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Oil Revenue, Inflation and Growth in Iran: A pre- Exchange Rate reform examination of Dutch disease

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Abstract:

The present paper investigated the impact of oil revenue on the inflation and growth rates of Iran in the period of pre-exchange rate reform of 1993. In doing so, dynamic equations for growth, inflation, the exchange rate, money and foreign inflation were estimated. The equations were then used to run a number of simulations of inflation and growth. As a result, it was found out that oil revenue only influences growth by a slow direct effect. Inflation is influenced by oil revenue through a direct effect, foreign prices, and the real exchange rate. The net effect is that greater oil revenue has tended to reduce inflation, though the effect has been greatest since the revolution. A large part of the volatility in inflation and growth appears to be due to the variation in oil revenue rather than boom in themselves.

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1. Introduction

There is a considerable literature on the economic impact of a natural resource. These studies consider how a boom in one sector of the economy influences the remaining sectors of the economy. The most well-known strand of this research is the ‘Dutch disease’ literature, in which the resource boom squeezes the non-boom tradable goods sector as the real exchange rate appreciates. In addition, there is a direct squeeze on the non-boom section as resources shift to the boom sector.

The process by which a resource boom affects the economy is complex, and depends upon such things as the ownership of the resource, how the revenues are used, and the structure of the economy in question. Given these considerations, it is not surprising that there is a broad range of models of ‘Dutch Disease’. The purpose of this paper is to examine how oil booms and slumps have affected the Iranian economy in particular growth of the non-oil sector and inflation. To do this, equations for the key endogenous variables were estimated; then, these equations were used to firstly simulate the impact of oil revenue on the Iranian economy, and secondly to consider how the Iranian economy would have performed without the revenue from the first boom of 1973.

2. Dutch Disease

This term refers to the effects of the boom sector revenues on the other economic sectors including the non-oil tradable (Lagged) sector and the non-tradable sector (see, for instance, Corden, 1984). In the general model of Dutch Disease, a resource boom has two effects on the economy. First, there is the resource movement effect. This is the drawing of mobile factors of production away from other sectors of the economy to the booming sector. This process tends to reduce the output in the non-boom tradable and non-tradable sectors. Second, there is the spending effect. The boom raises incomes and so raises demand for tradable and non-tradable goods. The prices of the former are fixed by world markets, but the latter prices tend to rise with domestic demand. The result is a real appreciation of the exchange rate which stimulates the production of non-tradable and deters the production of tradable.[1]

A number of factors may make an oil economy deviate from these stylized patterns. Price controls and import liberalization can limit the appreciation of the real exchange rate by deflecting demand onto imports. Next, if traded sectors are able to respond strongly to investments financed by oil revenues, the pull towards the non-traded sectors may be counterbalanced, particularly if labor markets are slack so that expanding non-traded sectors do not draw labor from the traded sectors. However, the overall impact of higher public spending on growth may be low if the quality of investment projects declines with accelerating spending, or if subsidies and other expenditures drain resources from the public investment programmed.[2]

Beyond this simple model of Dutch Disease, there are some alternative channels through which a boom can be accommodated. First, if the boom sector does not show a strong participation in the domestic factor market, the resource movement effect would not be significant (see for example, Fardmanesh, 1991a and 1991c; van Wijnbergen, 1984 and Neary, 1985). The oil sector in the oil exporting developing countries, for instance, can often be considered an ‘enclave’ (Pinto, 1987 and Valadkhani, 2006), that is a capital-intensive and hyper-
42 nologic sector (with minimum competition with the non-oil economy) and so there does not emerge a considerable resource movement effect in such economies[3].

Fardmansh (1991c) argues that in some oil exporting developing countries, the oil boom appeared to give rise to

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[1] The magnitude of this expansion depends on various elasticities operating in this process: income-elasticity of demand for non-traded goods, output-elasticity of supply with respect to the real wage and so on.

[2] The results of Gelb (1986) suggest that the impact of expanded investment on growth of non oil GDP was unsatisfactory during the (oil boom of) 1972-81 compared with 1967-72 (see Gelb, 1986, p. 79).

[3] See also McKinnon (1976) for evidence on the ‘enclave nature’ of the oil sector in oil-exporting developing countries.

growth in non-oil traded (manufacturing) goods, the opposite to what the simple Dutch disease model predicts. Instead, it was the agriculture sector which faced a considerable reduction in its share in GDP. He explains that although the expenditure effect could undermine the traded goods sector, a rise in the world price of manufactured goods relative to agricultural products (the world price effect) following the oil boom may dominate the negative expenditure effect and lead to an expansion in manufactured output. The observed expansion of the non-oil traded sector in most oil-exporting developing countries has been explained in various ways. For example, Neary and van Wijnberg (1986) consider this sector in these countries to be a protected sector and so classify this sector under the non-traded category. Benjamin, et al. (1989) attribute the unexpected expansion to the 'imperfect substitutability between domestic and foreign goods as well as to their linkages with the rest of the economy.' (p.90). They argue that in a typical agricultural country, the importable sector is the industrial one, which is somewhat insulated from foreign competition by reason of the fact that its products are imperfect substitutes for imported goods. They show that in some cases this sector may actually expand its output in the wake of an oil boom.[4] Gelb (1986), in a comparative study of this issue, pointed out that Indonesia has been successful in using oil revenues to expand the non-oil tradable manufacturing sector. Usui (1996) confirms that the 1978 devaluation undertaken in Indonesia has been instrumental in this achievement.

Resource booms may also operate on the economy through monetary effects. Monetary aspects of the boom are parallel forces by which the boom revenue is accommodated into the domestic economy (Edwards, 1986b, 1986c) and which can reinforce the real effects. The foreign reserves earned from the boom could give rise to an expansion of the money supply. Noorbakhsh (1990) argues that conversion of oil revenues from

[4] Their findings explain why the agricultural sector contracted in all oil exporting countries during the period 1974-82, while the industrial sector actually expanded in all but two of the countries.

foreign exchange into domestic currency became the most significant source of increases in the money supply in the oil exporting developing countries. But he also added that the magnitude of change in the domestic money supply depends not only on the magnitude of foreign exchange proceeds from oil exports but also on the extent to which the monetary authorities sterilise these proceeds to neutralise their effect on the domestic money supply. Aghevli and Sassanpour (1982, p. 184) argue that unlike domestic taxes, foreign revenues in the form of royalties on natural resources do not induce a reduction in disposable income, and their domestic spending leads to the creation of additional money." However, the consequences of such a boom depend upon the responses of money demand to the boom. If the change in money demand is equal to the supply response then the monetary effects may be of little consequence for the rest of the economy. Furthermore, in the case of oil, it is not certain that a money supply expansion will follow the boom. In developing countries, oil revenue typically accrues to the state; only if the state injects this money into the economy, for example through raising the budget deficit, will the money supply expand (see Morgan, 1979). This raises the possibility of some deflationary pressure following the boom if the money supply fails to expand as fast as any increase in money demand that may follow the boom.

3. The case of Iran

From the above discussion it is clear that the consequenses of oil booms on an economy depend upon the nature of the economy in question. It is, then, important to consider the characteristics of the Iranian Economy. Firstly, the revenue from oil sales accrues to the state, which sells the dollars earned to the Central Bank for Rial. This revenue is then used to finance government expenditure. To some extent, the effect of oil revenues on the economy will depend upon how the government uses the revenue. Clearly, investment in industry and infrastructure could offset some of the adverse effects of resources moving from the non-oil sector to the oil sector. Second, the oil sector of the Iranian economy can be considered an enclave of the economy (see Pinto, 1987), which is highly capital intensive and has low linkages to the rest of the economy. This would act to reduce the resource movement effect. Third, following booms, current and capital expenditures of the government have been raised, usually in excess of the absorption capacity of the economy, which would lead to more pressure on domestic prices. The prices of traded goods are mainly determined externally and so most of the inflationary pressure is reflected in higher prices for non-traded goods. The rise in relative prices of non-traded goods (real appreciation) increases the relative demand for imports. The long run effect of high oil revenue could be, then, to depreciate the nominal exchange rate as imports rise.

A further complication is the exchange rate system. Iran has operated a system of multiple fixed exchange rates. Alongside the fixed official market, there has existed a free market for foreign exchange. Sometimes, there has been little free market activity, but at other times the free market has been the dominant source of foreign currency Generally, the free market has been the dominant source of currency for marginal transactions. This is particularly true of recent years, as foreign exchange has been strictly rationed at the hugely overvalued official exchange rate. Thus, we expect that the influence of the free market rate upon economic activities dominates the effects of the official exchange rate.

A final complication is the massive disruption caused to the economy by the revolution and the war with Iraq. Both events resulted in large losses of human and physical capital. The consequence of these events is a huge loss of productive capacity, which is indicated by an average annual rate of investment since 1979 of - 6.29% (according to Mazarei, 1996), and an increasing dependency on imports. This switch from a booming economy to an almost collapsing one presents a number of problems for our study, in particular, it is possible that some effects of oil may have become stronger or weaker since the revolution. For example, as the ability of the economy to absorb demand fell following the revolution, the inflationary impact of oil revenue may have risen. We consider this possibility by using a post-revolution dummy to incorporate parameter shifts.

4. The Model for Estimation

The equations of primary interest determine the rate of growth of non-oil output and the rate of inflation. We represent the general equations in error-correction form.

$$\begin{aligned}\Delta rnoy_t = {} & d_1 + d_2(rnoy - rnoy^*)_{t-1} + d_3(l)\Delta re_t + d_4 re_{t-1} + d_5(l)\Delta oil_t \\ & + d_6(l)\Delta rnoy_{t-1} + d_7 DR + e_{1t}\end{aligned} \quad (1)$$

$$\begin{aligned}\Delta p_t^d = {} & b_1 + b_2(l)(\Delta p^f + \Delta e)_t + b_3(l)\Delta(m^s - m^d)_t + b_4(p^d - p^{d*})_{t-1} \\ & + b_5\Delta oil_{t-1} + b_6(l)\Delta p_{t-1}^d + b_7 DR_t + e_{2t}\end{aligned} \quad (2)$$

where Δ is the difference operator, λ is the lag operator, $rnoy_t$ is real non-oil output, e is the nominal exchange rate (Rial per US Dollar), re_t is the real exchange rate, oil_t is oil revenues, p^d_t is domestic prices, p^f_t is foreign prices, m^s is the money supply, m^d is the money demand, DR_t is a post-revolution dummy which equals 1 since 1979 and 0 before, ε_{jt} is an error term, stars indicate a long run value, and lower cases indicate variables measured in natural logarithms.

Non-oil output growth is given by equation (1). Output in excess of the long run trend ($rnoy^*$) is expected to slow growth down, $\delta_2 <0$. The spending effect of the boom operates through the real exchange rate. Both δ_3 and δ_4 are expected to be positive, so that real appreciations reduce growth in the non oil sector. The resource effect is picked up by δ_5, which should be negative according to the standard Dutch Disease Model. Since the revolution, the average growth rate of non oil output has been below the pre-revolution average, and so $\delta_7 <0$ is expected.

Inflation is determined by equation (2). Inflation tends to be higher if foreign prices are rising faster than the rate of appreciation of the Rial, $\beta_2 > 0$; if growth in the supply of money exceeds growth in money demand, $\beta_3 > 0$; and if the price level is below the equilibrium value, $\beta_4 < 0$. We experiment with 2 long run equilibria for prices. These are an inverted money demand function and an inverted PPP relationship. If 'core' inflation has been higher since the revolution, then $\beta_7 > 0$. Finally, growth in oil revenue is permitted to influence inflation directly through β_5, as well as indirectly through monetary effects[5].

To complete the model we need to consider the influence of oil revenue on the other variables in equations (1) and (2). The exchange rate is given by equation (3). In the long run, the real exchange rate is assumed to be a function of oil revenue, and the domestic-foreign price differential (through Purchasing Power Parity). This makes the real exchange rate dependent upon oil revenue. To restore the equilibrium real exchange rate $\alpha_7 < 0$.

$$\begin{aligned} \Delta e_{bt} &= a_0 + a_1(L)\Delta e_{t-1} + a_2(L)\Delta p_t^d + a_3(L)\Delta p_t^f + a_4 DR_t + \\ & a_5(L)\Delta oil_t + a_7[e - (f_1 p^d + f_2 p^f + f_3 oil)]_{t-1} + e_{3t} \end{aligned} \quad (3)$$

For PPP to hold in the long-run we require $a_7 < 0$ and $f_1 = -f_2 = 1$. If the equlibrium real exchange rate has been lower since the revolution, then $a_4 > 0$. In the standard model of Dutch Disease higher oil revenue causes an appreciation in the exchange rates and so we expect $a_5 < 0$, $f_3 < 0$. Initially we assume that the parameters are invariant over time, but later we allow for differing values before and after the revolution.

The growth of money is given in equation (4). This is a conventional money demand function with the addition of oil revenue terms to pick up this influence on money creation. The long run effect can be interpreted as coming from the demand for money, which is expected to rise in a boom (see for example Buiter and Miller, 1981). The effects of Δoil could come from the

[5] Noorbakhsh (1990) suggests that if non-oil GDP does not grow at a sufficient rate to balance the increase in aggregate demand, a consequence could be an increase in the rate of inflation.

demand for money but may also be responses to money supply shocks when prices are sticky, and so we expect γ_5 >0. Stability requires γ_4 <0 and we would expect γ_1 and γ_3 >0.

$$\Delta(m-p^d)_t = g_0 + g_1(l)\Delta(m-p^d)_{t-1} + g_2(l)\Delta p^d_{t-1} + g_3(l)\Delta y_t + g_4(m-p^d - t_1 y - t_2 oil)_{t-1} + g_5(l)\Delta oil_t + g_7 DR + e_{4t} \quad (4)$$

$$\Delta p^f_t = h_0 + h_1(l)\Delta p^f_{t-1} + h_2(l)\Delta oilp_t + e_{5t} \quad (5)$$

Finally, in equation (5), we model foreign inflation as an autoregressive process with addition on oil price effects, we expect $\eta_2 > 0$.

All of the equations (except equation 5) include an intercept dummy for the post-revolution period. This may capture: changes in the underlying growth rate in equation (1); change to the underlying inflation rate in (2); either a shift in the real exchange rate in (3) or simply an accelerated rate of depreciation; and either a shift in the tendency for government deficits to be converted into money growth or a shift in the demand for money in equation (4).

5. Estimation

Our data set consists of annual observations over the period 1960-1990 for real GDP (y), real non-oil GDP (rnoy), the quantity of money, M2 (m), domestic consumer prices (p^d), the US GDP deflator (p^f), the black market Rial/Dollar exchange rate (e_b), oil revenue (oil) and the Dollar price of oil (oilp). Estimation of the full system is infeasible `given the shortage of data, and so we proceed by estimating single equations. But even with the single equations it is not possible to apply Hendry's general-to-specific approach to modelling[6]. Our approach is to try alternative specifications and settle on those which appear to best correspond to general economic theory whilst having acceptable

[6] However, where it is applicable we choose this methodology as the strategy of the estimation.

statistical properties. We then test the best equations for shifts in the slope parameters since the revolution, and then test any cross equation restrictions before settling on our preferred specifications.

We first test the orders of integration in the data. The Phillips-Perron test for unit roots was applied and the results are shown in table below (1). The variables all appear to be I(1).

Table 1: Phillips-Perron Unit Root for Stationarity

Variables	**Level**		**First difference**
	Z_α	Z_t	Z_α
y	-2.83	-2.31	-14.30
m	0.17	0.35	-27.00
p^d	1.7	3.79	-7.06
p^f	0.36	0.65	-5.91
e_b	1.41	1.11	-22.77
oil	-3.2	-1.59	-26.62

Notes: RATS software was used to produce these results.

Z_t and Z_α are Perron and Phillips test statistics for Unit roots respectively with and without deterministic trends. The 5% critical values (for 25 observations) are -3.0 without trend and -3.6 with trend. The number of lagged difference terms in each equation is 4.

6. Results

In the results reported below SER is the standard error of the equation, LM(x) is the Lagrange multiplier statistic for serial correlation of upto order x, and A is the test statistic for first order ARCH. Both LM(x) and A are distributed as χ^2.

Non-Oil Growth Rate

Equation (1) is our general model of growth in non-oil output. A variety of specifications, including various definitions of the trend level of real non oil GDP were estimated. We were unable to find any evidence for an influence of the deviation of output from trend upon growth, which is not that surprising given the unbalanced growth of the recent decades[7].

Our results are presented below (equations (6) and (7)). We find that increasing oil revenue decreases the rate of growth of non-oil output by about a 1/4 of the growth rate of oil revenue. There is a long lag on this effect, which probably reflects the slowness of the resource transfer to the oil enclave and also the short term success of government spending to stimulate the non-oil sector. The only evidence of a spending effect is through growth in the real exchange rate, a real depreciation produces extra growth, but this effect is not significant from zero at the 10% level. This finding is consistent with that of Edwards (1986a) who shows the neutrality of devaluation on real output, and explains this through the stimulus given to products by falling costs of imported inputs. Finally, the underlying growth rate has changed from a high positive rate before the revolution to a slightly negative (though insignificant from zero) rate since the revolution. This is consistent with the rapid pre-revolution expansion, the post-revolution stagnation, and the strongly negative rates of investment since the revolution.

$$\Delta rnoy_t = \underset{(3.05)}{0.11} - \underset{(-3.36)}{0.19}\Delta oil_{t\text{-}4} - \underset{(-2.45)}{0.15}\text{DR} + \underset{(1.41)}{0.21}\Delta re_{bt-1} \quad (6)$$

Period, 1965 1990; $\overline{\text{R}}^2 = 0.30$; DW = 2.09; LM(1) = 0.13; LM(4) = 7.44; SER = 0.13; A = 0.21

$$\Delta rnoy_t = \underset{(2.80)}{0.10} - \underset{(-3.17)}{0.18}\Delta oil_{t\text{-}4} - \underset{(-2.0)}{0.11}\text{DR} \quad (7)$$

Period, 1965 1990; $\overline{\text{R}}^2 = 0.29$; LM(1) = 0.00; LM(4) = 5.8; SER = 0.13; A = 0.07

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[7] We modelled the long-run trend in output as a simple trend, and also as a split trend in which the increments reflect the relative average growth rates before and after the revolution, or the relative rates of capital formation before and after the revolution.

7. Inflation

Our prefered inflation equation has a long run solution based on Purchasing Power Parity, and so is estimated jointly with the exchange rate equation to take account of the cross equation restrictions implied by the common long run solutions.

$$\Delta p_t^d = -0.68 + 1.7\Delta p_{t-1}^f + 0.17\Delta my_{t-1} + 0.40\Delta p_{t-1}^d - 0.07\Delta oil_{t-1}$$

(-3.19) (3.1) (3.02) (3.9) (-5.4)

$$0.11[e_b - (p^d - p^f) - 0.15DR * oil]_{t-1} \qquad (8)$$

(3.28) (7.98)

Period, 1965 1990; $\overline{R}^2 = 0.79$; LM(1) = 3.7); LM(4) = 8.8;

SER = 0.04; A = 0.28

In the short run, a rise in foreign price inflation is matched by an equal rise in domestic inflation. Only in the long run does inflation respond to the domestic price of foreign goods rather than the dollar price. Our estimated exchange rate equation offers some explanation for this as the exchange rate is found to be "sticky" in the sense that e_b responds slowly to the lagged level of foreign prices, but does not respond to foreign inflation (see below). Hence, in the short run, a rise in foreign prices is almost equivalent to a rise in the Rial price of imports.

It was we found in the present study that a long-run relationship for prices based upon Purchasing Power Parity is considerably more robust than an inverted long-run money demand equation. Hence, when the real exchange rate is overvalued then inflation tends to fall. There is some degree of inertia in the inflation process, indicated by the significant lagged value of domestic inflation. Excess money growth adds to inflation. We prefer the ratio of money growth to real income growth as a proxy for excess money (Δmy), though we also experimented with the lagged residuals of a money demand equation. There is no significant contemporaneous effect of oil revenue on inflation [t-ratio=-0.51]. Growth in oil revenue is found to reduce inflation after a one year lag. The short run direct negative effect of oil revenue on inflation is probably explained by the increased availibility of imports as a consequence of greater foriegn currency earnings, which takes pressure off domestic prices. The long run effect differs between the pre- and post-revolution periods. Before the revolution, oil revenue had no long run effect on prices, but after the revolution greater oil revenue tended to reduce the equlibrium price level, and hence reduced inflation.

8. Exchange Rate

Our prefered equation is reported below. It is free from serial correlation and provides a reasonable fit to the data. Purchasing Power Parity is only found to hold as the long run equilibrium exchange rate (i.e. $f_1 = -f_2 = 1$) when oil revenue enters the equation. But we find that oil revenue only appears significantly in the equation when it is allowed to interact with the post revolution dummy variable[8]. We believe this is due to a reduction in the ability of the economy to absorb the increased demand which greater oil revenue generates. Before the revolution, the economy was growing rapidly, import substitution was being encouraged and foreign currency reserves were plentiful, thus extra demand was met by increased domestic production with little consequence for the exchange rate. But after the revolution, as production stagnated,[9] extra aggregate demand caused higher inflation, increased the demand for imports and diverted non-oil exports to the domestic market. With the official exchange rate becoming increasingly overvalued in real terms, increased oil revenue raised the demand for foreign currency in the parallel market, and caused the black market exchange rate to

[8]This result also holds if we test for cointegration using Johansen's (1988) method.

[9] Arguably the productive capacity of Iranian economy actually fell after the revolution. According to Pesaran (1995) over the period 1978-1988, the real output and investment fell by annual average rates of 1.8 and 6.6 per cents, respectively. See also Pesaran (1992).

depreciate[10]. We find no evidence of any other pre- and post-revolution asymmetries in the slope parameters of the exchange rate equation.

$$\Delta e_t = 1.74 - 0.40\Delta e_{t-1} - 0.60\Delta e_{t-4} +$$
$$\quad (7.44) \quad (5.39) \qquad (8.29)$$
$$0.47 DR_t - 0.30\left[e - (p^d - p^f) - 015 DR * oil\right]_{t-1}$$
$$(12.03) \qquad (7.52) \qquad\qquad (7.98)$$

Period, 1965-1990; $\overline{R}^2$ = 0.92; SER = 0.060; LM(1) = 0.01; LM(4) = 4.24; A = 0.10

The positive value of α_4 is consistent with a fall in the equilibrium real exchange rate following the revolution and is also consistent with depreciation caused by the flight of capital. Cointegration is present ($\alpha_7 < 0$) since in absolute value the t-statistic on α_7 exceeds Mackinnon's critical value[11](-3.58). The imposition of relative prices on the long-run equilibrium is not rejected ($\phi_1 = -\phi_2 = \phi$, χ^2 (1) = 0.07), and neither is a unit price differential elasticity ($\phi = 1$, $\chi^2 = 1.25$). The long-run solution (ignoring the constant and dummy) is $e = (p^d - p^f) + a\,(oil)$, where $\alpha = 0$ before the revolution and $\alpha = 0.15$ from 1979.

The dynamics of the equation are far from smooth, with the depreciation of the Rial being negatively related to past depreciations. We suspect that this finding, which we find to be very robust, is due to a mixture of policy responses and expectations of such responses. In particular, the government has tended to raise revenue by selling dollars in the black market (Pesaran 1992). If government sales of dollars are greater when the Rial has depreciated quickly, then this may partly explain the

[10] Without the oil variable interacting with the dummy the equation performs very poorly, there is no evidence of a long-run relationship, and essentially the rial is determined by an auto-regression with an intercept shift after the revolution. We found no significant pre-revolution effects for the oil revenue variable.

[11] MacKinnon's critical values have been reproduced by Banerjee et al (1993).

dynamics, as this intervention would slow down the rate of depreciation.

Money

The key issue with regard to money is whether oil revenue creates monetary disequilibrium that then iaffects inflation. We investigate this issue with an amended version of a standard money demand equation.

Bahmani-Oskooee (1996), using Iranian data, estimates demand for money equation applying Johansen's methodology. He concludes that a stable long-run demand for money function in Iran would include real M2, real GDP, the inflation rate, and the black market exchange rate as its arguments. We modeled demand for M2 using prices, non-oil output and oil output. An interest rate is not included due to the post revolution ban on usury. However, the rate of inflation may proxy for the return on money, especially as in developing countries financial alternatives to money are held to very few people.

The results show that the oil-revenue elasticity of money demand, although significantly greater than 0, is dramatically less than that of non-oil GDP ($\tau_1 = \tau_2$, $\chi^2(1)=14.12$). A unit price elasticity cannot be rejected ($\chi^2(1) = 0.11$). Our prefered equation is given below.

$$\Delta(m-p)_t = -2.9 + 0.32DR - 0.48[(m-p) - 0.83noy - 0.21oil]_{t-1} \tag{9}$$

(-3.57) (3.58) (-5.73) (7.23) (3.63)

Period, 1961-1990; $\bar{R}^2 = 0.70$; LM(1) = 0.80; LM(4) = 4.56;

A = 4.30; SER = 0.06

The equation is very simple, consisting of only the long run residuals, and a shift dummy. The high t-statistic associated with the long run residuals indicates that real money, non oil and oil output are cointegrated. The significant positive γ_7 is likely to be indicative of an upward shift in the growth rate of real money balances since the revolution, but could also indicate an exogenous increase in the long run demand for money.

A remaining issue for our analysis of the impact of oil revenue on the economy is whether higher oil revenue leads to excessive expansions of the money supply. The problem is that we cannot identify the money supply and demand equations. If prices adjusted fully within one year to the excess creation of money then we would find no contemporaneous correlation between real money holdings and oil revenue, which is our finding. The fact that we found no contemporaneous correlation between inflation and oil revenue or excess money holdings suggests that there is not a quick adjustment of prices to excess money. Another possibility is that, with sticky prices, agents may willingly hold excess money until prices have risen to absorb the excess money (see Laidler 1976). But there is no sign of oil revenue influencing money holdings except in the long run, thus we find no evidence of such short run buffering behaviour. We must conclude that oil revenue has not been responsible for a significant degree of monetary disequlibrium.

9. Foreign Inflation

We find that a rise in oil prices raises foreign prices, and that there is considerable inertia in the process. In the long run, a 10% rise in oil prices raises foreign inflation by only over 1%.

$$\Delta p_t^f = 0.01 + 0.67\Delta p_{t-1}^f + 0.04\Delta oilp$$
$$(3.14) \quad (8.58) \qquad (5.77)$$

Period, 1961-1990; $\overline{R}^2 = 0.82$; LM(1) = 2.04; LM(4) = 5.01; A = 0.35

Our findings maybe summarised as follows:

1. There is a slow negative direct effect of oil revenue on the non-oil sector, but there does not appear to be a significant expenditure effect.

2. Oil revenue has a complex influence on inflation. There are negative direct effects in the short and long run, plus a

positive indirect effect through foreign prices and the exchange rate.

3. We found no evidence of siginificant monetary effects.

10. System of equation method

To get more efficient results, all final models except money demand model(see finding 3 above) taken from previous section were restimated using SUR (Seemingly Unrelated Regression) method[12]. Full results are reported below. All coefficients confirm the results obtained in previous section and appear more precisely with lower standard errors.

Equation: $$\Delta p_t^d = b_1' + b_2' \Delta p^f{}_{t-1} + b_3' \Delta my_{t-1} + b_4' (re_b - b_3 DRoil)_{t-1} + b_5' \Delta oil_{t-1} + b_6' \Delta p_{t-1}^d + n_t$$

Observations: 29

R-squared	0.831412	Mean dependent var	0.103998
Adjusted R-squared	0.785434	S.D. dependent var	0.082448
S.E. of regression	0.038191	Sum squared resid	0.032088
Durbin-Watson stat	2.587987		

[12]In the case that the disturbances of the equations are correlated, this method of estimation produces more efficient results compared with equation-by-equation method (see Maddala 1992 for example).

Equation: $$\Delta e_{bt} = a_0 + a_{11}\Delta e_{t-1} + a_{14}\Delta e_{t-4} + a_4 DR_t + a_7(re_b - b_3 DRoil)_{t-1} + e_t$$

Observations: 26

R-squared	0.921563	Mean dependent var	0.109057
Adjusted R-squared	0.901954	S.D. dependent var	0.193775
S.E. of regression	0.060676	Sum squared resid	0.073630
Durbin-Watson stat	1.821665		

Equation: $$\Delta p_t^f = h_0 + h_1\Delta p_{t-1}^f + h_2\Delta oilp_t + w_t$$

Observations: 29

R-squared	0.835765	Mean dependent var	0.050829
Adjusted R-squared	0.823131	S.D. dependent var	0.030423
S.E. of regression	0.012795	Sum squared resid	0.004256
Durbin-Watson stat	1.458855		

Equation: $$\Delta rnoy_t = d_1 + d_{54}\Delta oil_{t-4} + d_7 DR + m_t$$

Observations: 26

R-squared	0.322341	Mean dependent var	0.044243
Adjusted R-squared	0.263414	S.D. dependent var	0.155004
S.E. of regression	0.133031	Sum squared resid	0.407039
Durbin-Watson stat	1.932583		

Estimation Method: Iterative Seemingly Unrelated Regression				
Sample: 1960 1990				
Convergence achieved after 7 iterations				
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
β'_1	-0.679942	0.214928	-3.163583	0.0021
β'_2	1.057036	0.345360	3.060680	0.0029
β'_3	0.173452	0.057049	3.040392	0.0031
β'_6	0.414753	0.102345	4.052510	0.0001
β'_4	0.113899	0.035020	3.252360	0.0016
β_3	0.156675	0.018742	8.359459	0.0000
β'_5	-0.071344	0.013145	-5.427686	0.0000
α_0	1.804874	0.223066	8.091208	0.0000
α_{11}	-0.437282	0.071702	-6.098573	0.0000
α_{14}	-0.597157	0.069192	-8.630446	0.0000
α_4	0.477238	0.038839	12.28748	0.0000
α_7	-0.309535	0.037831	-8.181994	0.0000
η_0	0.013518	0.003843	3.517293	0.0007
η_1	0.683284	0.066589	10.26129	0.0000
η_2	0.041075	0.006576	6.246393	0.0000
δ_1	0.103714	0.032726	3.169139	0.0021
δ_{54}	-0.175781	0.046426	-3.786292	0.0003
δ_7	-0.094920	0.046257	-2.052018	0.0430
Determinant residual covariance			4.97E-12	

Simulation

Given the complexity of the influence of oil revenue on inflation, we will use our estimated equations to simulate the effect of a boom on domestic prices. Equation (4) is redundant as we have argued that there is little evidence of monetary disequilibrium, and so for these simulations we will impose $\Delta my = 0$. Figures 1 and 2 show the actual rates of inflation and growth together with dynamic simulations from our equations. To gain some understanding of the impact of oil revenue on inflation, figure 3 compares the actual and dynamic simulated inflation rate with the inflation rate predicted for if the price of oil and oil revenue had remained constant at the 1973 boom level. Figures 4 and 5 show how inflation and growth would have evolved had real oil revenue and the price of oil remained constant at pre-1973 boom level.

Given the poor quality data and the search to explain the movements in growth and inflation related to oil revenue, we should not repeat a particularly good fit of the simulated data to the actual observations. Our inflation simulations (figure 1) suggest that a major peak in inflation in 1976 is not explained by oil revenue, but otherwise a large part of the variation in inflation since the 1973 boom can be explained by oil revenue. A significant number of the major turning points in growth (figure 2) can also be explained by oil revenue movements, though not surprisingly our simulation is poor in the immediate post-revolution period.

Figure 3 shows that had oil revenue been maintained at the level of the 1973 boom then Iranian inflation performance would, on average, have been considerably better, especially over the post-revolution period when oil earnings crushed due to sanctions and then falling oil prices. Whilst the oil boom initially caused inflation through the effect on foreign prices, over the medium and long run, oil revenue actually dampens inflationary pressure as the equilibrium real exchange rate rises after the revolution.

Figures 4 and 5 show that had the price of oil remained at the 1972 level then inflation and growth in Iran would have been more stable. This is true not only for a comparison with actual growth and inflation but also for a comparison with the simulations presented in figures 1 and 2. However, a comparison with figure 3 suggests that the price level would have been more stable if the boom had occurred and then prices and revenue remained constant. It would seem that the variation in oil prices and revenue can expalin a large part of the volatility of inflation and growth. In itself, the 1973 boom only had temporary effects.

11. Conclusion

Given the weaknesses of our data set and the problems of modeling, such a turbulent economy as Iran’s, our conclusions are very tentative. It seems that there has been a slow negative impact of oil revenue on the non-oil sector, which has constituted to the volatility of growth in non-oil GDP. Oil revenue appears, on balance, to have reduced inflationary pressures. Perhaps the findings regarding inflation should not surprise us, as oil makes up a very large part of Iran’s foreign currency earnings extra oil revenue, greatly to its ability to import goods to meet domestic demand.

With such a problematic data set, perhaps the best way to take this research forward would be to use data from a number of oil exporting developing countries in a panel data study. However, in many ways, Iran’s economy is unique and the way it responds to oil revenue movements may be very different from how the economies of other oil exporters respond.

Graphs:

Figure 1 Actual and Simulated Inflation

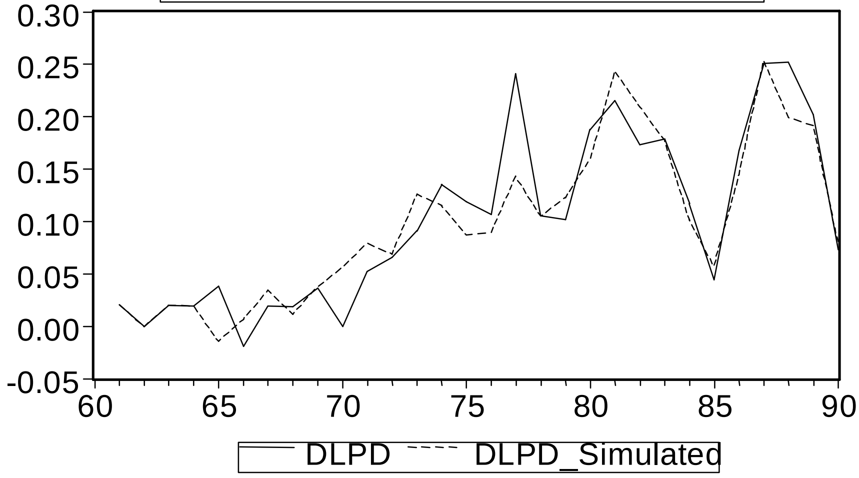


Figure 2 Actual and Simulated Growth of Non-oil GDP

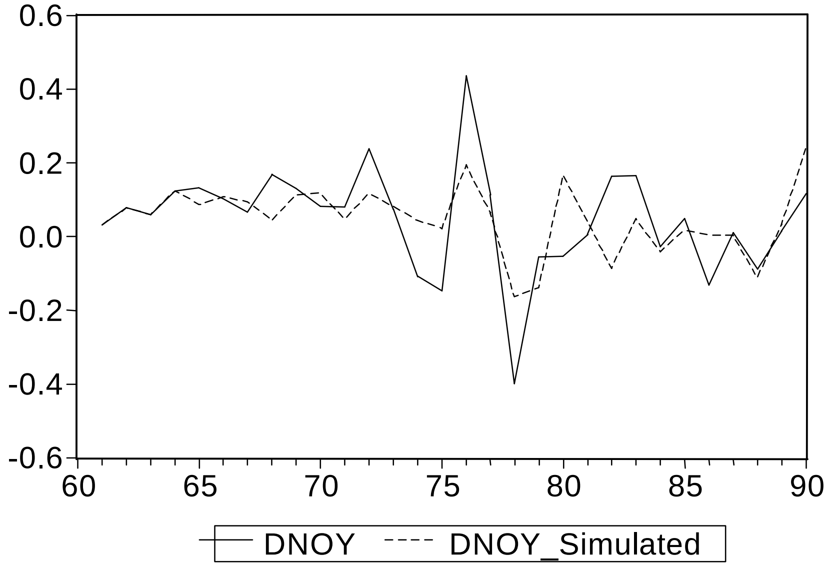


**Figure 3 Actual and Simulated Inflation
Oil price and revenue constant
at boom level**

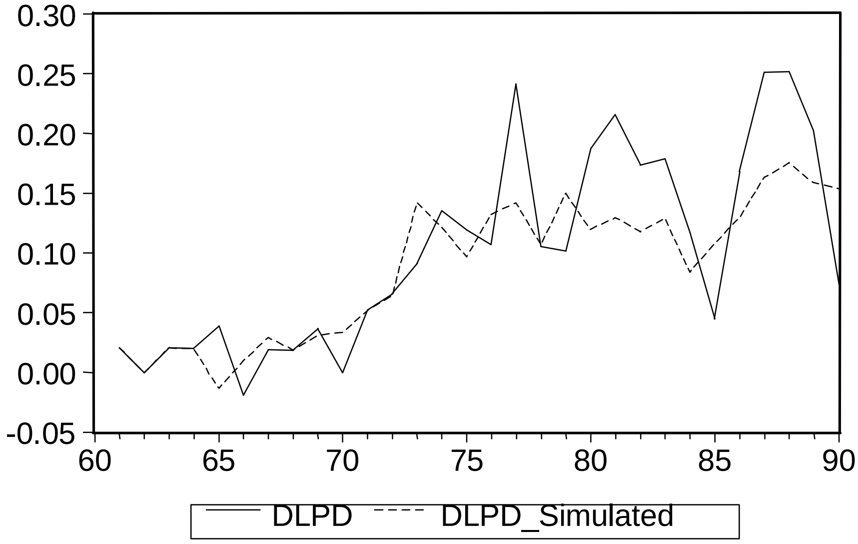


Figure 4 Actual and Simulated Inflation, no oil boom

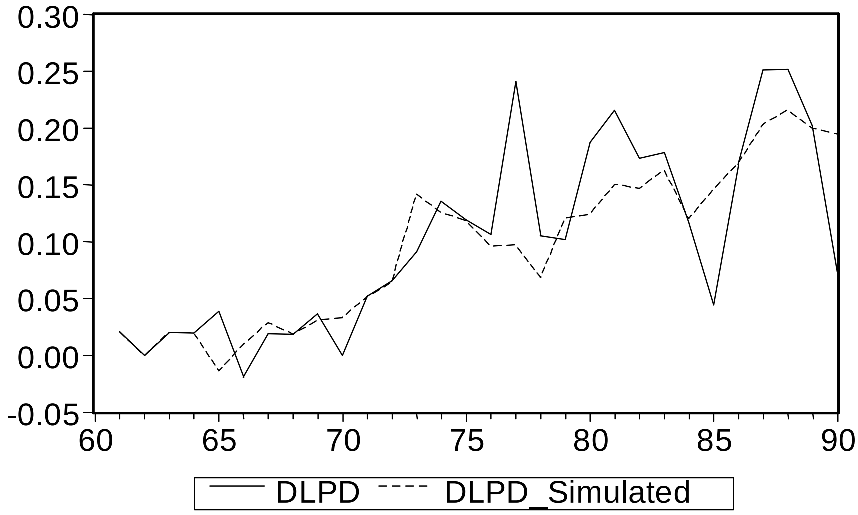
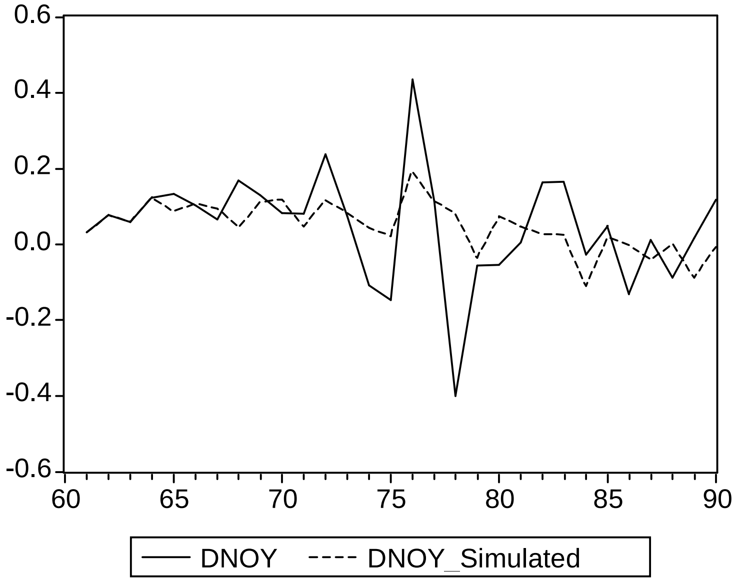


Figure 5 Actual Growth with Simulated Growth, no oil



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