilon_t < 0$, and otherwise. In this model, good news, $\varepsilon_t > 0$, and bad news, $\varepsilon_t < 0$, have different effects on the conditional variance: good news has an impact of α, while bad news has an impact of $+\gamma$. If $\gamma > 0$, we say that the leverage effect exists. If $\gamma \neq 0$, the news impact would be asymmetric. For the higher-order specification of the TARCH model, we can estimate the following model:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 d_{t-1} + \sum_{j=1}^{p} \beta\sigma_{t-j}^2 \qquad (7)$$

The estimated TARCH (1,1) model results are reported in Table 2. The results show that RER has an asymmetric behavior, indicating oil income had an asymmetric effect on relative prices in Iran's economy during the last decades.

Table 2. Result for TARCH (1, 1).

Mean Equation	$RER_t = \alpha + \beta RER_{t-1} + \gamma DUMoil_t + \varepsilon_t$			
	RER_{t-1}	$DUMoil_t$	R^2	$D.W$
	0.99 (52.4)	0.01 (1.24)	0.9	2.13
Variance Equation	$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 d_{t-1} + \sum_{j=1}^{p} \beta\sigma_{t-j}^2$			
	Const.	ε_{t-1}^2	$\varepsilon_{t-1}^2 d_{t-1}$	σ_{t-1}^2
	–6.53E–06 (–0.99)	–0.165 (–2.6E+100)	0.151446 (20.03)	1.24 (1.52E+102)

Note: Dummy variable stands for revolution. It takes zero for before 1979 and one thereafter.

The leverage effect term (γ) is significantly positive, showing the asymmetric effect of oil income on relative prices in Iran's economy during the three last oil shocks.

5.3. GAR model

A more general form of nonlinear autoregressive model (NLAR) is GAR given by:

$$y_t = \alpha_0 + \sum_{i=1}^{p}\alpha_i y_{t-i} + \sum_{i=1}^{p}\sum_{j=1}^{p}\sum_{k=1}^{r}\sum_{l=1}^{s}\alpha_{ijkl}\, y_{t-i}^k y_{t-j}^l + \varepsilon_t \qquad (7)$$

where p is the order of the process, and r and s are integers greater than or equal to one. This process extends AR(p) capable of several functional forms[9]. In this paper, we estimated a GAR (2). The results are reported in Table 3.

Table 3. Results for GAR (2) model.

$R(-1)$	$R(-2)$	$R(-1)*R(-2)$	$R(-1)^2$	$R(-2)^2$	$R(-1)^2*R(-2)$	$R(-2)^2*R(-1)$	R^2	**D.W.**
–16.79 **[–2.02]**	**18** **[2.14]**	**16.32** **[2.49]**	**–30.32** **[–2.14]**	**13.55** **[1.98]**	**–29.62** **[–1.99]**	**29.3** **[1.99]**	**0.88**	**1.89**

Note: R stands for the real exchange rate (RER), and numbers in prentices are t-statistics.

[9] AIC and SBC can be used to choose optimal lags.

The results show that RER depends on degree one and two lags. While the first lag has a significant negative effect, it positively correlates with the second one. Terms for asymmetry, i.e., $R(-1)^2 * R(-2)$ and $R(-2)^2 * R(-1)$ show that at 95% of probability.

6. Conclusions

Over the past decades, developing countries rich in natural resources have performed significantly less well in economic terms than resource-poor ones. According to existing literature, resource abundance lowers economic growth.

Dutch disease models describe the negative effect of oil revenues on resource allocation in exporting countries. Oil has had a dominant role in Iran's economy during the last decades. Oil income had reshaped the whole economy and changed the role of the public sector after it became the primary source of foreign exchange and public revenue. Using the cointegration approach, we showed that oil revenues determined relative prices in Iran's economy. The results show that contrary to purchasing power parity, the real exchange rate is not only constant but also changes fundamentals such as oil income capital outflow, which varies underlying demand and supply in the real sector and changes relative prices.

Oil shocks have different implications for importing and exporting economies. Nevertheless, the asymmetric effect of oil shocks on both economies is a standard feature. Fiscal rigidity of state causes positive and negative oil shocks to have different effects on exporting countries. This paper used nonlinear time series models to show the asymmetric effect of oil shocks on resource allocation in Iran's economy. Estimated GAR and TARCH models show that positive and negative oil shocks do not affect relative prices in Iran's economy.

Sanctions on Iran's economy show that sanctions had a significant adverse effect on the government budget, resulting in an exchange rate jump during the last decade. Although it was expected that local currency devaluation has a positive effect on export, investigations show that sanctions harmed export momentum similar to adverse oil shocks. Our results are consistent with studies investigating the effect of sanctions on sanctioned economies.

The results imply that the government should conduct contradictory fiscal policies during positive oil shocks. A sovereign wealth fund (SWF) could be used to buffer positive oil shocks. In the time of positive oil shocks, extra funds could be reserved in SWF and used in the time of negative oil shock. Meanwhile, the size of the government budget should be modified. The government should also be committed to implementing resilience economy policies.

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