

OIL WEALTH AND ECONOMIC BEHAVIOR: IRAN 1960-2000

NILOUFAR ENTEKHABI

Avril 2002

Abstract

The purpose of this research is to examine the short-run macroeconomic implication of natural resource availability in the case of an oil exporting developing country, Iran. We will examine how the economy of such a country is influenced by variations in the flow of income generated by oil resources and could lead to a higher disturbance of the economy, greater in intensity and longer in duration.

Université de Montréal

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Sommaire

Cette étude a comme principal objectif d'analyser le comportement d'une petite économie ouverte, en voie de développement, exportatrice de pétrole, face à un choc exogène sur les prix du pétrole et les effets de ce choc sur l'ensemble de son économie. Plus particulièrement, l'analyse porte sur ce que l'on appelle le "Syndrome Hollandais" dans un pays riche en matière première.

Nous nous basons sur des données économiques iraniennes de 1960 à 2000, période durant laquelle l'économie iranienne a connu des événements très variés: l'alliance avec l'OPEC, la crise pétrolière de 1973, la Révolution Islamique de 1979, la guerre imposée avec l'Iraq (1980-1988), la guerre du Golfe de 1990, et finalement le développement du pays à la fin du 20 ième siècle.

Notre travail est organisé comme suit.

Dans une première partie, nous présentons une brève revue de la littérature sur le Syndrome Hollandais et sur l'histoire de l'économie Iranienne. Dans la section 2, nous présentons le modèle à l'aide d'un système d'équations simultanées. Nous l'estimons à partir des données iraniennes en testant sa validité grâce à des simulations dynamiques. Nous présentons les résultats dans la section 3.

Nous trouvons, entre autre, qu'un boom sur le prix de pétrole mène à une augmentation des dépenses dans le tertiaire (même si elle est faible), et à plus long terme à une augmentation du niveau des prix dans ce même secteur qui aboutira à une diminution de la production intérieure à long terme.

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This is my dedication to my mother, Shahin Banou Vazirzadeh.

Abstract

The purpose of this research is to examine the short-run macroeconomic implication of natural resource availability in the case of an oil exporting developing country, Iran. We will examine how the economy of such a country is influenced by variations in the flow of income generated by oil resources and could lead to a higher disturbance of the economy, greater in intensity and longer in duration.

We develop a model for the Iranian economy with time series annual data for the period 1960-2000. The choice of our sample study is based on the characteristics of the Iranian economic behavior during this period. From alliance with OPEC (1960) to the oil shock of 1973, the Islamic revolution of 1979 and the war with Iraq (1980-1988), Gulf attack of 1990 and the recent development of the country at the turn of the century, Iran has experienced different expansion and recession periods.

The paper is organized as follows. At the beginning we will introduce to the big push literature. The first section is a brief review of the Iranian economy. Section 2 introduces the model and its specification. We replicate the model with the Iranian data and try to highlight the reliability of it through some dynamic simulation in section 3 and 4 respectively. The results of the simulation, among other findings, indicate that the impact of an oil boom on the national income, however small, leads to an extra spending on non traded goods, raises their prices and decreases the home production ultimately.

All the technical notes, our detailed tests and data constructions are in the appendices.

KEY WORDS: Big push; Dutch Disease.

INTRODUCTION

Low-income equilibrium traps are important in economic development, so a big push is necessary for development. Natural resource booms can then be potentially important catalysts for growth and development. The big push literature, exemplified by Rosenstein-Rodan (1943, 1961) and Murphy et al. (1989), stresses that poor economies need some sort of large demand expansion. Whether it comes from a large public spending program, foreign aid, discovery of minerals or a rise in the world price of a natural source, it should expand the size of the market so that the entrepreneurs find profitable to incur the fixed costs of industrialization. Sachs and Warner (1999) try to take some examples from the seven Latin American countries and demonstrates that natural resource booms are sometimes accompanied by declines in per capita GDP. Gordon and Neary (1992) try to separate the two effects of a boom: the spending effect and the resource movement effect. They assume that the income gains from a boom are spent by the factors that directly gain real incomes. The spending effect is sensitive to the manner in which the government spends its extra revenue. Wijnbergen (1984) claims that higher oil revenues in oil exporting Gulf countries is like a transfer, where a higher transfer leads to excess demand for non-tradable goods. The domestic spending of these revenues increases aggregate demand for tradable and non-tradable goods and would lead to an increase in import and eventually the prices. In the absence of any exchange rate adjustment, prices of tradable goods are determined from outside and most of the inflationary pressure is reflected in higher prices for non-tradable goods. The important question is to what extent the increase in government expenditures, resulting from extra oil revenue, could be absorbed into the economy and could increase the output and not the prices.

In this research, we look at the big push, coming from an oil boom on the economy of one the biggest oil exporting countries, Iran. Through a macroeconomic model for the whole country, a simultaneous system of behavioral equations, we try to trace the effect of an oil shock on the model. We will see that the answer is clearly dependant on the size of the increase in oil revenues as well as the choice of the development projects undertaken by the government and the absorptive capacity of the economy. Furthermore, the exhaustibility of the oil resource affects both the choice of domestic development strategy and the mode of participation in the international adjustment process. The economy of such a country is dependent on the rest of the world for trade, investment, transfer of technology and flows of labor. At the same time, its oil production and pricing affect the consuming countries. No other mineral is so lucrative for the world market, has such a large economic rent, or is as vital for the maintenance of economic power, military strength and political forces as oil. So there is a vital need for cooperation and collaboration between Iran and the rest of the world.

1 IRAN AT A GLANCE

The economic development of a country is influenced not only by its geography, but also by the availability, richness and variety of its raw material endowments.

Iran is endowed with 92.6 billion barrels of proven oil reserves, or roughly 9% of the world's total reserves¹. However, with the discovery of Azadegan oil field, this amount increased to at least 100 billion barrels, placing Iran as the second largest oil producer in the Middle East, and fourth in the world, accounting for about 27% of Mideast, and more than 10% of global production. It is also the second largest world oil exporter after Saudi Arabia². Oil production started in 1908 in Naftoon region of Masjed Soleyman in southern Iran[7]. The vast majority of Iran's crude oil reserves are located in giant onshore fields in the Khuzestan region near the Iraqi border and Persian Gulf terminus.

From the first concession for exploitation of oil in Iran, granted by Nassereddin Shah (Qajar dynasty) to Julius de Reuter (1872) up to the present day, the oil and gas sector has supplied the lifeblood and driving force of the economy and the growth performance of the Iranian economy, which hence owes much to the behavior of this sector.

The ownership and exploitation rights to petroleum deposits in Iran belong to the state, since the nationalization of this industry led by Dr. Mohammad Mossadeq in 1956. The Anglo-Iranian Oil Company (AIOC) was dissolved and the British ownership and influence on Iran's oil industry was terminated. On March 19th, 1951 (29th day of Esfand 1329, Persian Calender) the first national oil company in the Middle East, National Iranian Oil Company (NIOC), was established. From that time, the state has been the sole owner-producer, and oil export earnings go directly to the national treasuries.

In 1960, following a cut in the posted price³ of oil in the Persian Gulf by the Consortium⁴, Iran, Iraq, Saudi Arabia, Kuwait and Venezuela gathered in Cairo and formed the Organization of Petroleum Exporting Countries (OPEC) as a defense mechanism against erosions of their oil revenues in the hands of the Oil Majors. The OPEC basket (a term given by the Geneva agreements I & II), which contained the 11 currencies, took the Arabian light crude (API 34⁰) as the representative. In the 1960, Iran experienced one of the most rapid and most fundamental socio-economic transformations in modern times. Of all the OPEC members, she also had the most profound transformation between 1974 and 2000.

In the first oil boom in 1973, Iran adopted a proscriptive plan for the public sector

¹Mash'al, publication of Oil Ministry, Sept.2000, No.183, page 30.

²BP statistical review, 2001.

³The price at which royalties and taxes were calculated.

⁴Consortium of Western Oil Companies was established in 1954 to recognize the principle of nationalization and the 50-50 profit sharing formula. It was led by the British Petroleum Company. It was given a 40 percent interest in the consortium, followed by Royal Dutch Shell (14 percent), five major American oil companies, and Compagnie Francaise des Petroles (six Percent).

and an indicative plan for the private side. The bulk of oil revenues was earmarked for direct, public, fixed capital formation in specific fields, and the private sector was induced through incentives and assistance to invest in other fields. The first oil shock began with a big-push industrialization, it has been ended by an oil bonanza and new rich generation. Between 1974-1979, Iran had a mixed economy, where both public and private sectors had their roles to play: it was a free-enterprise economy guided by the state. Most of the windfall was spent domestically and the adjustment process was through domestic absorption plus a reduction in some import taxes.

The 1979 Revolution resulted not only in the regime's change from a constitutional monarchy to a theocratic republics, it also increased the uncertainties regarding private property, free enterprise, the rule of law and the direction of the economy.

The post-revolution economy was still mixed, but the emphasis was directed toward self-sufficiency and redistributive justice. The Iran/Iraq war, starting in 1980, caused a decline in the global oil supply and became the second oil bonanza. The economic policy during this period developed a policy of import substitution. A consumption model emphasizing the avoidance of luxury consumption items was formulated by the government to guide the peoples' daily life.

After the cease-fire with Iraq (1988), Iran's Oil industry operated at less than 40% of its capacity. So the government decided to adopt a peacetime strategy of reconstruction. The new first five-year plan for 1989-1993 was ratified in 1990, with a priority to oil and gas industry[7].

The third oil boom, with the Gulf war (1990), lead the country to foreign debt. Believing that the oil price rise would continue, the government opened the imports gate, using short term export credits. Imports almost doubled in the following year and brought the country into short-term debt. Confronted with severe macroeconomic imbalances, including depressed oil prices, declining reserves, rising prices, external deficits and limited access to the world capital market, Iran was not able to inaugurate her constructive plan in 1994⁵. So the economy was subjected to renewed economic restrictions and regulations. The government introduced a new dual exchange rate system, reimposed import and export controls, reinstated non-oil exporters' obligation, banned all exchange transactions outside the official channels, established strict allocation of oil revenues at the new official exchange rate of rial, Rls 1750=\$1 and set the rate for all other transactions at rial, Rls 3000=\$1. The pace of privatization was also considerably slowed, and the attraction of foreign private investment faced new resistance. In sum, the state's intervention intensified during this period. In 1995, President Clinton signed executive orders prohibiting U.S. companies and their foreign subsidiaries from conducting business with Iran, while banning any "contract for the financing of the development of petroleum resources", located in Iran. The U.S. Iran-Libya Sanctions Act (ILSA) of 1996 imposes mandatory and discretionary sanctions on non-U.S. companies investing more than \$20 million annually in the Iranian oil and gas sectors. Iran was hit hard by record-low oil prices during 1998

⁵Second five year plan

and early 1999, but with the rebound in oil prices since then, has recovered to a large degree. For 2000, Iran's real GDP grew by around 4.5%-5%⁶. Iran's currency, the rial, has been relatively strong as well and the country enjoyed large trade surpluses. Crude oil production remained at 3.6 million barrels per day (mbbl/d) in 1999/2000, in line with the quota set by OPEC from 1993/94. A modest increase in domestic consumption in combination with a decline in exports of refined products maintained crude oil exports at 2.44 million barrels per day (mbbl/d) during these years. The average price of crude oil exports was approximately US\$20 per barrel during this period⁷. Domestic consumption of petroleum grew during this period. To supply the domestic market with refined products, to reduce the dependence of crude oil exports and to concentrate on export products with higher value added, Iran has continued to expand its domestic refining capacity. In addition to the development of domestic refineries, the government has sought to promote expansion of the petrochemical industry, which also generates products with higher value added. Non-oil exports have increased significantly in 90s'. The country was also hoping to attract billions of dollars worth of foreign investment by creating a more favorable investment climate (i.e., reduced restrictions and duties on imports, creation of free-trade zones). The Iranian constitution prohibits the granting of petroleum rights on a concessionary basis or direct equity stake. However, the Petroleum Law permits the establishment of contracts between the Ministry of Petroleum, state companies and local and foreign natural persons and legal entities. Buyback contracts are the most efficient contracts for the moment. In this arrangement, the contractor funds all investments, receives remuneration from NIOC⁸ in the form of an allocated production share and then transfers operation of the field to NIOC once the contract is completed. This system has drawbacks for both sides; by offering a fixed rate of return, NIOC bears all the risk of low oil prices. If prices drop, NIOC has to sell more oil or gas to meet the compensation figure. At the same time, companies have no guarantee that they will be permitted to develop their discoveries.

Now with this general idea on the Iranian economy, we develop our model economy in the next section.

⁶IMF staff papers, No. 98/27, 2001.

⁷BP statistical review, 2000.

⁸National Iranian Oil Company

2 THE MODEL

Our model is based on the one developed by Vaez-Zadeh (1989) for Venezuela. We replicate the model with Iranian time series 1960-2000. We add a behavioral equation for investment. Investment is a volatile variable and will help to highlight the dynamics of adjustment after some exogenous shocks more rapidly.

The model consists of eight behavioral equations and two identities, explaining 10 endogenous variables. Furthermore, seven exogenous variables will be used with the lagged values of our endogenous variables (given from the past period). What will distinguish our research from the previous papers in this field, are our methodology in treating the time series, the econometrics approach we will use and our dynamic simulations. We begin our work by a preliminary analysis of our data set. The results are all in appendix III. Our level data test does not reject the null hypothesis of a unit root for any choice of variable. However, the first differences of the data became stationary. For this reason, we estimate our model not in the level but in the first difference. The Δ , later in the text, is the operator of the first difference.

The equations are all log linear. In the description of the model and then later in the text, lowercase letters refer to the logarithms of the variables represented by the corresponding uppercase letters⁹. Sign -1, in front of some of the exogenous variables means the one-period-lagged value.

All the variable, but oil price, are measured in the local currency, rials.

The model is estimated by the two stage least squares method¹⁰, where the endogeneity of the variables have been tested by running a Hausmann test on the first differences of the variables.

The cointegration test highlights the long run relationship in three out of our ten equations. We estimate these equations by the error correction models¹¹.

The choice of our country has been inspired by a personal interest. However, the availability and reliability of the data made the research subject to some quantitative restrictions.

The definitions of the relevant variables are presented in Table 1.

⁹Only the interest rates are not in logarithmic form.

¹⁰Once the endogeneity is accepted, the OLS estimator are no longer consistent and we estimate our system by TSLS (see appendix II for technical notes).

¹¹We correct for the long run relationship by this method.

Table 1. The Variables

Variables	Definition
Endogenous	
GE	Government expenditure
DR	Domestic revenue
GR	Government revenue
P	Domestic price level
P ⁿ	Price of nontraded goods
E	Private expenditure
IM	Imports
I	Investment
M	Money supply (Liquidity)
Y	Domestic real income
Exogenous	
P ^t	Price of traded goods
Cr	Credit to private sector
r	Rate of return on five years deposits
OR	Government oil revenue
fr	Foreign interest rate (one month US. deposit, London offer)
Gnoil	Non oil growth
Exp	Exports (non oil)
GE ₋₁	Government expenditure lagged value
DR ₋₁	Domestic revenue lagged value
L ₋₁	Investment lagged value
E ₋₁	Private expenditure lagged value
M ₋₁	Liquidity lagged value

(See the appendix IV for the construction of the variables).

The complete model contains ten equations, eight of which are behavioral and two are identities, determining ten endogenous variables. The model is estimated by the two stage least squares method (TSLS) for the period 1960-2000, using annual data. However, by our preliminary analysis of the data, it has been shown that equations 1, 2 and 8 are cointegrated. We estimate them by an error correction model (See appendix II and III for more details).

The ten equations of the model are listed in Table 2.

Table 2. The Stochastic Equations

1.	$\Delta ge_t = \alpha_0 + \alpha_1 \Delta gr_t + \alpha_2 \Delta ge_{t-1}$ $\alpha_1, \alpha_2 > 0$
2.	$\Delta dr_t = \beta_0 + \beta_1 \Delta y_t + \beta_2 \Delta dr_{t-1}$ $\beta_1, \beta_2 > 0$
3.	$\Delta gr_t = \gamma_0 + \gamma_1 \Delta or_t + \gamma_2 \Delta m_t$ $\gamma_1, \gamma_2 > 0$
4.	$\Delta p_t = c_0 + c_1 \Delta p_t^n + c_2 \Delta p_t^t$ $c_1, c_2 > 0$
5.	$\Delta p_t^n = d_0 + d_1 \Delta m_{t-1} + d_2 \Delta y_t + d_3 \Delta (p^t - p^n)_t$ $d_1 > 0, d_2 < 0, d_3 < 0$
6.	$\Delta e_t = h_0 + h_1 \Delta m_t + h_2 \Delta y_t$ $h_1 < 0, h_2 > 0$
7.	$\Delta im_t = k_0 + k_1 \Delta ge_t + k_2 \Delta e_t + k_3 \Delta (p^t - p^n)_t$ $k_1, k_2 > 0, k_3 < 0$
8.	$\Delta i_t = m_0 + m_1 \Delta r_t + m_2 \Delta fr_t + m_3 \Delta gnoil_t + m_4 \Delta i_{t-1}$ $m_1, m_2 < 0, m_3 > 0$ and $0 < m_4 < 1$.
9.	$\Delta m_t = ge_t - dr_t + cr_t + exp_t - im_t$
10.	$y_t = ge_t + e_t + i_t + exp_t - im_t$

(Here we add the error correction terms in equation 1, 2 and 8).

2.1 Equation 1: Government Expenditures

This dynamic equation highlights the variation of the government expenditure with the government revenue and the adjustment, which takes place with its lagged value. By the error correction term which we add at the end, one could argue that there is a long run, historical average relation between the variables, in which the difference between the lags of variables, would be a stationary random variables, even though the variables by themselves exhibit a unit root.

$$\Delta ge_t = \alpha_0 + \alpha_1 \Delta gr_t + \alpha_2 \Delta ge_{t-1} + \alpha_3 (gr_{t-1} + ge_{t-1} + c) \quad (1)$$

Where $\alpha_1 > 0, 0 < \alpha_2 < 1$ and $\alpha_3 < 0$.

Government Expenditure is assumed to be planned on the basis of a balanced budget policy in each period. It means that the government does not issue debt and in the long run, the authorities desire to spend all of the available revenues. In the short run, expenditures are adjusted with a lag to any changes in previous expenditures.

Government revenues have two components:

1. Oil revenue which can be considered exogenously and could lead to monetary expansion.
2. Domestic revenue that is related to non-oil income and comes basically from direct taxes on income and properties and indirect taxes on trade. These taxes are

generally adjusted in line with the increase in income. These lags may conduct to the creation of large budgetary deficits and lead to higher rate of monetary expansion and result an increase in the inflation rate.

2.2 Equation 2: Government Domestic Revenue

This dynamic equation highlights the variation of the government domestic revenue, coming from direct and indirect taxes, with the adjustment of these revenues with its lagged value.

$$\Delta dr_t = \beta_0 + \beta_1 \Delta y_t + \beta_2 \Delta dr_{t-1} + \beta_3 (y_{t-1} + dr_{t-1} + c) \quad (2)$$

With $\beta_1 > 0, 0 < \beta_2 < 0$ and $\beta_3 < 0$.

Non oil revenue is the value added of the economy excluding the oil sector.

2.3 Equation 3: Government Revenue

Total government revenue is mostly a function of oil revenue and the level of monetary expansion.

$$\Delta gr_t = \gamma_0 + \gamma_1 \Delta or_t + \gamma_2 \Delta m_t \quad (3)$$

where $\gamma_1, \gamma_2 > 0$.

The sale of oil generates foreign currency to the government and increases total revenue. Any budgetary deficit could be financed almost entirely through borrowing from the central bank¹² with zero interest, no-maturity loans. In accordance with Islamic banking, the government does not sell treasury instruments to the private sector as a means for auto-financing. However, it plans to issue "participation certificates" to finance infrastructure and other capital outlays. The oil revenue could increase the liquidity demand and consequently lead to a monetary expansion.

2.4 Equation 4: Domestic Price

The domestic price level P is the weighted average of the prices of traded and non-traded goods.

$$\Delta p_t = c_0 + c_1 \Delta p_t^n + c_2 \Delta p_t^t \quad (4)$$

With $c_1, c_2 > 0$.

This equation is, to some extent, a feature of the domestic inflation. The price of traded goods is determined exogenously in the world markets. It is the weighted average of trading partners' export prices adjusted for exchange rate¹³. Non-traded goods are so costly to ship that they do not enter international trade. Services, local

¹²Bank Markazi

¹³See the appendix II for more details.

transport and handicrafts are the example of these goods. In this research, we use the home good price index, as an approximation for the non-traded prices. These prices result from variations in money market disequilibrium or from changes in the excess of demand over potential supply in the good markets.

An improvement in the real exchange rate, in favor of non-traded goods, could be expected to stimulate the supply of non-oil output. Non-traded goods make up the bulk of domestic non-oil production. However, the increase in the relative price of non-traded goods may shift the consumption pattern away from such commodities, and thus induce a cutback in production.

2.5 Equation 5: Non-traded Goods Prices

The price of non-traded goods is given by money market.

$$\Delta p_t^n = d0 + d1\Delta m_{t-1} + d2\Delta y_t + d3\Delta(p^t - p^n)_t \quad (5)$$

Where the expected coefficients have the following signs: $d1 > 0$, $d2 < 0$, $d3 > 0$.

The relative price of nontraded goods would be determined by the interaction of supply and demand. We assume that the price of non-traded goods is adjusted to equilibrate the domestic market. Any excess of money increases the pressure on the price of non-traded goods. Any rise in the price of traded goods, coming from international market, leads the demand away from this goods and pushes the price of non-traded goods in the domestic market. As a result the demand and hence the price of non-traded increase. It is important to note that non-tradable goods can not be transformed into capital, so they could not trace the adjustment process of the economy.

2.6 Equation 6: Private Consumption

Private consumption is a function of real money supply and real income. In oil exporting countries, any boom due to an increase in oil prices would not be absorbed in the economy. In most cases, it would increase the consumption, that is the Dutch Disease phenomenon.

$$\Delta e_t = h0 + h1\Delta m_t + h2\Delta y_t \quad (6)$$

Where $h1 < 0$, $h2 > 0$

In this monetary version of expenditure function, a disequilibrium in money market directly affects real expenditure, in contrast to a Keynesian version, in which an excess supply of money affects expenditure through the interest rate channel.

Oil exports and oil revenue have negligible domestic value added, so they do not contribute directly to the income of the domestic residents until is spent by the government.

2.7 Equation 7: Real Import

This dynamic equation demonstrates the pattern of real import. We want to see how the imports of our country are influenced by the government and private consumption, and furthermore by the change in the relative prices.

$$\Delta im_t = k_0 + k_1 \Delta ge_t + k_2 \Delta e_t + k_3 \Delta (p^t - p^n)_t \quad (7)$$

With $k_1, k_2 > 0, k_3 < 0$.

In other words demand for imports is specified as a function of government expenditures and private consumption. Any excess supply of, or demand for, money is partly satisfied through the adjustment of private expenditure and imports.

2.8 Equation 8: Real Demand for Investment

This equation reveals the adjustment process of our economy. Investment is the more volatile variable in our model economy.

$$\Delta i_t = m_0 + m_1 \Delta r_t + m_2 \Delta fr_t + m_3 \Delta gnoil_t + m_4 \Delta i_{t-1} + m_5 (i_{t-1} + r_{t-1} + fr_{t-1} + gnoil_{t-1} + c) \quad (8)$$

with $m_1, m_2, m_5 < 0$ and $m_3 > 0$ and $0 < m_4 < 1$.

Most studies of investment behavior in Developing Countries do not include interest rates as an explanatory variable. The reason is the lack of adequate information. Our economy is governed under Islamic banking. We consider the rental price of capital in government constructive projects as the interest rate. In each period, the Central bank may adjust the interest rate to a level consistent with its policy objectives. Our economy, as a small economy, is influenced by the foreign interest rate of a big economy such as the US. So we consider this variable in our model. The Dutch Disease literature indicates that the oil revenue growth in a developing country would not lead to an increase in investment projects and would be absorbed totally by the consumption expenditure of the households. However, the non oil economic growth would lead to an increase in investment.

Equations 9 and 10 are identities included in the model. The broad money identity in equation 9 is:

$$\Delta m_t = ge_t - dr_t + cr_t + exp_t - im_t \quad (9)$$

Because of limited sources of financing in many of the developing countries, changes in the budget deficit are correlated with the rate of money creation. It implies that monetary and fiscal policies must be coordinated and can not be chosen independently.

The real income identity in equation 10 is as follows:

$$y_t = ge_t + e_t + i_t + exp_t - im_t \quad (10)$$

We have excluded oil exports from the definition of income. However, their effects are captured by the bias of the government expenditure in our model.

3 EMPIRICAL RESULTS

This section presents the results of our estimations. The behavioral relationships are in general well estimated and the model as a whole appears to capture the essential features of the Iranian economy.

All of our estimations are in growth rate, which is very common for macroeconomic data. The t-statistics in the parentheses should be compared with $t_{n-k,0.05}$ ($t_{30,0.05} = 2.002$).

We have a dynamic system of the form Vector Autoregressive. Equation 1, 2 and 8, which have shown the cointegrations, are estimated by the use of an error correction model.

The rest of the system will be estimated by the two stage least squares method and takes the following variables as instruments:

$$p^t, cr, or, fr, gnoil, exp, ge_{-1}, i_{-1}, e_{-1}, m_{-1}.$$

The choice of the instruments is based on their relevance and consistency; high correlation of the instruments with endogenous variables and low correlation among themselves (For a more detailed discussion, see the appendix II and III). The estimation results are summarized in Table 3.

As we don't work in an Ordinary Least Squares environment, the standard test statistics, such as R^2 and D.W., are no longer valid. However, it is common to use other measures to test the validity of our model. We will present the correlation between actual and fitted values of stationary data in Table 4. The residuals of our estimation are depicted in Figure 4 of Appendix V. We want to have a white noise (stationary) form of the residuals.

Table 3. Estimation

1.	$\Delta ge_t = 0.0006 + 0.129 \Delta gr_t + 0.014 \Delta ge_{t-1} - 0.42$ <p style="text-align: center;">(0.18) (1.09) (0.09) (-2.35)</p> $(gr_{t-1} - 0.75 ge_{t-1} - 0.06)$ <p style="text-align: center;">(-4.91)</p> $R^2 = 0.39 \quad AIC = -0.23$
2.	$\Delta dr_t = 0.015 - 0.34 \Delta dr_{t-1} + 0.23 \Delta y_t - 0.57$ <p style="text-align: center;">(-4.34) (-1.71) (1.13) (-2.2)</p> $(dr_{t-1} - 2.002 y_{t-1} + 0.18)$ <p style="text-align: center;">(-3.94)</p> $R^2 = 0.54 \quad AIC = 0.32$
3.	$\Delta gr_t = -0.087 + 0.058 \Delta or_t + 1.22 \Delta m_t$ <p style="text-align: center;">(-0.47) (0.63) (1.39)</p> $R^2 = 0.08 \quad D.W = 2.1$
4.	$\Delta p_t = 0.02 + 0.82 \Delta p_t^n - 0.062 \Delta p_t^t$ <p style="text-align: center;">(0.21) (1.29) (-1.29)</p> $R^2 = 0.89 \quad D.W = 1.29$
5.	$\Delta p_t^n = -0.013 + 0.13 \Delta m_{t-1} + 0.65 \Delta y_t + 0.01 \Delta (p^t - p^n)_t$ <p style="text-align: center;">(-0.13) (0.18) (0.72) (0.017)</p> $R^2 = 0.128 \quad D.W = 1.23$
6.	$\Delta e_t = -0.01 - 0.055 \Delta m_t + 0.43 \Delta y_t$ <p style="text-align: center;">(-0.01) (-0.055) (0.43)</p> $R^2 = 0.18 \quad D.W = 1.26$
7.	$\Delta im_t = 0.14 - 0.24 \Delta ge_t + 1.68 \Delta e_t - 1.32 \Delta (p^t - p^n)_t$ <p style="text-align: center;">(1.87) (-0.55) (1.39) (-0.5)</p> $R^2 = 0.34 \quad D.W = 2.37$
8.	$\Delta i_t = -0.007 - 0.15 \Delta i_{t-1} - 1.3310^{-6} \Delta r_t - 0.32 \Delta fr_t +$ <p style="text-align: center;">(-0.13) (-0.15) (-0.04) (-1.28)</p> $0.29 \Delta gnoil_t - 0.039 (i_{t-1} + 6.410^{-5} r_{t-1} + 0.49 fr_{t-1} -$ <p style="text-align: center;">(-1.28) (-0.32) (3.33) (1.93)</p> $1.98 gnoil_{t-1} - 0.48)$ <p style="text-align: center;">(-3.33)</p> $R^2 = 0.25 \quad AIC = 0.5$
9.	$\Delta m_t = ge_t - dr_t + cr_t + exp_t - im_t$
10.	$y_t = ge_t + e_t + i_t + exp_t - im_t$

Table 4. Correlation Between Actual and Fitted Values, 1960-2000

Variable	Correlation
Δge_t	0.45
Δdr_t	0.31
Δgr_t	0.29
Δp_t	0.49
Δp_t^r	0.51
Δe_t	0.47
Δim_t	0.68
Δi_t	0.34
Δm_t	1
y_t	1

The greater the correlation, the better is the estimation. However, there is a lot of debate over the meaning of a greater correlation. Our results in any case seem satisfactory.

3.1 Government Expenditure

$$\begin{aligned} \Delta ge_t = & 0.0006 + 0.129 \Delta gr_{t-1} + 0.014 \Delta ge_{t-1} - 0.42 \\ & \quad \quad \quad (0.18) \quad \quad (1.09) \quad \quad (0.09) \quad \quad (-2.35) \\ (gr_{t-1} - & 0.75 ge_{t-1} - 0.06) \end{aligned} \quad (11)$$

$$\quad \quad \quad (-4.91)$$

Our estimation indicates that any one percent growth in the government revenue, will lead to increase equal to 0.129 percent in government expenditures. Furthermore, for $\alpha_3 = -0.42$, our estimation asserts that had government expenditure previously been a larger than normal share of government revenue, government expenditure would be lower for any given values of the other explanatory variables. The term $(gr_{t-1} - 0.75 ge_{t-1} - 0.06)$ is viewed as the error from the long run equilibrium relation, and -0.42 gives the correction to government expenditure caused by this error.

This equation indicates that in the absence of any debt policy the government budget would be balanced over the longer term.

3.2 Domestic Revenue

$$\begin{aligned} \Delta dr_t = & 0.015 - 0.34 \Delta dr_{t-1} + 0.23 \Delta y_t - 0.57 \\ & \quad \quad \quad (-4.34) \quad (-1.71) \quad \quad (1.13) \quad \quad (-2.2) \\ (dr_{t-1} - & 2.002 y_{t-1} + 0.18) \end{aligned} \quad (12)$$

$$\quad \quad \quad (-3.94)$$

Domestic government revenue is based on direct and indirect taxes. This estimation indicates that one percent increase in non oil income will lead to an increase of 0.23 percent in domestic revenue. The correction term has the right sign and it has significant value at 5% critical value.

3.3 Government Revenue

$$\Delta gr_t = -0.087 + 0.058 \Delta or_t + 1.22 \Delta m_t \quad (13)$$

$$\quad \quad \quad (-0.47) \quad \quad (0.63) \quad \quad (1.39)$$

Government revenue is based on the oil revenue and the seignorage, or money creation. As the oil revenue is like an exogenous variable, due to the dependency on the market oil price, the only government instrument to respond to its need will be money creation. The government also collects a modest tax on domestic sales of petroleum products.

The estimated results assert that one percent increase in money expansion has a greater effect on the government revenue (1.22%) than one percent increase in oil revenue (1.22).

Whenever the need for the revenue was present, the authorities would implement the "classical quantity theory of money", which is to increase the monetary base by some factor $\lambda > 1$ (a "helicopter drop" of money) leaving all of the parameters of the economy fixed (including the fiscal policy parameters). This has to be shown the least costly experiment a government could afford.

3.4 Inflation

$$\Delta p_t = 0.02 + 0.82 \Delta p_t^n - 0.062 \Delta p_t^t \quad (14)$$

(0.21) (1.29) (-.129)

We use the variation of the price level (inflation) instead of the price level itself. This is due to some technical reasons (the suspicion about integration of degree 2, I(2)). Our result indicates the inflationary effect of the nontraded and deflationary effect of the traded goods.

The base year for the calculation of our price index was 1982. So it is normal that using this price index, we see a deflation in the previous period, before 1982. However in 1979-1980, Iran was confronted with a high inflation rate. As the classical monetary doctrine indicates, the sustained government deficits could be one of the major cause of that inflation. The small economy takes the price of traded goods as given. Over time, the evolution of the relative price of nontraded depends on the technology and the exogenous rental rate on capital.

Any increase in revenue will increase the demand and would lead to a real appreciation. Even in oil exporting countries where the financial markets do not work efficiently, this theory is still true. So, after the oil bonanza of the first oil shock, it was normal that the country experienced an appreciation (deflation) in its price level. This is what we call in our paper "a big push". Later in our results we try to highlight the effect of this push on our economy and to demonstrate what is called "Dutch Disease" in the economic jargon, in our model.

There are at least two reasons why the relative price of nontraded goods in terms of traded should increase with a country's income.

First, traded good production is relatively capital-intensive, where as nontraded goods are relatively labor intensive. While this may be true for some services, it is not true that all services are nontradable or that they are labor intensive. Financial services are sold at home and abroad by international banks, which make them tradable. However these services are not very popular in our study, or generally speaking in oil exporting developing countries. Furthermore, transportation and housing services which are in the category of nontraded, are evidently capital intensive.

Second, price of nontraded goods will increase when technological growth is biased toward the capital-intensive sector.

If either of these scenarios are realized, it follows that fast growing economies will experience a rising relative price of nontraded goods and a real appreciation over time.

It is noteworthy that Iran passed through the different phase for its exchange rate; from fixed to flexible and to dual. There is a presumption that any fixed exchange rate regime must eventually collapse. In this environment, the exchange rate is a policy variable. Income and money supply are endogenous variables. The monetary base is made up of the sum of the domestic credit and international reserves. In the absence of any other shocks, there is no long run change in the money supply and there is no long run change in output. Upon the initial expansion of the domestic

credit, the money supply does increase. The interest rate must remain fixed at the world rate, however; domestic residents are unwilling to hold additional money. They eliminate the excess money by accumulating foreign interest bearing assets and run a temporary balance of payments deficit. The domestic monetary authorities evidently have no control over the money supply in the long run, and monetary policy is said to be ineffective as a stabilization tool under a fixed exchange rate regime with perfect capital mobility. The increase in foreign interest rate has a contractional effect on domestic output and money supply. To defend the exchange rate devaluation, the monetary authorities could sell foreign exchange reserves.

3.5 Nontraded Prices

$$\Delta p_t^n = -0.013 + 0.13 \Delta m_{t-1} + 0.65 \Delta y_t + 0.01 \Delta (p^t - p^n)_t \quad (15)$$

(-0.13)
(0.18)
(0.72)
(0.017)

To get a better interpretation of the estimates, we will normalize this equation. We get:

$$\Delta p_t^n = 0.012 + 0.129 \Delta m_{t-1} + 0.559 \Delta y_t + 0.01 \Delta p_t^t \quad (16)$$

The estimation indicates that the money expansion will contribute to an increase in the price of nontraded goods. A one percent increase in non oil revenue will increase the non tradable prices by 0.559%. One percent increase in the traded goods price will lead the demand towards the nontraded goods. As the production capacity of the country, given the factor of production and the technology, is limited, this increase will lead to 0.559 percent increase in the price of the nontraded goods.

3.6 Private Expenditure

$$\Delta e_t = -0.01 - 0.055 \Delta m_t + 0.43 \Delta y_t \quad (17)$$

(-0.01)
(-0.055)
(0.43)

As we can see by this estimation, not all the money creation will lead to an increase in the private expenditure. Money creation creates inflation. In many developing countries with hyperinflation, the most important question is to what extent the hyperinflation results from the attempt by the government to collect seigniorage for financing its large budget deficit. In our case, we find 0.055%. One percent increases in money creation will decrease the private expenditure by 0.055%. A one percent increase in non-oil revenue however will increase the private expenditure by 0.43%.

The growth rate of money is equal to the rate at which nominal money holdings lose real value. Seigniorage is equal to the tax rate on real balances, times the amount being taxed.

3.7 Import

$$\Delta im_t = 0.14 - 0.24 \Delta ge_t + 1.68 \Delta e_t - 1.32 \Delta(p^t - p^n)_t \quad (18)$$

(1.87)
(-0.55)
(1.39)
(-0.5)

Government expenditure has little contribution in import. Among all the reasons, in our sampling, we believe that the most important factor is the import substitution policy implemented by the government in Iran. Through all the sanctions and trade embargo the country had faced, the percentage of changes in import is to decrease by 0.24%, whenever the government expenditure increase by 1%. The higher the income, the bigger is the private expenditure and the greater are the import. The sensitivity of the import to the private expenditure is 1.68%. This is the channel that highlights the “Dutch Disease” once again in our model. In developing countries, due to mismanagement of banking systems, political and financial instability and inflation, the households do not have any incentive to save their money through in banks. The people prefer to diversify their portfolios to decrease any associated risks. This could be the main reason why the theory of endogenous growth would not be effective in our economy. In certain developing countries, macroeconomic mismanagement is the primary cause of the crisis. The government faces short-term domestic financing constraints that it feels are more important to satisfy than long run maintenance of external balance. While this is not a completely satisfactory way to model the actions of the authorities, it allows us to focus on the behavior of speculators and their role in generating crisis. Speculators observe the decline of the central bank’s international reserves and time a speculative attack in which they acquire the remaining reserves in an instant. Faced with the loss of all of its foreign exchange reserves, the central bank is forced to abandon the peg and to move to a free-float rate. The speculative attack on the central bank during the final moments of the peg provokes a balance of payment, or a foreign exchange crisis. Concerning the prices, our equation is consistent with the reality. The higher the traded prices, which are the exogenous prices of the international markets, the lower is the import. Inversely, the higher the interior (the home prices) the higher is the import.

3.8 Investment

$$\Delta i_t = -0.007 - 0.15 \Delta i_{t-1} - 1.3310^{-6} \Delta r_t - 0.32 \Delta fr_t +$$

(-0.13)
(-0.15)
(-0.04)
(-1.28)

$$0.29 \Delta gnoil_t - 0.039 (i_{t-1} + 6.410^{-5} r_{t-1} + 0.49 fr_{t-1} -$$

(-1.28)
(-0.32)
(3.33)
(1.93)

$$1.98 gnoil_{t-1} - 0.48) \quad (19)$$

(-3.33)

This estimation for investment demand indicates the existence of the long run relationship in our model, where any devaluation will be corrected by an error correction term. All our estimation seems to have the right signs. The investment demand function is a function of changes in the level of output and the interest rate. Our model as a small open economy is influenced by the foreign interest in its allocating

decision. Whenever the marginal rate of capital in a foreign country is higher, investment is profitable abroad. We consider the non-oil growth of the economy in the investment decision. The reason is quite intuitive and simple. Any increase in the oil revenue will increase the consumption path and not the saving of the agents. Any decrease in saving will decrease the capital accumulation and decrease the investment ultimately.

4 SIMULATION

This section analyzes the results of various simulation exercises. The major objectives are as follows. First, to examine the overall explanatory power of the model. Second, to explore the impact of alternative policy scenarios on key macroeconomic variables. Finally, to predict the dynamic behavior of the economy.

For the purpose of investigating the overall performance of the model, the system of the estimated behavioral equations were simulated dynamically during the observation period, 1960-2000. In dynamic simulation, the lagged endogenous variables are generated by the model and the errors are accumulated over time. In static simulation, the actual values rather than fitted values are used and we can do the forecast “one-step-ahead”.

The simulation results for the endogenous variables are depicted in first set of charts. The comparison between the actual and fitted (simulated) variables suggests that the model as a whole tracks the economic development of our economy rather well. The turning points are in average well captured by the simulated results, sometimes with a leads and lags due to the lagged values in our model. However, the gaps between the actual and the fitted values do not seem to be excessive on average and the model follows the theoretical economy quit well.

To examine the effects of policy actions and changes in exogenous factors, we run a second set of simulations. We use the time path that would historically be predicted for the variables following an anticipated change in oil prices. We assume an oil price increase of 50% in 1986. After a positive shock in oil revenue, government revenue would be increased. We trace the effect of this shock to the overall system. An anticipated shock that generates the new value for the endogenous variable of the system. The economic agents have perfect foresight in our model and they are rational. We want to see the economic adjustment to a new equilibrium path under this anticipated shock.

Finally, we try to find the response of our economy to an unanticipated real exogenous shock. Is the effect of the shock permanent or transitory and, of the latter, how long would it last?

4.1 Comparing the Actual and the Fitted Values

In average, the model behaves well. The simulations are stationary as well and could be a good proxy for the economy as a whole.

For the government revenue the data are more volatile than the estimations. The domestic revenue follows the data with a lead and lag behavior. It could be due to the lagged value of the domestic revenue in the equation. However, for some observations, the estimation capture a better result than the data. We say that the model absorbs the shocks or the problem of data construction.

The price level shows a big deflation in 1978 before the Islamic Revolution. It

means that local currency was at its maximum value before the revolution. This unanticipated deflation would lead to a bigger gap in the wealth distribution of the country. This was one of the major reasons leading to the revolution of 1979. Those who lived on capital income tend to gain more, while wage earners, the middle class, tended to lose. The inflation is estimated around 18%, in 2000. Go back to the data, a 20% inflation is declared for 2000, so the model explains quite well. The non tradable goods, which are the home goods and services in our model, have flown a stable path in our economy, highlighting a good capture of our economy. Private expenditure, is high when the oil price is high and decline even though the prices fell in 1977-8. There is another symptom of Dutch Disease, the big push comes from abroad; even though the people are rich in average and the domestic prices are at their lowest historical level, the people would not increase their local demand, they will buy the luxuries from the foreign countries; a big push would not lead to industrialization.

The import level has increased after the first oil shock. This is evident in data and estimations. Then it attains its lowest level at the revolution era.

Investment is very volatile. It is influenced by the exogenous variables. When the interest rate is high, the cost of investment is high, so the investment expenditure will decrease. With the lack of financial markets in Iran, and generally speaking in oil developing countries, the investment is limited by the internal source. The foreign investment is very limited, partly because of the Iranian law and partly due to the high risks, political risks as well as financial risks.

The two last equations for identities lies on the historical data perfectly. We conclude that the model, with no loss of generality, behaves well.

(See figures 5-14).

4.2 A One Period Shock on Oil Prices

An important feature of our model and generally speaking, of all the structural adjustment models in developing countries, is that agents' expectations are forward-looking. These expectations are formed rationally for all relevant future variables. Furthermore, the simulations reports a stronger assumption of perfect foresight, since they are carried out in a nonstochastic environment.

Our simulation consists of a transitory increase in oil revenues due to an oil price increase. We choose 1987, where the oil prices has decreasesharply from 28 (\$/bl)¹⁴ to 16 (\$/bl). We assume that the oil price had increased by 50%, to 42 (\$/bl) in 1997. What would have been its effect on oil revenue, and ultimately on the economy as a whole? We will see that this is the amount needed to hold the oil price at its historical level.

We test this scenario:

$$or_t = or_t \text{ for } t < 1987$$

$$or_t = or_t + 50\%or_t \text{ for } t=1987.$$

¹⁴Dollar per barrel

The oil price shock influences our model implicitly via a change in government revenue. We will see that the anticipation of a higher revenue have macroeconomic effects in this model. Because of the forward-looking expectation hypothesis, the effects begin as soon as the expectations are formed.

(See figures 15-22).

Simulated government revenue fits his actual value for 1986 and will follow the estimation path in the aftermath of the shock. Domestic revenue which is based on taxes is not influenced by this increase. A comparison between the fitted and the simulated values for the price level reveals that an increase in oil revenue will induce to higher rate of inflation and this effect is more pronounced in non tradable goods prices. The tradable goods prices are taken exogenously as a weighted average of trading partners' export prices and would not capture any home good price change. In average, import is higher with a higher government revenue. The investment is much more volatile that can be rigorously traced by this change. *Ceteris paribus*, any increase in GDP, would increase the investment.

We brought back the results of this simulation to the level data as well.

4.3 Impulse Response to One-Standard-Deviation Innovation

In this section, we continue our simulation exercises. We want to trace the effects of a one-standard-deviation shock in oil revenue on current and future values of the endogenous variables.

A shock to the i -th variable directly affects the i -th variable, and is also transmitted to all of the endogenous variables through the dynamic structures of our system (Vector Autoregressive).

Figure 23 illustrates the response of the system to a one-standard-deviation shock in government revenue. We are looking to see how the economy behaves in the period after the shock and then in 20 successive periods.

A temporary rise in government revenue following an innovation in oil revenue has a permanent effect on our economy. The stationarity of the data set should not be forgotten. The shock will not last the same for all of our variables.

After a positive shock to the government revenue, the government expenditure will increase. This effect is transitory and will last for maximum ten periods. This transitory increase in spending is expansionary. Domestic revenue demonstrates more volatility after the shock. *Ex-post*, the government is richer and will decrease its consumer taxes. However, as the country becomes wealthier, the income based taxes and the oil taxes will increase. Price level increases after the first period and the inflationary impact of oil revenue will last for a long period. The increase in the relative price of non-traded goods may decrease the demand of such commodities and induce a cutback in their production. The dynamic response of non oil revenue (non oil GDP) (chart 27) is in an opposite side. An oil bonanza has never led to

an increase in production, at least at its first period. Output falls after the shock. After an oil shock and an increase in the government revenue, the private expenditure which is determined by the non-oil GDP and the money reserves may decrease. Private expenditure and import are highly correlated. Most of the import is for the consumption need and/or the luxury goods, with a large income elasticity. The effect will last for about 10 periods. The investment decreases sharply and could become even negative after the shock. Liquidity and the non oil production would decrease as well.

Throughout our simulation exercises, this shock, which can be a policy shock as well, has a positive but temporary effect on our economy.

5 CONCLUSION

In this paper, we have developed a macroeconomic framework to evaluate the impact of a rapid increase in oil revenues on the domestic economy of one of the oil exporting countries, Iran. Our results confirm that higher oil revenues were crucial in improving the growth of the economy. Because of limitations on excess capacity in the economy, the higher growth rates were accompanied by higher rates of inflation in the prices of nontraded goods. This is a version of "Dutch Disease". Given a fixed exchange rate, which we considered in our study, the increase in the prices of nontraded goods led to a reallocation of resources from the traded goods sector to the nontraded goods sector. Between the first oil shock and the revolution (1973-1979), non oil export had vanished, and imports as a proportion of income had grown substantially. The import substitution was limited to those industries that were afforded substantial protection. Our economy acted on its comparative advantage in oil. However, this policy ignores the fundamental difference between production of other goods and services. Oil resources represent a stock of capital assets in the economy. If the capital stock is not to be depleted, oil revenues should be invested, either domestically or abroad, to provide a flow of income over time. Whether capital should be consumed at all, is obviously an intergenerational choice. It can be argued that in a less developed economy capital should not be depleted and in fact part of the earning should be invested toward further diversification.

The basic policy implication of this analysis is that, in the longer run, oil producing countries need to develop non oil industries and promote their traded goods sector. Financial policies should therefore be geared to the achievement of this longer objective. An important element of these policies would be to limit government domestic expenditures to levels consistent with the absorptive capacity of the economy. Otherwise, the rapid deterioration of relative prices against the traded goods sector should inhibit its development. The private investment should be encouraged. The financial facilities such as the foreign loans and credits are essential in this regard.

Our model behaves quite well empirically. However, it could be rendered more appropriate by endogenizing other important variables as the behavior of banks, represented by the excess reserves ratio, and the behavior of the private sector, such as the cash deposit ratio.

A major avenue of future research should thus consist in developing a more precise model, explicitly incorporating other policy variables to reveal better the reality of the Iranian economy.

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APPENDIX

Appendix I. Econometrical Notes

(See Hamilton (1994) [4] for a more detailed discussion).

Studies in empirical macroeconomics almost always involve nonstationary in data. These data are characterized by a “random walk”, even after a deterministic trend has been removed. When the series are nonstationary and not cointegrated, statistics such as the t and DW and measures such as R^2 , do not retain their traditional characteristics and the asymptotic (limiting) distributions of the variables are nonstandard. In this case, running regressions with such data could produce spurious results.

If the data are shown to be nonstationary, on the basis of an appropriate unit root test, it is tempting to purge the nonstationarity by differentiating and estimate using only differenced variables. A variable is said to be integrated of order d, written $I(d)$, if it must be differentiated d times to be made stationary.

Let $y_t = \alpha y_{t-1} + \epsilon_t$, where ϵ_t is a stationary error term. If $|\alpha| < 1$, then y is $I(0)$, stationary, but if $\alpha = 1$ then y is $I(1)$, nonstationarity. Thus formal tests of stationarity are tests for $\alpha = 1$, and because of this are referred to as tests for a unit root. The case of $|\alpha| > 1$ is ruled out as being unreasonable because it would cause the series y_t to explode.

If the levels data are $I(1)$ and the linear combination of them is $I(0)$, these variables are said to be cointegrated. The cointegrating combination is interpreted as a long-run equilibrium relationship.

Consider the relationship:

$$y_t = \beta_0 + \beta_1 x_t + \beta_2 x_{t-1} + \beta_3 y_{t-1} + \epsilon_t$$

Where x and y are measured in logarithms, with economic theory suggesting that in the long run x and y will grow at the same rate, so that in equilibrium $(y - x)$ will be a constant, save for the error. This relationship can be manipulated to produce:

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_t + (\beta_3 - 1)(y_{t-1} - x_{t-1}) + \epsilon_t$$

This is an Error Correction Model representation of the original specification, interpreted as reflecting disequilibrium responses. The terminology can be explained as follows: if in error y grows too quickly, the last term becomes bigger, and since its coefficient is negative ($\beta_3 < 1$ for stationarity), Δy_t is reduced, correcting this error.

Unit Root Test

The Dickey-Fuller Test

Consider first, an AR(1) process:

$$y_t = \mu + \rho y_{t-1} + \epsilon_t$$

with $\epsilon_t \sim i.i.d (0, \sigma^2)$.

The hypothesis of a stationary series can be evaluated by testing whether the absolute value of ρ is strictly less than one:

H0: $\rho = 1$

H1: $\rho < 1$,

Let $\hat{\rho}$ be the estimator of ρ obtained by ordinary least squares (OLS). In contrast with what happens when $|\rho| < 1$, the asymptotic distribution of $\hat{\rho}$ is not normal. More precisely, we can show that

$$\text{plim}_{T \rightarrow \infty} \sqrt{T}(\hat{\rho} - 1) = 0$$

However, $T(\hat{\rho} - 1)$ has an asymptotic distribution which does not depend on σ^2 . Similarly, the t statistic associated with H),

$$t_{\rho-1} = (\hat{\rho} - 1) / [s^2(\sum_{t=1}^T Y_{t-1}^2)^{-1}]^{1/2}$$

has an asymptotic distribution which does not depend on σ^2 . We consider one-sided critical regions of the form:

$$T(\hat{\rho} - 1) < c1(\alpha) \text{ or } t_{\rho-1} < c2(\alpha).$$

If the series is correlated at higher order lags, the assumption of white noise disturbances is violated.

The Augmented Dickey-Fuller approach controls for higher-order correlation by adding lagged difference terms of the dependant variable y to the right-hand side of the regression.

So the test will be:

$$\Delta y_t = \mu + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \dots + \delta_{p-1} \Delta y_{t-p+1} + \epsilon_t$$

H0: $\gamma = 0$

H1: $\gamma < 0$

An important result obtained by Fuller is that the asymptotic distribution of the t-statistic on γ is independent of the number of lagged first differences included in the ADF regression.

The Phillips Perron Test

Phillips and Perron (1988) propose a nonparametric method of controlling for higher-order serial correlation in a serial correlation in a series. Their method is to correct the t-statistic of the γ coefficient from the AR(1) regression to account for the serial correction in ϵ . The correction is nonparametric since we use an estimate of the spectrum of ϵ at frequency zero that is robust to heteroskedasticity and autocorrelation of unknown form. It is common to use the Newey-West heteroskedasticity autocorrelation consistent estimator:

$$\omega^2 = \gamma_0 + 2 \sum_{j=1}^q (1 - j/q + 1) \gamma_j$$

$$\gamma_j = 1/T \sum_{t=j+1}^T \hat{\epsilon}_t \hat{\epsilon}_{t-j}$$

It is to be noted that the power of these tests; the probability that they will correctly lead to rejection of a false null hypothesis, are not significantly high.

Cointegration

The components of the vector x_t are said to be cointegrated of order $d, b, x_t \sim CI(d, b)$ if

- i) All components of x_t are $I(d)$;
- ii) There exists a vector α ($\alpha \neq 0$) such that $z_t = \alpha' x_t \sim I(d-b), b > 0$. α is called the cointegrating vector. z_t is often called the equilibrium error. The vector α defines the long-run relationship between the various variables, so that deviations from this long-run relationship can be viewed as temporary deviations, hence the error from equilibrium.

An approach for testing for cointegration is to construct test statistics from the residuals of a cointegrating regression. If a test statistic is smaller than critical values, then the variables are cointegrated. We can estimate the model by the use of a fully modified OLS or by an Error Correction Model.

Vector Autoregression

A p th-order vector autoregression, denoted VAR (p), is a vector system of the form:

$$y_t = c + \Phi_1 y_{t-1} + \dots + \Phi_p y_{t-p} + \epsilon_t$$

where the ϵ_t is a vector generalization of white noise disturbance:

$$\begin{aligned} E(\epsilon_t) &= 0 \\ E(\epsilon_t \epsilon_\tau') &= \Omega \text{ for } t=\tau \text{ and } 0 \text{ otherwise} \end{aligned}$$

with Ω an ($n \times n$) symmetric positive definite matrix.

Thus, a vector autoregression is a system in which each variable is regressed on a constant and p of its own lags as well as on p lags of each of the other variables in the VAR. The assumption that y_t follows a vector autoregression is basically the assumption that p lags are sufficient to summarize all of the dynamic correlations between elements of y .

The Impulse Response Function

Consider a Vector Autoregression model, write in $MA(\infty)$ form as:

$$y_t = \mu + \epsilon_t + \Psi_1 \epsilon_{t-1} + \Psi_2 \epsilon_{t-2} + \dots$$

Thus, the matrix Ψ_s has the interpretation

$$\frac{\partial y_{t+s}}{\partial \epsilon_t} = \Psi_s$$

that is, the row i , column j element of Ψ_s identifies the consequences of a one unit increase in the j th variable's innovation at date t (ϵ_{jt}) for the value of the value of the

ith variable at time $t+s$ ($y_{j,t+s}$), holding all other innovations at all dates constant. A plot of the row i , column j element of Ψ_s

$$\frac{\partial y_{i,t+s}}{\partial \varepsilon_{jt}} = \Psi_s$$

as a function of s is called the impulse-response function. It describes the response of $y_{j,t+s}$ to a one-time impulse in y_{jt} with all other variables dated t or earlier held constant.

Appendix II. Estimation Instrumental Variables

A fundamental assumption of regression analysis is that the right hand side variables or the explanatory variables should be uncorrelated with the error terms. This condition, known as the orthogonality condition, is however violated in special cases. The most famous one is in the dynamic equations where the error terms are correlated over time and the right hand side variables are endogenously determined. We define the variables which are correlated with the residuals as endogenous, and variables that are not correlated with the residuals as exogenous or predetermined. Consider a linear model:

$$y = Z_t' \beta + u_t$$

where Z_t a $(k \times 1)$ vector of explanatory variables. Suppose now that some of the explanatory variables are endogenous, so that:

$$E(Z_t u_t) \neq 0.$$

A method which is widely used in econometrics to handle this problem is the method of instrumental variables (IV). We will review this method in the next section.

Method of Instrumental Variable

Consider the equation:

$$y = Z_t' \beta + u_t$$

We have seen that the orthogonality assumption is violated in this case and x_t are endogenous. The method of IV suggests that we can choose a set of variables that are not correlated with error terms, but highly related with explanatory variables. Furthermore, to avoid the problem of multi-collinearity, the correlation among the instruments should not be considerable.

Let x_t be an $(r \times 1)$ vector of predetermined explanatory variables that are correlated with Z_t but uncorrelated with u_t :

$$E(x_t u_t) \neq 0$$

Consider the problem of instrument selection in the case of models with i.i.d. observations to be estimated by instrumental variables (IV). The method is exposed in the case of the univariate linear regression model. The orthogonality condition in this case is:

$$E[Z_t u_t(\beta)] = 0$$

where Z_t is a $k \times 1$ vector of instruments assumed to be chosen from some candidate set of l instruments denoted Z_t that are orthogonal to $u_t(\beta) = y_t - Y_t' \beta$ and β is the true value of the parameter.

A widely used class of tests in econometrics is the Hausman test (1979). He originally proposed a test statistic for endogeneity based upon a direct comparison of coefficient values.

Selection of Instruments

The literature on the selection of instruments is a very recent one and is still at its beginning. To apply this method, one needs instruments that verify two main conditions:

1.Exogeneity: Instruments should be orthogonal to the error terms in the structural equation to be estimated.

2.Relevance: Instruments should be correlated with the endogenous explanatory variables.

For many years, all that empirical researchers cared about was the exogeneity condition, neither relevance nor the number of instruments to be used were not a concern until recently. The most important consequence of weak instruments is the inadequacy of the standard asymptotic theory. The asymptotic distributions of many usual estimators are far from normality and depend on nuisance parameters.

One way to proceed in choosing the variables, is to define formally the notion of relevance and then choose the instruments that are most relevant. This approach has been particularly followed by Hall (2000) who proposed the canonical correlation between instruments and endogenous explanatory variables as a measure of relevance. His approach is to select the set of instruments that minimizes a correlation criterion. Another way to find the relevant instruments is to construct the matrix of partial correlation between each endogenous explanatory variable and the set of instruments.

To ensure identification, which means that there exist at least as many instruments as explanatory variables, we may tend to select a large number of instruments. However this may be harmful, in finite samples the consequences are different. In small samples, the consequence of adding instruments depends on their relevance. If the instrument is weak it will increase variance.

We consider here the case of one endogenous explanatory variable. This case is interesting because it is often the case considered in empirical analysis and at the same time the exact distributions of the usual estimators and test statistics are relatively tractable. Furthermore, many recent papers have considered the same framework to provide interesting results on instrumental variables.

In presence of endogenous variables, the OLS regressions are biased and inconsistent. The approach we are using in this paper is to handle this problem by using the two-stage least squares (TSLS or 2SLS). TSLS is a special case of instrumental variables. In this method, we separate two stages in our estimation. In the first stage, TSLS finds the portions of endogenous and exogenous variables that can be attributed to the instruments. This stage involves estimating an OLS regression of each variable in the model on the set of instruments. The second stage is a regression of the original equation, with all of the variables replaced by the fitted values from the first stage regression.

Hausman Test

To decide whether it is necessary to use Instrumental Variables (IV) rather than least squares, we have to ask whether a set of estimates obtained by least squares is consistent or not. In a very influential paper, Hausman (1978) proposed a family of tests designed to answer to this question. His basic idea is that one may base a test on a vector of contrasts, that is, the vector of differences between two vectors of estimates, one of which will be consistent under weaker conditions than the other. So we should compare the OLS estimator $\hat{\beta} = (X^T X)^{-1} X^T y$ with the IV estimator $\beta = (X^T P_W X)^{-1} X^T P_W y$.

The Hausman test is based on the vector of contrasts $\beta - \hat{\beta} = (X^T P_w X)^{-1} X^T P_w M_x y$.

$$H = (\beta - \hat{\beta})^T \left(V \left(\beta \right) - V \left(\hat{\beta} \right) \right)^{-1} (\beta - \hat{\beta}) \rightarrow \chi^2$$

To test the endogeneity, we run an artificial regression:

$$y = X\beta' + P_w X^* \delta + \text{residuals}$$

and we test the effect on the estimates of β of any endogeneity that may be present. The null hypothesis is that the OLS estimates $\hat{\beta}$ are consistent, not that every column of X is asymptotically independent of u (the residuals). The alternative hypothesis is the consistency of the β , calculated IV method.

See Davidson and MacKinnon (1993) page 239 for more details.

When the model indicates a cointegration relation between its variable, one of the widely used method to estimate it is the error correction models.

Error Correction Models

Suppose that the two $I(1)$ variables y_t and z_t are cointegrated and the cointegrating vector is $[1, -\theta]$. Then all three variables $\Delta y_t = y_t - y_{t-1}$, Δz_t and $(y_t - \theta z_t)$ are $I(0)$. The error correction model:

$$\Delta y_t = \beta' X_t + \gamma(\Delta z_t) + \lambda(y_t - \theta z_t) + \varepsilon_t$$

describes the variation in y_t around its long-run trend in terms of a set of $I(0)$ exogenous factors x_t , the variation of z_t around its long-run trend, and the error correction $(y_t - \theta z_t)$, which is the equilibrium error in the model of cointegration.

Appendix III. Tests and Results

We first look at our data set at level. There is an evidence of exponential trend in them (by looking at their graphics- chart 0) . We linearize the data set by taking the natural logarithm of them. These transformed data are in lower case.

Then, we test the data for unit root. We use two different approaches: Augmented Dicky Fuller and Phillips-Perron, at 5% confidence level.

We can not reject the null hypothesis of unit root in level. We differentiate the data set and we test the new data set for the presence of the unit root.

All the variables are integrated of order 1, $I(1)$. It means that the first differences of the data are stationary.

We write the model.

We run the cointegration test by applying an appropriate unit root test to the residuals from each regression.

If cointegration is accepted, we use the lagged residuals from the cointegrating regression as an error correction term, and we estimate the equation using an error correction model.

If cointegration is rejected, we take the first differences of the data set. As we have a system of simultaneous equations, we are suspicious about the endogeneity of our variables. We test the endogeneity of our model by running a Hausman test on the differentiated datas. In presence of endogeneity, we will estimate our model by using a two stage least squares (TSLS) method.

The choice of the relevant instruments is crucial. We test the relevancy conditions of our variables by constructing the correlation matrix of our variables.

Hausman Test

We test the endogeneity by running the Hausman test in an artificial regression. The procedure is as follows. First, we regress the suspect variable on all exogenous variables and instruments. We retrieve the residuals. Then, we re-estimate the initial equation including the residuals from the first regression as additional regressors. Under the null hypothesis, we have the absence of endogeneity in our model. The alternative hypothesis confirms the presence of endogeneity among variables. In this case, least square estimation are no longer consistent and two stage least square are consistent.

Here are our results:

Variable	Coefficient	t-statistic	p-values	Results
dgr_t	0.8	0.31	0.014	H0 is rejected
dr_t	0.28	1.39	0.1	H0 is rejected
dor_t	2.39	1.53	0.126	H0 is rejected
dm_t	-2.91	-1.1	0.27	H0 is rejected
dp_t^n	0.85	1.57	0.4	H0 is rejected
dp_t^t	-.055	0.07	0.45	H0 is rejected
dy_t	0.28	1.39	0.17	H0 is rejected
dge_t	-0.0077	-0.01	0.32	H0 is rejected

H0: Absence of endogeneity in the model.

H1: Presence of endogeneity in the model.

In our case, we accept the alternative hypothesis (H1) in all the cases.

Unit Root Test

The results of the unit root tests (ADF and PP tests) demonstrate that all are variables are random walked and become stationary after the first difference, so they are I(1). The price level, however could be I(2). We work with the growth rate of the price level which is inflation and is I(1).

Variable	Unit Root Results
ge	I(1)
gr	I(1)
dr	I(1)
y	I(1)
or	I(1)
m	I(1) ?
p	I(2) ?
p ⁿ	I(2) ?
p ^t	I(1)
im	I(1)
e	I(1)
i	I(1)
r	I(1)
fr	I(1) ?
gnoil	I(1)

Cointegration Test

By running the cointegration test on the residuals, we have three out of eight equations to be cointegrated. These equations are estimated by an error correction model (ECM).

Appendix IV. Data Sources

Data gathering for this research was cumbersome and led the research to some quantitative restrictions. The data used in the study have been obtained from various sources, basically from the International Monetary Fund's International Financial Statistics (CD-ROM 2001), Direction of trade statistics (various issues), IMF balance of payments yearbook (various issues), Petroleum Argus (July 20th, 2001), International Petroleum Encyclopedia (various issues), Petroleum Economist (March 2001), World Development Indicators (CD-ROM 1999) of World Bank and some internal publications of Central Bank¹⁵ of Iran (2000).

Here we have the definition of the uppercase letter, where the lower case refer to the natural logarithm of these upper cases.

¹⁵Bulletin Bank-e-Markazi

GE (Government expenditure)	Current and development expenditure
P (Domestic price level)	Consumer price index (CPI)
P^n (Price of nontraded good)	Home good price index
P^t (Price of traded good)	<p>This is based on the weighted average of trading partners' export.</p> <p>$P_t^t = \text{Export of trading partners to Iran in year } t / \text{Total import of Iran in year } t$</p> <p>*export price index of trading partner in year t.</p> <p>The stable trading partner of Iran during our sample are as follows: Italy, France, Germany, China, Japan and United Arab Emirates.</p>
E (Private expenditure)	Private consumption
IM	Import
I (Investment)	Gross fixed capital formation + changes in stock of inventories.
Y (Domestic real income)	GDP at market price minus oil revenue.
M (Liquidity)	M2 = money and quasi money
GR (Government revenue)	Total revenue and grants from the government finance account (fiscal position) = oil + non oil revenue + earmarked revenue
DR (Domestic revenue)	Revenue based on direct and indirect taxes.
OR (Oil revenue)	Revenue based on oil export. It is exogenously given by the international oil market and OPEC quota.
r (Interest rate)	Rate of return on five year deposit for the construction project is our proxy in our Islamic banking system.
fr (Foreign interest rate)	One month US deposit, London offer
Cr (Credit)	Credit to the private sector
Exp (Export)	Non oil export

Appendix V. Graphics

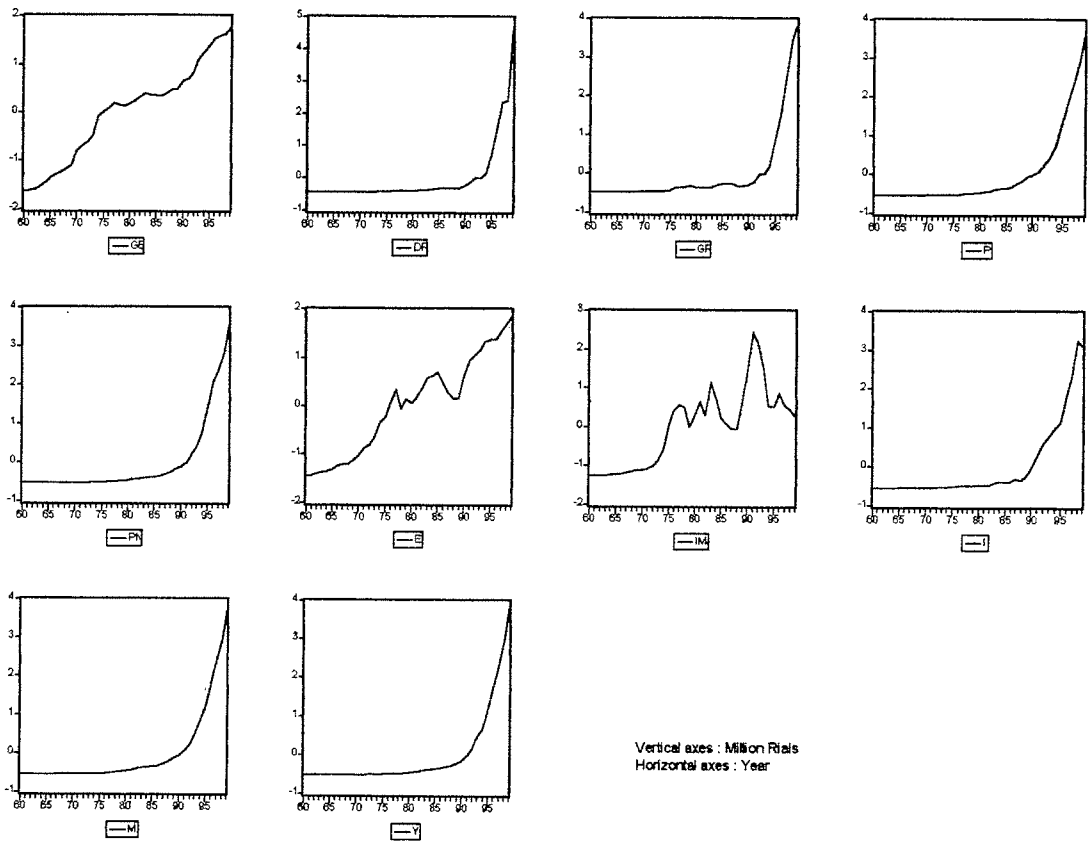


Figure 1: Raw Endogenous Data

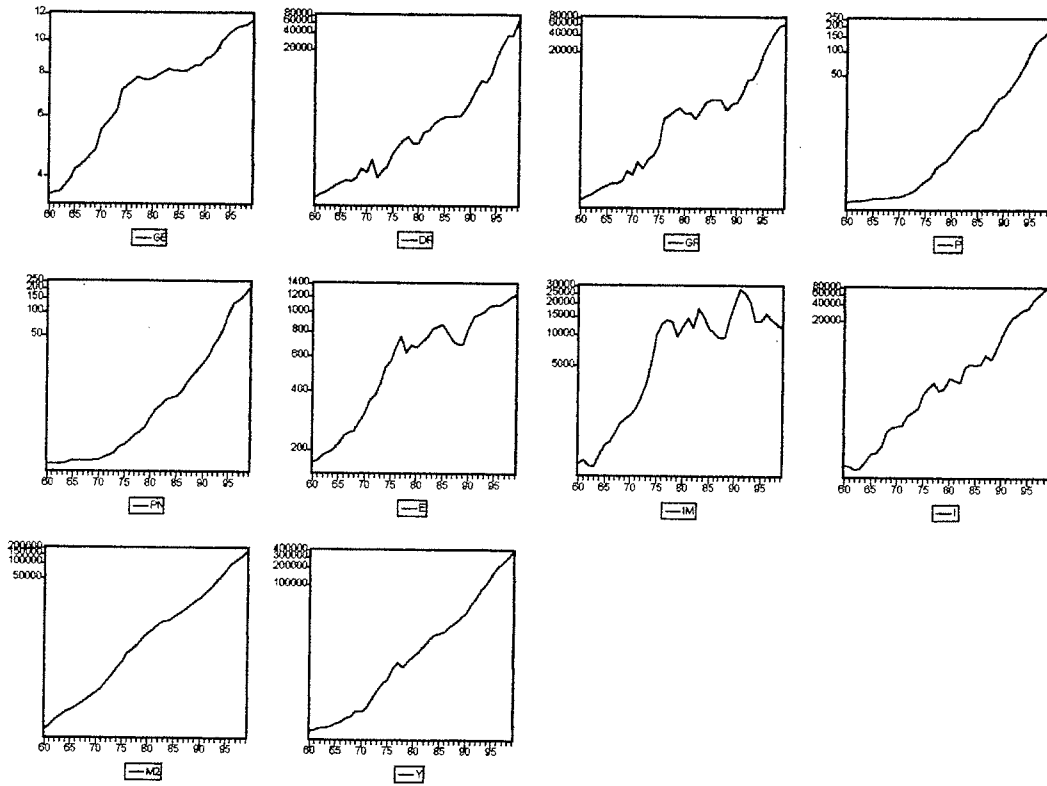


Figure 2: Linearized Data (Logarithmic scale)

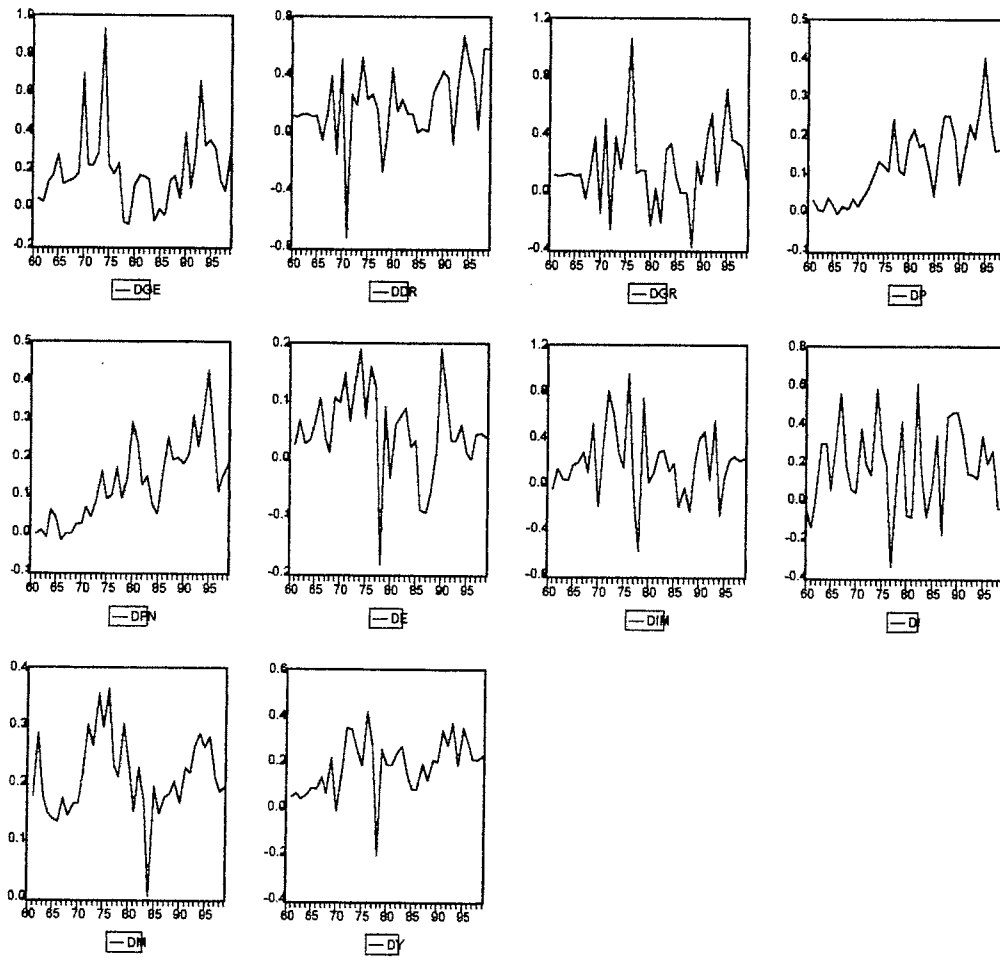


Figure 3: First Differences of Our Endogenous Variables

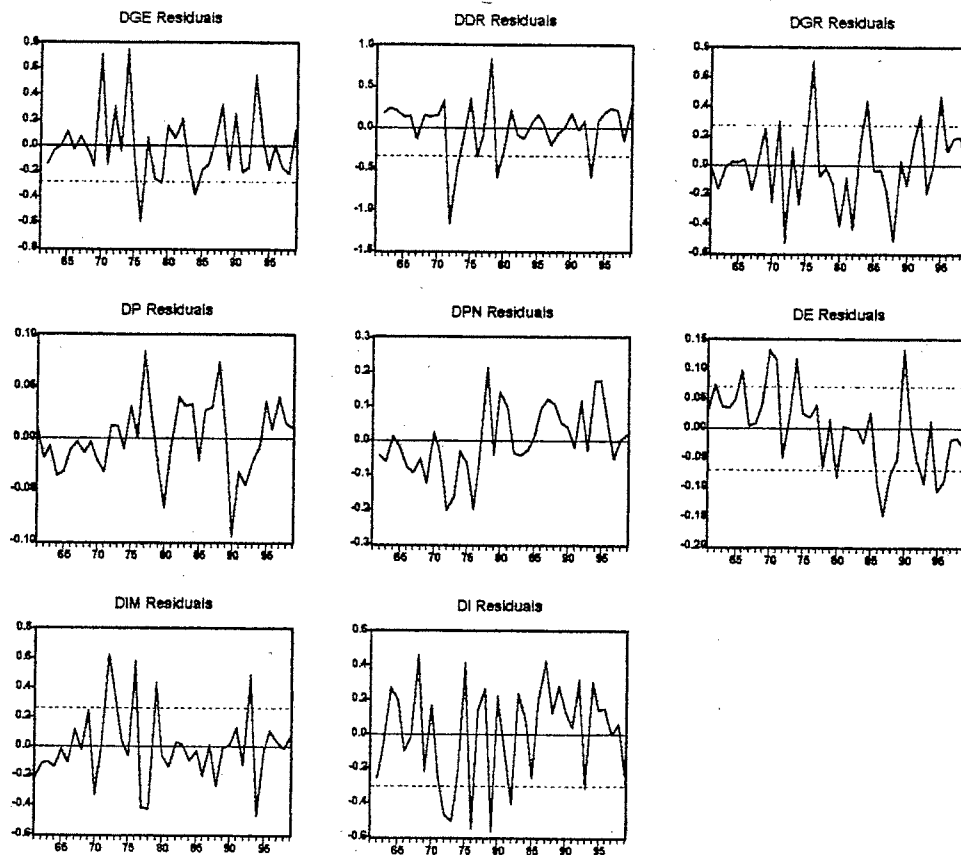


Figure 4: Residual of the Endogenous Variables

Simulation I. Comparing Actual and Fitted Values of the Endogenous Variables

- f in the end of the variables means fitted
- d in front of variables means first difference of the data
- Sim in front of variables means simulated values
- The first set is for data in first difference and the second one is for the data in level

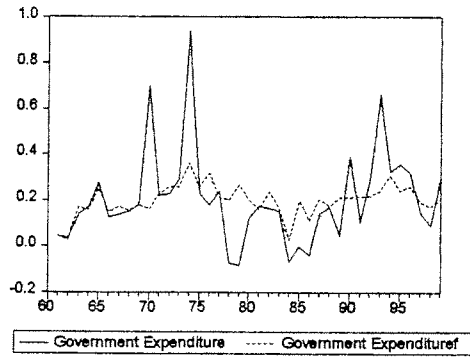


Figure 5: Government Expenditure

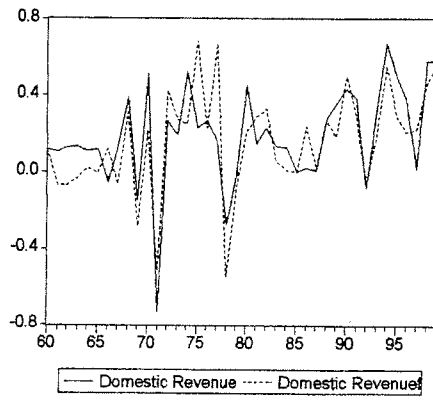


Figure 6: Domestic Revenue

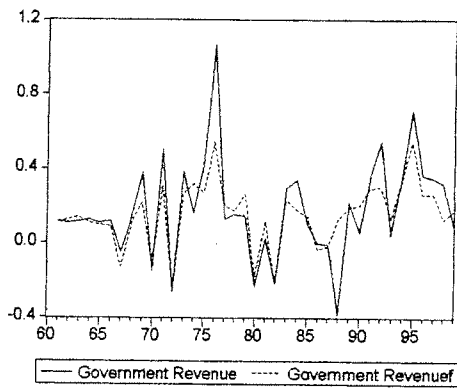


Figure 7: Government Revenue

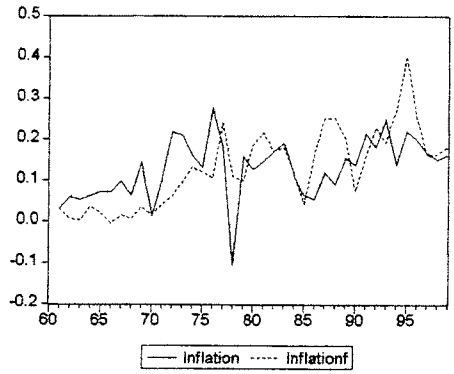


Figure 8: Inflation

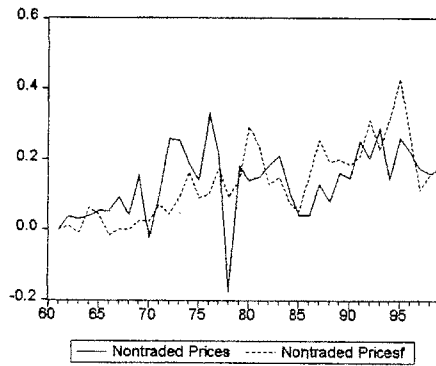


Figure 9: Nontraded Goods Prices

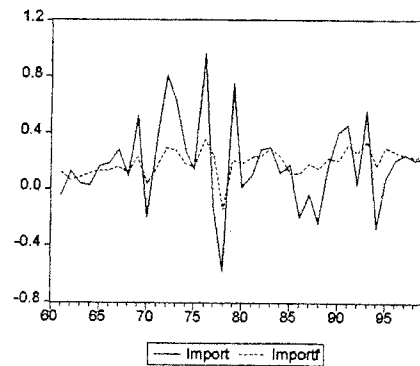


Figure 10: Import

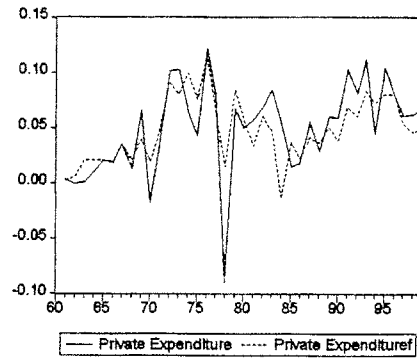


Figure 11: Private Expenditure

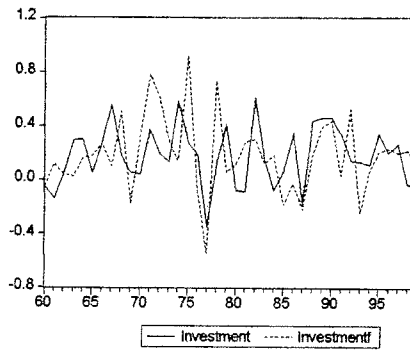


Figure 12: Investment

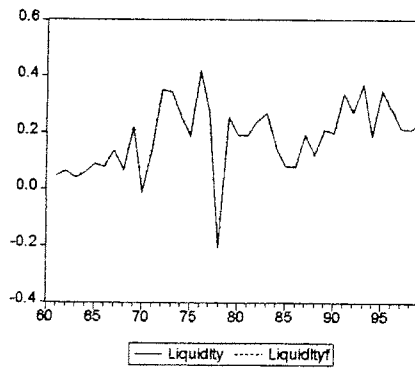


Figure 13: Liquidity

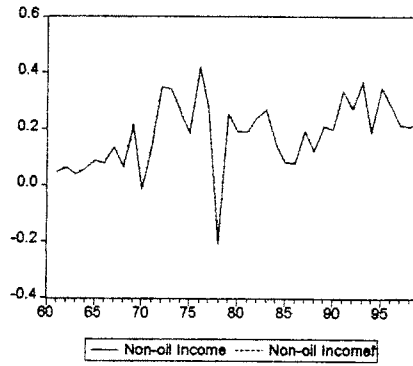


Figure 14: Non oil Income

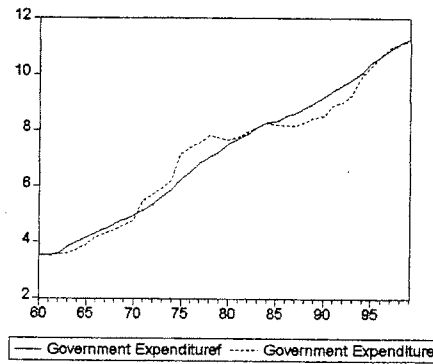


Figure 15: Government Expenditure

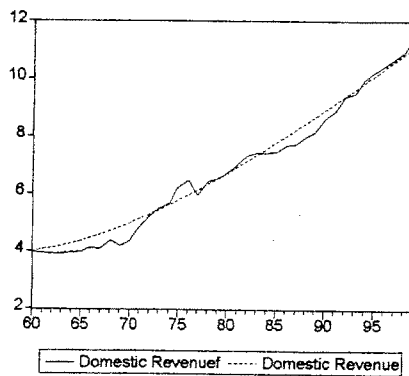


Figure 16: Domestic Revenue

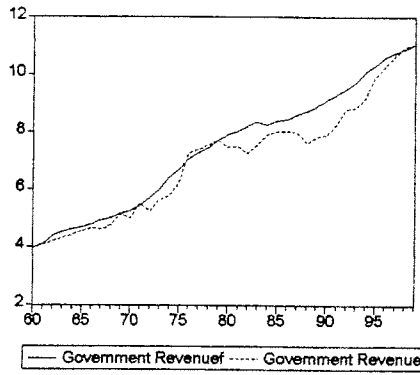


Figure 17: Government Revenue

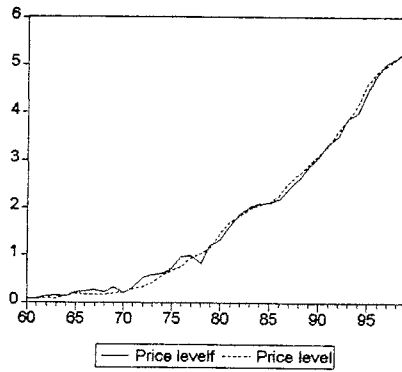


Figure 18: Price Level

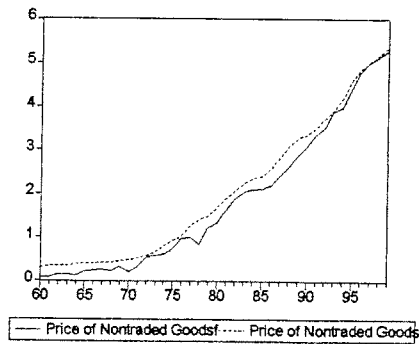


Figure 19: Nontraded Goods Prices

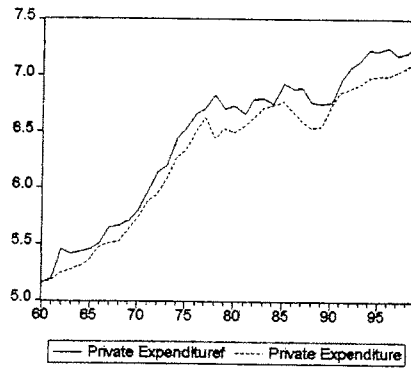


Figure 20: Private Expenditure

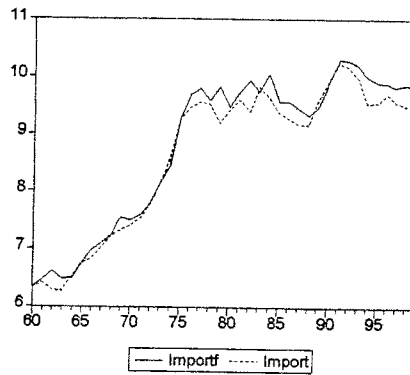


Figure 21: Imports

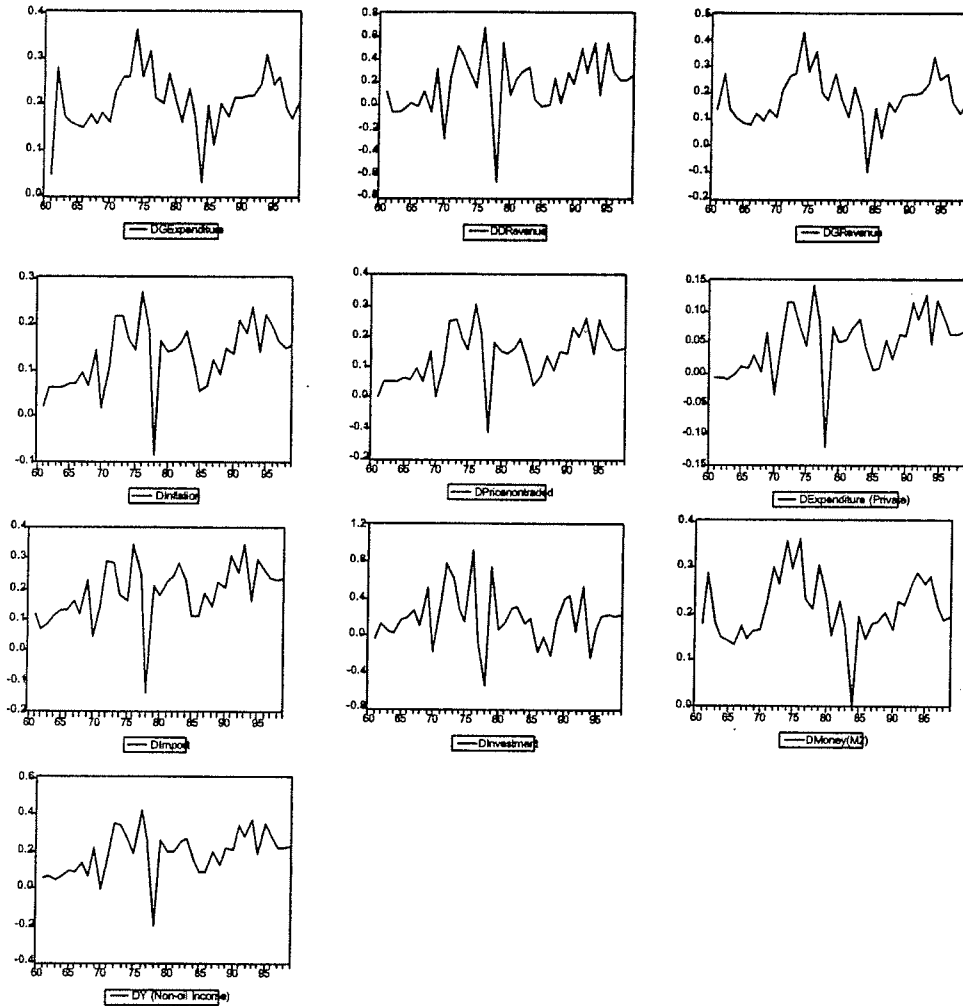


Figure 23: Fitted Value of the First Differences of the Endogenous Variables

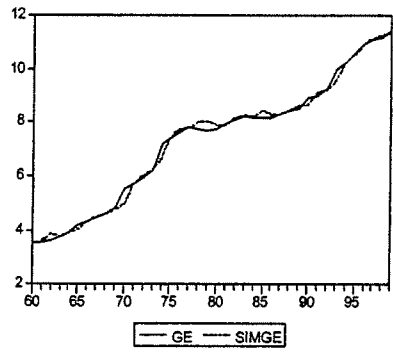


Figure 24: Government Expenditure

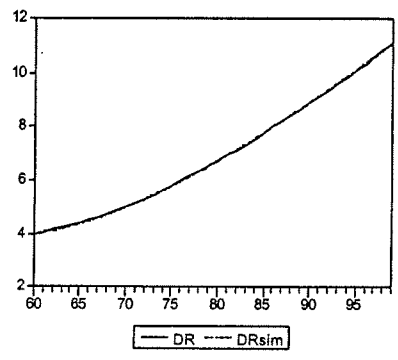


Figure 25: Domestic Revenue

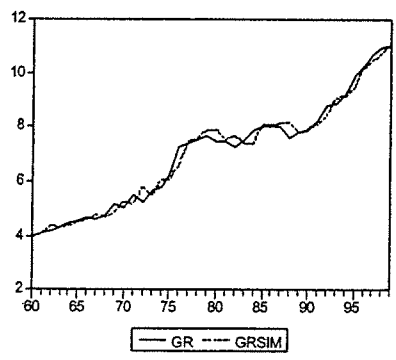


Figure 26: Government Revenue

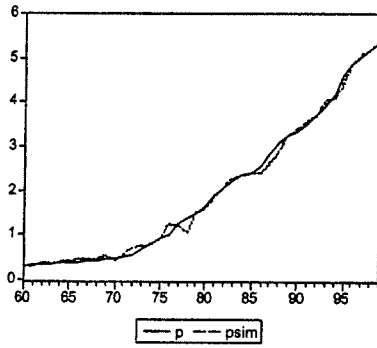


Figure 27: Price Level

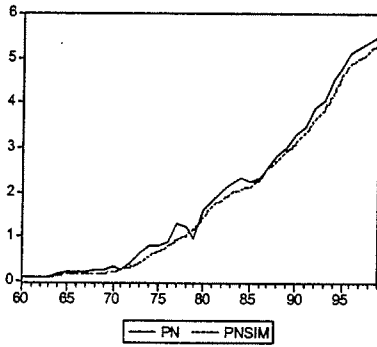


Figure 28: Nontraded Goods Prices

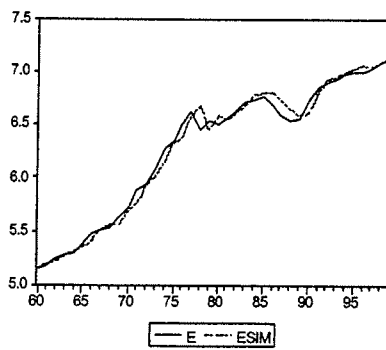


Figure 29: Private Expenditure

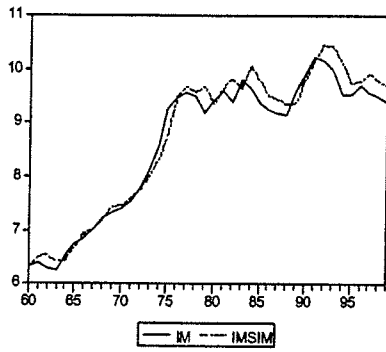


Figure 30: Import

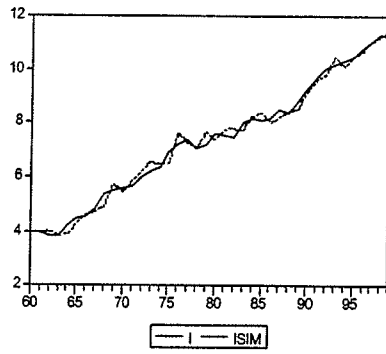


Figure 31: Investment

Simulation III. Impulse Response Functions

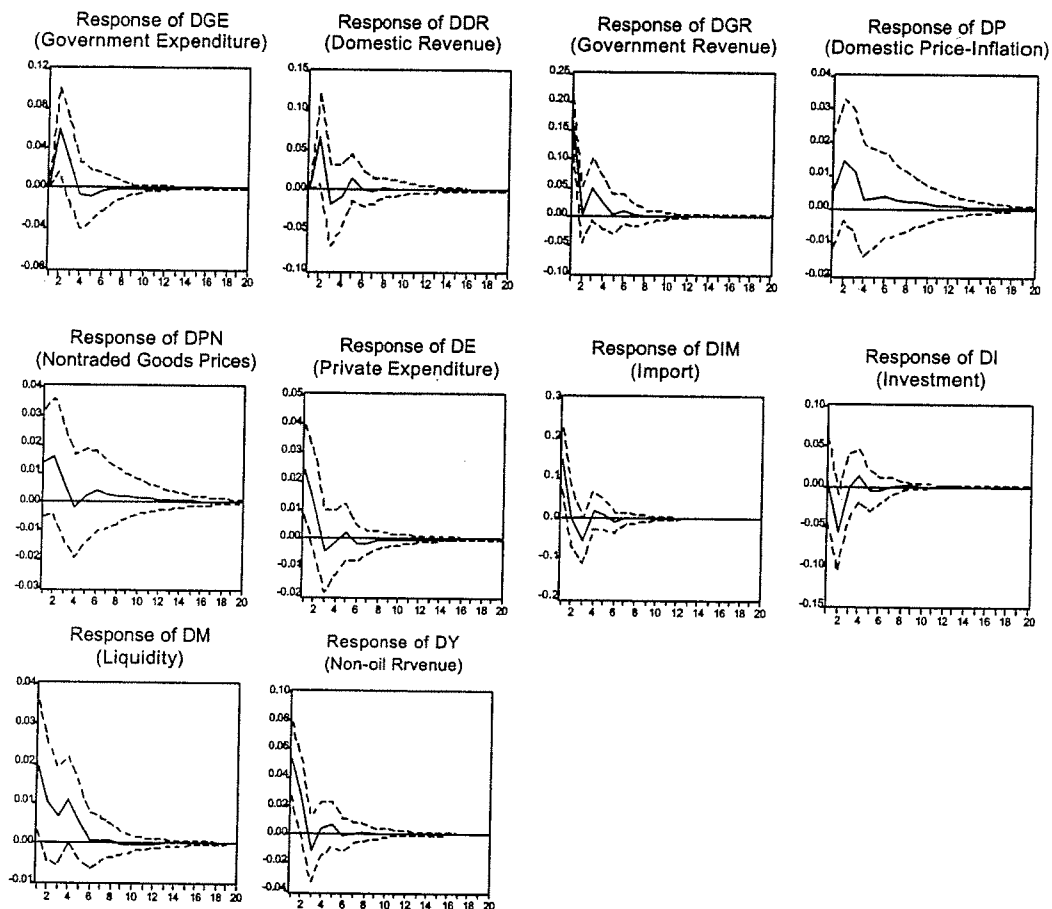


Figure 32: Dynamic Simulation (Response of our Economy to One S.D. Innovation in Oil Revenue \pm 2 S.E.)

