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The Parallel Market for Foreign Exchange in an Oil Exporting Economy: The Case of Iran, 1978-1990

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Abstract

This paper provides a model for the determination of the parallel market exchange rate premium in a country where oil export earnings accrue directly to the government, and foreign exchange is centrally allocated for the importation of specific goods. Next, it studies the parallel market for foreign exchange in the Islamic Republic of Iran during the period 1978-90. The paper then examines the various time series properties of parallel market exchange rate in Iran, and the evidence of the role of oil and non-oil exports in the determination of the parallel market premium.

JEL Classification Numbers:

F31, F32, F41, O53

1/ I am thankful for discussions with and comments from P.R. Agénor, P. Cashin, M. El-Erian, H. Golriz, Z. Iqbal, A. Leijonhufvud, S. Lizondo, and M.H. Pesaran.

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Summary

The first aim of this paper is to provide a model for exploring the determination of the parallel market premium for foreign exchange in an oil exporting country. The model extends the work of Lizondo (1991) to incorporate some of the features specific to these economies, such as the accrual of oil export earnings to the government. The model incorporates a foreign exchange rationing board that obtains foreign exchange through oil export earnings and the surrender requirements on non-oil exports. It then allocates resources for the importation of different commodities.

Next, the above framework is used for understanding the developments in the Islamic Republic of Iran during 1978-90, when an active parallel market for foreign exchange developed in response to a number of domestic and foreign political shocks and to the exchange and trade restrictions adopted by the Iranian authorities. Iran's postrevolutionary experience with the parallel market for foreign exchange is particularly marked by its long duration and sizable premium, which exceeded 2,000 percent.

After a discussion of the theoretical determinants of the parallel market premium, the statistical properties of the parallel market exchange rate in Iran are examined in detail. This examination pointed to the presence of predictable patterns in the Iranian foreign exchange market. Finally, the theoretical model is econometrically examined. Although the empirical results obtained were not strong, they do provide some evidence for the negative impact of a decline in oil revenues on the parallel market premium in Iran.

I. Introduction

The purpose of this paper is to develop a theoretical model for the determination of the parallel market exchange rate premium in an oil exporting economy where oil revenues accrue directly to the government. Furthermore, it attempts to analyze empirically developments in the parallel market premium for the U.S. dollar in Iran during the period 1978-1990, up to the major reform of the exchange system in January 1991.

Iran has experienced severe balance of payments pressures since 1978 on account of a number of domestic and external shocks, such as the Iranian revolution, capital flight, economic sanctions by the West, the protracted war with Iraq (1980-88), and by an overall decline in oil export earnings since the revolution. The decline in oil and gas revenues, which accounted for about 96 percent of Iran's total exports during the period 1978-90, was particularly detrimental. Such exports declined from about US$21 billion in 1978 to a low of about US$6 billion in 1986, and rose to US$12 billion in 1990. The Iranian authorities responded to these balance of payments pressures through the imposition of severe capital controls and a multiple exchange rate system. Although Iran had a dual exchange rate regime immediately after the revolution, the system gradually grew in complexity and in certain periods over ten different exchange rates were in effect. The authorities also adopted a highly restrictive policy of import compression, and centralized the allocation of foreign exchange through an annual foreign exchange budget which distributed foreign exchange to different sectors based on political and economic priorities.

As a result of the above developments, there arose a very active parallel market for foreign exchange. This market, which had been virtually dormant since the end of the balance of payments crisis of the 1960s, re-emerged on account of political developments in early 1978 and became one of the most important features of Iran's postrevolutionary economy. 1/ Chart 1 depicts the movements in the parallel market premium for the U.S. dollar. 2/ The premium (*PMP*), which exceeded 2,000 percent, is among the highest ever

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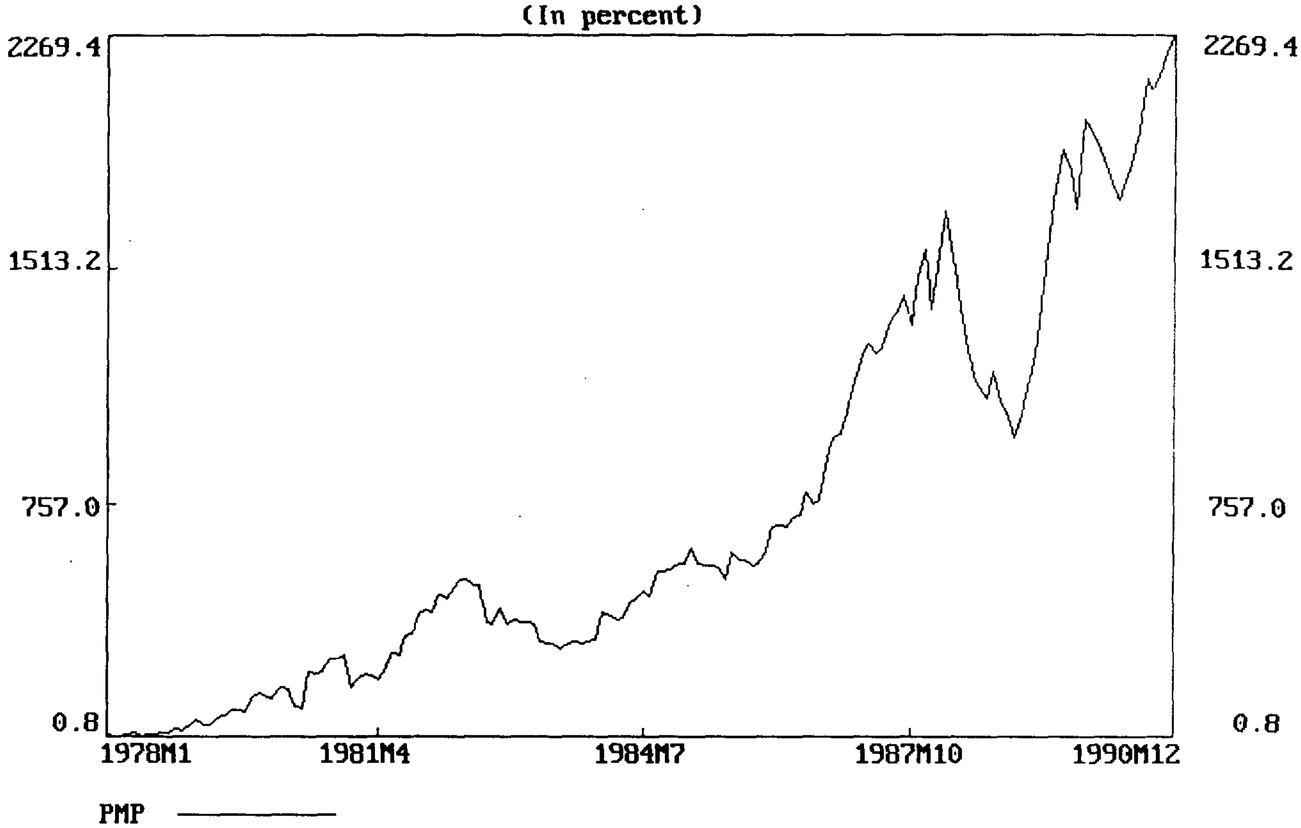
1/ With the exception of only a few years, Iran also had a parallel market for foreign exchange from 1930 to 1960. For discussions of Iran's foreign exchange system prior to and since the 1979 revolution, see Amuzegar (1977), Behdad (1988), Central Bank of Iran (1979), Khosropour (1956), Lautenschlager (1986), Mazarei (1995b), and Pesaran (1992).

2/ The parallel market premium is defined as the ratio of the parallel market rate to the basic official exchange rate, minus one. See Appendix III for definition of variables and sources of data used.

Chart 1: The Parallel Market Premium for the U.S. Dollar
(In percent)



observed internationally. The simple parallel market premium maintained its steep ascent from 1978 to 1990 with only one serious interruption, namely, the temporary decline in 1988 when the war with Iraq ended.

The Iranian foreign exchange system was partly reformed in January 1991 when the number of exchange rates was reduced from seven rates to three, including a floating exchange rate. Subsequently, the exchange rate system was temporarily unified in March 1993, and a floating exchange rate system was adopted. However, as the unification of the exchange system was anticipated long in advance, imports of goods that were permitted at the official rate rose sharply prior to the unification. At the same time, a decline in world oil prices diminished Iran's foreign exchange earnings. As a result of these developments, Iran accumulated sizable arrears on its external obligations, and the unified exchange rate system was abandoned in favor of a multiple exchange rate system. 1/

The remainder of the paper is organized as follows: Section II provides a model for the determination of the parallel market premium. Section III examines the statistical properties of the parallel market exchange rate in Iran, and provides an empirical test of the model. Section IV concludes the paper.

II. The Model

The framework presented here is an adaptation of the perfect foresight model provided in Lizondo (1991) to an oil exporting economy. 2/ It incorporates some of the specific features of these economies such as the receipt of oil revenues by the government in the form of foreign exchange. 3/ In addition, the model presented here includes a foreign exchange rationing board that allocates foreign exchange to various private sector imports by determining the type of goods which may be imported at the official exchange rate.

1/ The evolution of the Iranian foreign exchange system in the post-revolutionary period is discussed in more detail in Appendix I. It should be noted that Iran has not been the only oil exporter that has had a parallel market for foreign exchange. A number of other oil producers, including Algeria, Indonesia, Libya, Nigeria, and Venezuela, have at times had such a market. Parallel markets have come about in these countries as a result of balance of payments difficulties caused by a decline in oil revenues, or simply as a result of government policies aimed at restricting capital flight or certain types of imports.

2/ The model presented here is akin to the reserve adjustment version of Lizondo's model.

3/ Pinto (1987) discusses the parallel market exchange rate in Nigeria, an oil exporter, but does not provide a formal model. For general discussions of parallel markets for foreign exchange, see Agénor (1990), Dornbusch (1986a), and Edwards (1989).

The hypothetical oil exporting economy operates under a dual exchange rate system that comprises an official rate, e, and a parallel market rate, b. 1/ In order to simplify the analysis, the problem of leakages between the official and the parallel markets is ignored; this problem has been studied in detail in previous works such as Bhandari and Vegh (1990), Gros (1988), and Nowak (1984). 2/ It is assumed that the economy produces three types of goods: oil, h, which is produced and exported by the government, a non-oil exported good, x, and a nontraded good, n. The output of the nontraded good, q_n, and of the non-oil exported good, q_x, are fixed. Both the dollar price and the export quantity of oil (p_h, q_h) are determined by a *deus ex machina*, which can be called OPEC. Hence, total oil revenues ($H=p_h q_h$) received by the country are determined exogenously. The price of the non-oil exported good is assumed to be equal to one. 3/

Private sector agents spend a fraction, ω, of their nominal wealth on the consumption of nontraded and imported goods. It is assumed that agents behave as if they had a Cobb-Douglas utility function, and that they uniformly distribute a fraction α of their consumption on a continuum of imported goods, which is indexed by θ ($0 \leq \theta \leq 1$), and a fraction ($1-\alpha$) on the nontraded good. The world prices of the imported goods are also fixed at unity, while the price of the nontraded good, p_n, is determined endogenously by the market clearing condition in the nontraded good market. The government sector consumes only imported and nontraded goods; the government consumption of imported and of nontraded goods are represented by g_m and g_n, respectively.

The country has a foreign exchange board whose function is to allocate foreign exchange to different types of imports and determine the amount of goods that may be imported at the official exchange rate. Demand for foreign exchange for importing other goods, and asset demand for foreign exchange are left to be met in the parallel market. The board obtains foreign exchange from two sources, namely, the government and the surrender requirements on non-oil exports. In order to simplify the analysis, we assume that the fraction of the oil revenues allocated to the public sector for its consumption of imported goods is a fixed share, β, of total oil receipts. 4/ This implies that the government is obliged to sell the remaining portion

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1/ While Iran has actually had a system of numerous exchange rates, the model developed in this paper will contain only two rates. For a theoretical discussion of systems with more than two exchange rates, see Dornbusch (1986b).

2/ As Agénor (1995) argues, illegal trade and leakages are, however, likely to affect the dynamics of parallel market exchange rate.

3/ Another difference between the model presented here and the one in Lizondo (1991) is that in Lizondo's framework there exists a range of goods which are exported either at the official or the parallel market rate. In our model, however, there is only one non-oil export, but the authorities determine the surrender requirement rate on these exports.

4/ Hence, $g_m = \beta H$.

$(1-\beta)$ to the central bank at the official exchange rate. 1/ In addition, the foreign exchange board obtains foreign exchange through the surrender requirements on non-oil exports, which amount to $(1-\phi)q_x$. The surrender requirement rate, $(1-\phi)$, is determined exogenously. The total expected real foreign exchange available to the foreign exchange board, S, is as follows: 2/

$$S = (1-\beta)H + (1-\phi)q_x. \tag{1}$$

Given perfect foresight, the expected receipt of foreign exchange by the board is equal to the realized amount. The foreign exchange board determines the range of goods that may be imported at the official exchange rate based on the value of S. We define the range of the goods that can be imported at the official exchange rate as $(1-\theta)$. As the amount of foreign exchange surrendered to the board from various sources declines, it reduces the number of goods that can be imported at the official exchange rate. 3/ In view of the above institutional arrangements, the parameter θ is determined according to the following rule:

$$\theta = \theta(S), \quad \theta' < 0. \tag{2}$$

Equation (2) states that the range of goods imported by the private sector at the official exchange rate diminishes as the amount of foreign exchange available to it declines. 4/

1/ While the parameter β has been fixed in this model, it could conceivably be related to variables such as the total foreign exchange earnings of the country. Under such a setup, the value of this parameter would rise as total foreign exchange receipts increase, thereby allowing the fiscal authority to sell a smaller portion of its receipts to the central bank.

2/ The maximum real amount of foreign exchange (in terms of imported goods) that the foreign exchange board can obtain is $[(1-\beta)H + (1-\phi)q_x]/p_m$. Given the assumption of unitary import prices, this is equal to $[(1-\beta)H + (1-\phi)q_x]$.

3/ It should be remembered that we have assumed that our hypothetical economy can not borrow funds on the international capital markets. Consequently, the above framework suggests a tight relationship between a country's foreign exchange earnings and its official imports. Faini, Pritchett, and Clavijo (1988), Hemphill (1974), and Moran (1988) provide general discussions of the effect of foreign exchange earnings on the imports of the developing countries. Evidence of the strong influence of foreign exchange receipts on Iran's imports is provided in Mazarei (1995a).

4/ An alternative modelling strategy would be to assume that the authorities limit the amount of imports in general, with or without regard to the particular type of goods being imported.

Given the above structure, the consumer price index is:

$$P = p_n^{1-\alpha} e^{\alpha(1-\theta)} b^{\alpha\theta} = e\rho^{1-\alpha} d^{\alpha\theta}, \tag{3}$$

where $d = (b/e)$ is the parallel market premium for dollars, 1/ and $\rho = (p_n/e)$ is the price of the nontraded good relative to that of the traded goods, which is a measure of the official real exchange rate.

Let us proceed to a discussion of the private sector's portfolio choice. Agents hold their wealth, W, in the form of noninterest-bearing domestic and foreign currency, symbolized by M and f, respectively. Assuming that asset transactions are conducted on the parallel market, foreign exchange holdings are valued at the parallel market exchange rate. Hence, the representative agent's nominal portfolio is:

$$W = M + bf. \tag{4}$$

If equation (4) is deflated by the price level given in equation (3), the real private sector wealth is obtained:

$$w = m + f\rho^{\alpha-1} d^{1-\alpha\theta}, \tag{5}$$

where m is the real stock of money, M/P. The fraction of the agent's wealth that is held in the form of domestic currency, λ, is inversely related to the anticipated rate of depreciation of the parallel market exchange rate. Since agents are assumed to possess perfect foresight, the anticipated rate of depreciation of the parallel market rate is equal to the actual rate. Furthermore, given that the official exchange rate is fixed, the rate of change of the parallel market rate, $\dot{b}/b$, is equal to the rate of change of the differential between the official and the black market rate, $\dot{d}/d$. It is also assumed that foreigners are enjoined from holding domestic currency. In view of the above assumptions, demand for domestic currency is:

$$m = \lambda\left(\frac{\dot{b}}{b}\right)w = \lambda\left(\frac{\dot{d}}{d}\right)w, \quad 0 < \lambda < 1, \quad \lambda'(\cdot) < 0. \tag{6}$$

1/ More accurately, the premium should be defined as $(b/e)-1$. Throughout the remainder of this paper the ratio (b/e) is referred to as the parallel market premium.

Instantaneous clearing of the asset market provides the following portfolio relationship between the domestic and the foreign currencies:

$$m = \frac{\lambda\left(\frac{\dot{d}}{d}\right)}{1-\lambda\left(\frac{\dot{d}}{d}\right)} f\rho^{\alpha-1} d^{1-\alpha\theta}. \tag{7}$$

Movements in the supply of money are determined by changes in domestic credit, D, and by variations in official foreign exchange reserves, r:

$$\dot{M} = \dot{D} + e\dot{r}. \tag{8}$$

Assuming that tax revenues are equal to zero, and that the government cannot resort to foreign borrowing, changes in domestic credit are determined by the budgetary needs of the government. The budget deficit is equal to the difference between the expenditures on the nontraded good and oil revenues net of government purchases of the imported goods:

$$\dot{D} = e(g_m - H) + p_n g_n = p_n g_n - e(1-\beta)H. \tag{9}$$

The above formulation indicates that while the government will be operating with a surplus in its foreign transactions, its overall budget could, nevertheless, be in deficit. It is also evident from equation (9) that the receipt of petroleum revenues by the government in the form of foreign exchange significantly reduces the need to issue domestic credit and diminishes the chances of a foreign exchange crisis.

Movements in the level of foreign exchange reserves are determined by the developments in the official current account: 1/

$$\dot{r} = (1-\phi)q_x + (1-\beta)H - \alpha\omega(1-\theta)(m\rho^{1-\alpha}d^{\alpha\theta} + df). \tag{10}$$

1/ The expression for the private sector consumption of goods traded in the free market is obtained by dividing nominal wealth by the domestic prices of the goods traded on the parallel market, b. It should be recalled that the foreign price of the import and non-oil export goods have been set equal to one.

Using equations (8)-(10), changes in the real stock of money are determined as follows:

$$\dot{m} = (1-\phi)q_x \rho^{\alpha-1} d^{-\alpha\theta} - \alpha\omega(1-\theta)(m + f\rho^{\alpha-1} d^{1-\alpha\theta}) + g_n \rho^{\alpha} d^{-\alpha\theta} - \left(\frac{\dot{P}}{P}\right)m. \quad (11)$$

A significant feature of equation (11) is that neither oil revenues nor the government's consumption of imported goods affects the changes in the money stock if it is assumed that θ does not depend on oil revenues, H. 1/ Indeed, a corollary of this result is that the value of the government expenditure policy parameter β does not affect changes in the money stock either, so long as government expenditure on the nontraded good remains unchanged. 2/

Changes in the stock of foreign exchange held by the private sector are, as in Lizondo (1991), determined by the excess of the supply of dollars from non-oil exports to the parallel market, ϕq_x, over imports allowed in that market: 3/

$$\dot{f} = \phi q_x - \alpha\theta\omega(m\rho^{1-\alpha} d^{\alpha\theta-1} + f). \quad (12)$$

In the steady state, the market for the nontradable good clears, and the parallel market premium, the real money supply, the stock of foreign exchange in the parallel market, and the price level are constant

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1/ The lack of responsiveness of the money supply in a petroleum exporting economy, where oil revenues accrue to the government, to movements in oil revenues is discussed in Dailami (1979) and Morgan (1979).

2/ This follows from the general feature of our model that if oil export earnings are spent abroad, they would not affect the money supply. A shift in the parameter β leads to a reduction in government imports, but has no effect on private sector imports (assuming that θ does not depend on H). A decline in β reduces the growth rate of domestic credit (equation 9) and increases, by the same amount, the accumulation of reserves (equation 10). As a result, there is no impact on the money supply or any other variable in the model.

3/ This formulation abstracts from one of the interesting aspects of the Iranian parallel market experience, namely, the central bank's conducting of foreign exchange operations in the parallel market, which could bring about discrete changes in the parallel market exchange rate. The purpose of these open market operations was to raise revenues for the government and to influence the movements of the parallel market exchange rate.

$[\dot{d} = \dot{m} = \dot{f} = \dot{\rho} = 0]$. 1/ The equilibrium condition for the nontraded good market is: 2/

$$q_n = g_n + \omega(1-\alpha)(m\rho^{-\alpha}d^{\alpha\theta} + f\rho^{-1}d). \qquad (13)$$

The above equilibrium condition determines the price of the nontraded good and, consequently, the value of the real exchange rate.

Solving the system of equations (7) and (11)-(13) provides the steady-state values of the model. The steady-state value of d is reported below and those for m, f, and the equilibrium value of ρ are provided in Appendix II: 3/

$$d^* = \frac{\theta(1-\phi)}{\phi\left[q_n - \left\{1 + \frac{1-\alpha}{\alpha(1-\theta)}\right\}g_n\right]}. \qquad (14)$$

It should be noted that if the functional relationship between the variable θ on the total foreign exchange available to the banking system, S, is ignored, oil revenues and the volume of public sector imports, g_m, will have no effect on the steady-state value of the parallel market premium. The stability properties of the dynamical system (11)-(13), which exhibits saddlepath properties, are discussed in Appendix II.

1/ It is necessary to point out that in our model the steady state might be one in which international reserves are increasing or declining permanently. Such a decline in international reserves is indeed likely to invoke a Krugman-type balance of payments problem. One remedy to this problem is to modify the formulation of government finances to include a nondistortionary lump sum tax to cover the budget deficit so that the need for an increase in credit to the government is eliminated.

2/ Equation (13) in the text is obtained by dividing nominal wealth, $W = M + bf$, by the price of the nontraded good, P_n.

3/ Here, as in Lizondo (1991), it is assumed that $q_n > \left\{1 + \frac{1-\alpha}{\alpha(1-\theta)}\right\}g_n$ at all times.

Some Comparative Static Results

The sign of the effect of changes in oil revenues, non-oil exports, and the parameter β are as follows: 1/

$$(A)\ \frac{\partial d^*}{\partial H} < 0, \qquad (B)\ \frac{\partial d^*}{\partial q_x} < 0, \qquad (C)\ \frac{\partial d^*}{\partial g_n} > 0, \tag{15}$$

$$(D)\ \frac{\partial d^*}{\partial q_n} < 0, \qquad (E)\ \frac{\partial d^*}{\partial \beta} > 0, \qquad (F)\ \frac{\partial d^*}{\partial \phi} \gtrless 0. \tag{16}$$

Results *A* and *B*, not surprisingly, state that the parallel market premium declines as oil and non-oil exports rise. An increase in such exports would raise the level of foreign exchange available to the foreign exchange board, and lead to an extension in the range of goods that could be imported by the private sector at the official exchange rate. This would induce a lower demand for foreign exchange in the parallel market, and the premium would therefore decline. 2/ Also, an increase in non-oil exports implies that the supply of foreign exchange in the parallel market will increase, reducing the premium. Result *C* indicates that an increase in government expenditures on the nontraded good would lead to an increase in its price, and an increase in domestic credit to the government. The parallel market premium would then increase as private agents try to restore their portfolios to the desired level. An increase in the output of the nontraded good would lead to a decrease in the price of the nontraded good, and the premium (result *D*), since such an output increase would set in motion forces opposite to those caused by an increase in government expenditures on the nontraded good as discussed under result *C*. Result *E* states that if the government increases its own imports and lowers the amount of foreign exchange made available to the foreign exchange board for allocation to private sector importers at the official exchange rate, the demand for foreign exchange in the parallel market would rise, thereby leading to a higher premium. Result *F* suggests that a decrease in the parameter ϕ, which implies an increase in the surrender requirements on non-oil exports, would have an ambiguous impact on the premium. On the one hand, an increase in the surrender requirement rate would increase the foreign exchange available to the foreign exchange board and

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1/ Proofs of these results are not provided here, but are available upon request.

2/ Changes in the price and quantity of oil have the same impact in our model. In a more comprehensive model which allows for foreign borrowing by the government and exhaustibility of oil, price and quantity changes could have very different effects on the parallel market premium.

allow for more goods to be imported at the official rate, which would then lower the demand in the parallel market. On the other hand, a higher surrender requirement rate implies that non-oil exporters would reduce their supply of foreign exchange to the parallel market. The net impact of the lower demand and supply of foreign exchange on the premium is, therefore, ambiguous.

III. Empirical Examination

This section first examines the statistical properties of the parallel market exchange rate for the U.S. dollar in Iran. The model proposed in Section II is then econometrically examined.

1. Preliminary statistical analysis

The distribution of changes in the rial/dollar parallel market exchange rate

The basic statistics of the distribution of the rate of change of the rial/dollar parallel market exchange rate for the period covering January 1978 to December 1990 are provided in Table 1. It is worth noting that the reported statistic for skewness indicates some asymmetry in the distribution of the rate of change in the parallel market exchange rate. On the other hand, the distribution is characterized by leptokurtosis (fat tails), which indicates the presence of numerous large changes in the parallel market rate in Iran. This feature is also observed in other exchange rates. 1/

Chart 2 illustrates the monthly movements of the rate of change of the rial/dollar parallel market exchange rate. It indicates that the most volatile period in the parallel exchange market was between 1979 and 1982, which coincided with pronounced political upheavals. Since 1982, however, while the parallel market rate rose steadily, its volatility diminished.

1/ See Baillie and McMahon (1989).

Table 1. The Statistical Properties of the Rate of Change in the Rial/Dollar Parallel Market Exchange Rate

(in percent, January 1978 - December 1990)

Maximum Monthly Increase	60.74
Maximum Monthly Decrease	-27.92
Mean	2.36
Standard Deviation	9.32
Skewness	1.53
Kurtosis - 3	9.61
Coefficient of Variation	3.95

Note:

The maximum monthly increase in the parallel market rate occurred in June 1980 while the maximum decline in the parallel market rate occurred in December 1980.

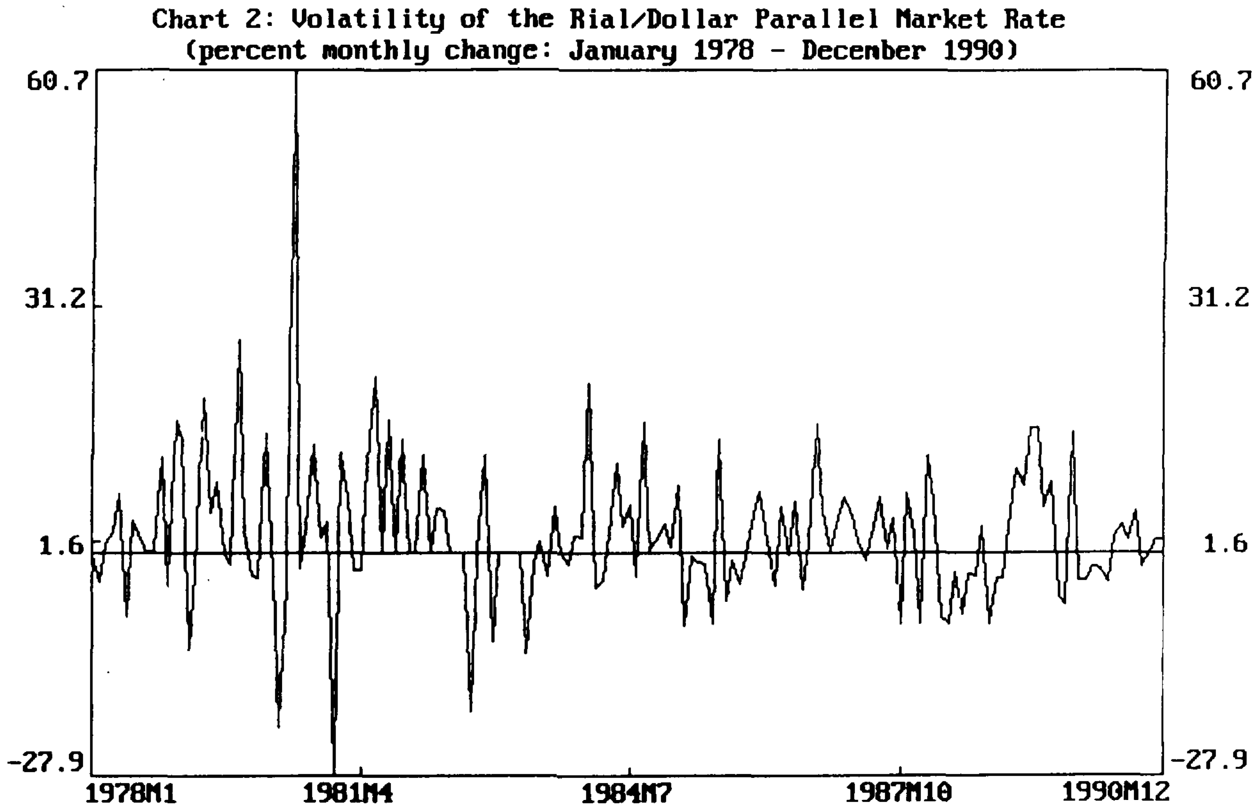
Chart 2: Volatility of the Rial/Dollar Parallel Market Rate
(percent monthly change: January 1978 - December 1990)
60.7
31.2
1.6
-27.9
60.7
31.2
1.6
-27.9
1978M1
1981M4
1984M7
1987M10
1990M12

Chart 3 presents the frequency distribution of the rate of change in the rial/dollar parallel exchange rate. 1/

Unit roots test

In order to examine the stationarity of the parallel market exchange rate series, unit root tests were conducted by estimating Dickey-Fuller and augmented Dickey-Fuller equations. 2/ The test results are reported in Table 2. Given that the τ_{τ} (the test statistic corresponding to δ) is -2.63, the hypothesis of a unit root in the logarithm of the parallel market exchange rate series cannot be rejected. Hence, the evidence indicates that the parallel market exchange rate series was nonstationary [$I(1)$]. Furthermore, the Φ_3 statistic is equal to 3.89 which suggests that the null hypothesis that the logarithm of the parallel market exchange rate follows a random walk with drift cannot be rejected at the 95 percent level of confidence. Dickey-Fuller and augmented Dickey-Fuller tests were also used in order to test for the

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1/ A pervasive issue in discussions of exchange rates is the distribution of the changes in the exchange rate. Various studies, such as Hodrick (1987), suggest that the distribution of exchange rate changes departs from normality. Among other consequences, this would have implications for the interpretation of statistical results, including autocorrelation tests, which are reported later in the paper. The non-normality of the distribution of changes in the rial/dollar parallel market rate was tested using the Jarque-Bera test. (See Bera and Jarque (1980)). The Jarque-Bera test statistic, JB, is given by:

$$JB = n\left[\frac{b_1}{6} + \frac{(b_2 - 3)^2}{24}\right],$$

where $(b_1)^{1/2}$ and b_2 are, respectively, measures of skewness and kurtosis of the distribution. The Jarque-Bera test statistic has a χ^2 distribution with two degrees of freedom. The value of the test statistic for the rial/dollar parallel market rate, computed using the information provided in Table 1 based on 156 observations, was equal to 661.44. Hence, the hypothesis of normality of the parallel market exchange rate was rejected. Lilliefors' version of the Kolmogorov-Smirnov test was also used to test for a possible departure of the observed distribution of the rate of growth of the parallel market rate from normality, and the null hypothesis of normality was rejected at the 1 percent level of significance. The Kolmogorov-Smirnov test is described in Daniel (1990).

2/ See Dickey and Fuller (1979, 1981).

Table 2. Unit Root Test Results for the Rial/Dollar Parallel Market Exchange Rate

(January 1978 - December 1990)

	Test of Unit Root in Parallel Market Rate[a]	Test of Unit Root in the First Difference of the Parallel Market Rate[b]
β	0.001 (2.307)	-0.000 (-1.002)
δ	-0.079 (-2.629)[c]	-1.092 (-5.435)[c]
Φ_3 [d]	3.889*	...
D.W.	1.970	2.033

Notes:

[a]The equation estimated is:

$$\Delta B_t = \alpha + \beta T + \delta B_{t-1} + \sum_{i=1}^{9} \gamma_i \Delta B_{t-i},$$

where B is the natural logarithm of the parallel market exchange rate, and T is a time trend. The lag length was chosen according to the Akaike Information Criterion [See Harvey (1990)]. The figures in parentheses are t-statistics. Initially, eleven monthly dummy variables were included in the regression equation in order to test for seasonality effects, yet all of their coefficients proved statistically insignificant.

[b]The equation estimated is:

$$\Delta^2 B_t = \alpha + \beta T + \delta \Delta B_{t-1} + \sum_{i=1}^{5} \gamma_i \Delta^2 B_{t-i}.$$

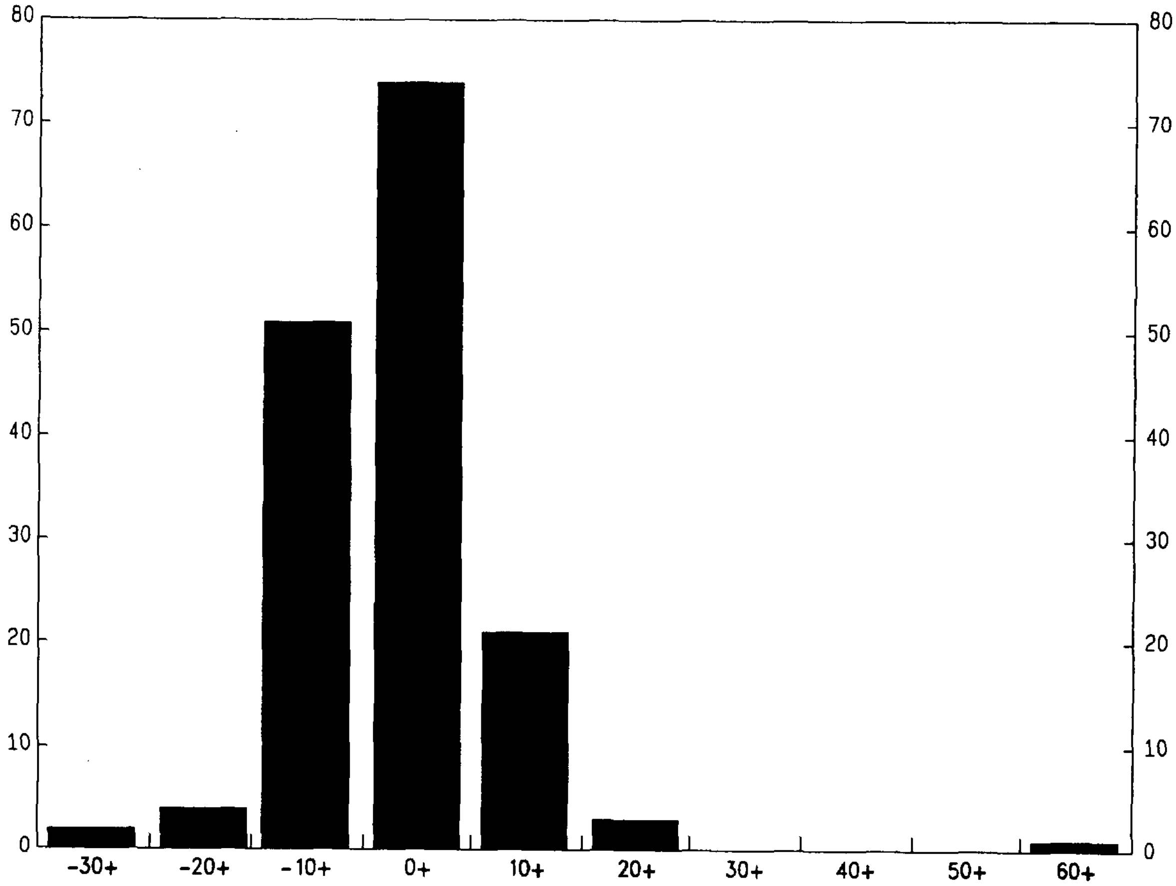
[c]The critical region for the Dickey-Fuller test at the $\alpha = 0.05$ level is -3.4398.

[d]The Φ_3 statistic is the Dickey-Fuller statistic for testing that the series follows a random walk with a drift ($\beta = \delta = 0$).

* Significant at the $\alpha = 0.05$ level.

Chart 3: Distribution of the Rate of Change in the Parallel Market Exchange Rate

(In percent: Jan. 1978-Dec. 1990)



existence of a unit root in the first difference of the series. The null hypothesis of a unit root in the first difference of the series was rejected (Table 2). 1/

The autocorrelation function

The autocorrelation function of changes in the logarithm of the parallel market exchange rate was estimated in order to obtain descriptive information about the parallel market exchange rate in Iran. Estimated autocorrelation coefficients are presented in Table 3. All estimated coefficients, except those for lag lengths 1, 2, 3, and 5, proved to be statistically significant, indicating the presence of serial correlation in the above series at high lag orders. Of particular interest is the sharp jump between the autocorrelation coefficients for lag lengths of 5 and 6 months, suggesting that the sixth order lagged value of the rate of change in the parallel market rate has some power in explaining the movements in the parallel market exchange rate in the current period. 2/

Runs test

A nonparametric test of the randomness of changes in the parallel market exchange rate is possible through a runs test. 3/ A run, R, is defined as a group of consecutive price changes of the same sign: +, -, or 0. For large samples, the sampling distribution of R is approximated by a normal distribution and, under the null hypothesis of the independence of price changes, the expected value and the standard error of R are:

$$E(R) = \frac{\left[N(N+1) - \sum_{i=1}^{3} n_i^2\right]}{N}, \qquad (17)$$

1/ The above results should be interpreted with the low power of unit root tests in mind.

2/ Indeed, these results should be considered with caution since the Box-Ljung test for the significance of the autocorrelation function depends on the assumption of normality of the time series being studied. It should be recalled that the normality test reported in section 3.1.1 indicated that the rate of change in the parallel market exchange rate does not have a normal distribution.

3/ For a discussion of runs analysis see Wallis and Roberts (1956). Applications of it to official and black market exchange rates are provided by Cornell and Dietrich (1978), and Gupta (1981), respectively.

Table 3. Autocorrelation Coefficients of the Rate of Change in the Rial/Dollar Parallel Market Exchange Rate

(January 1978 - December 1990)

Lag	Coefficient	Q(p)	Lag	Coefficient	Q(p)
1	-0.0603	0.5786	13	0.0354	38.1608
2	-0.1571	4.5299	14	-0.1650	42.8862
3	0.1245	7.0254	15	-0.1051	44.8168
4	0.1539	10.8660	16	0.0906	46.2622
5	0.0113	10.8869	17	-0.0760	47.2862
6	-0.2481	20.9990	18	-0.1542	51.5323
7	-0.0038	21.0014	19	0.0280	51.6735
8	0.1979	27.5257	20	0.0875	53.0621
9	0.0109	27.5455	21	0.0194	53.1308
10	-0.2421	37.4444	22	-0.1039	55.1161
11	0.0520	37.9044	23	-0.0423	55.4481
12	0.0153	37.9444	24	0.0604	56.1295

Notes:

Q(p) refers to the Ljung-Box statistic:

$$Q(p) = n(n+2)\sum_{j=1}^{p} (n-j)^{-1} r_j^2,$$

where n is the number of observations, p is the lag length, and r_j is the estimated autocorrelation coefficient. The Ljung-Box statistic is distributed approximately as a chi-square variate with p degrees of freedom.

* All autocorrelation coefficients, except for those for n = 1, 2, 3, and 5, were significant at the α = 0.05 level.

and

$$\sigma_R = \left[\frac{\sum_{i=1}^{3} n_i^2 \left[\sum_{i=0}^{3} n_i^2 + N(N-1) \right] - 2N\sum_{i=1}^{3} n_i^3 - N^3}{N^2(N-1)} \right]^{1/2}, \tag{18}$$

where n_i is the number of observations of each sign (+, -, or 0), and N is the total number of observations ($N = \Sigma n_i$). The test statistic is:

$$Z = \frac{R + 1/2 - E(R)}{\sigma_R},$$

which, under the null hypothesis, has a standard normal distribution in large samples. The 1/2 in the numerator is for discontinuity correction.

Table 4 provides details of actual runs of different length of the rate of change of the parallel market exchange rate around its mean. 1/ While the total number of positive and negative runs were roughly equal, as Table 4 indicates, the negative runs were longer in duration. Total expected and actual runs are reported in Table 5. Given a Z-score of -16.83, the hypothesis of the independence of changes in the parallel market exchange rate is soundly rejected. This result is in accordance with the Box-Ljung test results reported above, which indicated the presence of serial correlation in the parallel market exchange rate series. However, the presence of serial correlation differs from most of the results obtained by Gupta (1981) in his examination of parallel market exchange rates in India, South Korea, and the Taiwan Province of China. The contrasting results might be due either to a significant pattern of serial correlation in the fundamental determinants of the rial/dollar parallel market exchange rate (e.g., oil and non-oil export earnings), or possibly the presence of inefficiency in the Iranian foreign exchange market.

2. Regression results

The analysis in subsection 1 indicates that changes in the parallel market exchange rate exhibit predictable patterns, which in turn suggests the possibility of gaining some insight into the serial dependence of the changes

1/ These results were insensitive to the use of the median instead of the mean.

Table 4. Runs Analysis of the Rate of Change in the Rial/Dollar Parallel Market Exchange Rate

(January 1978 - December 1990: 156 months)

Run Length (months)	Sign		
	+	-	0
1	23	15	4
2	12	13	--
3	2	3	--
4	1	2	--
5	--	3	--
6	--	1	--
7	1	--	--
8	--	--	--
9	--	1	--
Total	39	38	4

Table 5. Summary Results of the Runs Analysis of the Rial/Dollar Parallel Market Exchange Rate

(January 1978 - December 1990)

Total Runs:	
Observed	81
Expected	137.89
Standard Deviation	3.35
Z-score	-16.83

in the logarithm of the parallel market exchange rate through regression analysis. 1/ The steady state value of the parallel market premium, which is given in equation (14), is determined by the proceeds from oil and non-oil exports, and by the output and the government consumption of the nontraded good.

Our efforts at empirically examining the relationship suggested by equation (14) is hampered since data on government expenditures and on the production of nontraded goods are available only on an annual basis. Hence, it was possible to conduct only a partial empirical examination using monthly series on oil and non-oil export earnings, which were available for the period January 1978-March 1990. Chart 4 illustrates both the decline and volatility in oil and non-oil export earnings in the period since the 1979 revolution. The autocorrelation tests reported above indicated that high order lags (lags higher than six periods) of the parallel market rate might have some explanatory power. Hence, lagged values of the premium were included in the regression equation. Lagged changes in the official exchange rate were also included in the regression in order to examine their impact on the parallel market premium; it would be expected that a devaluation of the official exchange rate might, on impact, lead to a decline in the parallel market premium, but that the premium would return to its previous level as steady state is regained.

Preliminary examination of the order of integration of the real oil and non-oil export earnings indicates that these series were stationary, while the time series for the parallel market premium was nonstationary. Such differences in the order of integration, as well as the absence of data on a number of the variables in equation (14), precluded an empirical examination using cointegration tests. Consequently, the estimation was done simply in first differences. The overall fit of the regression results was not good:

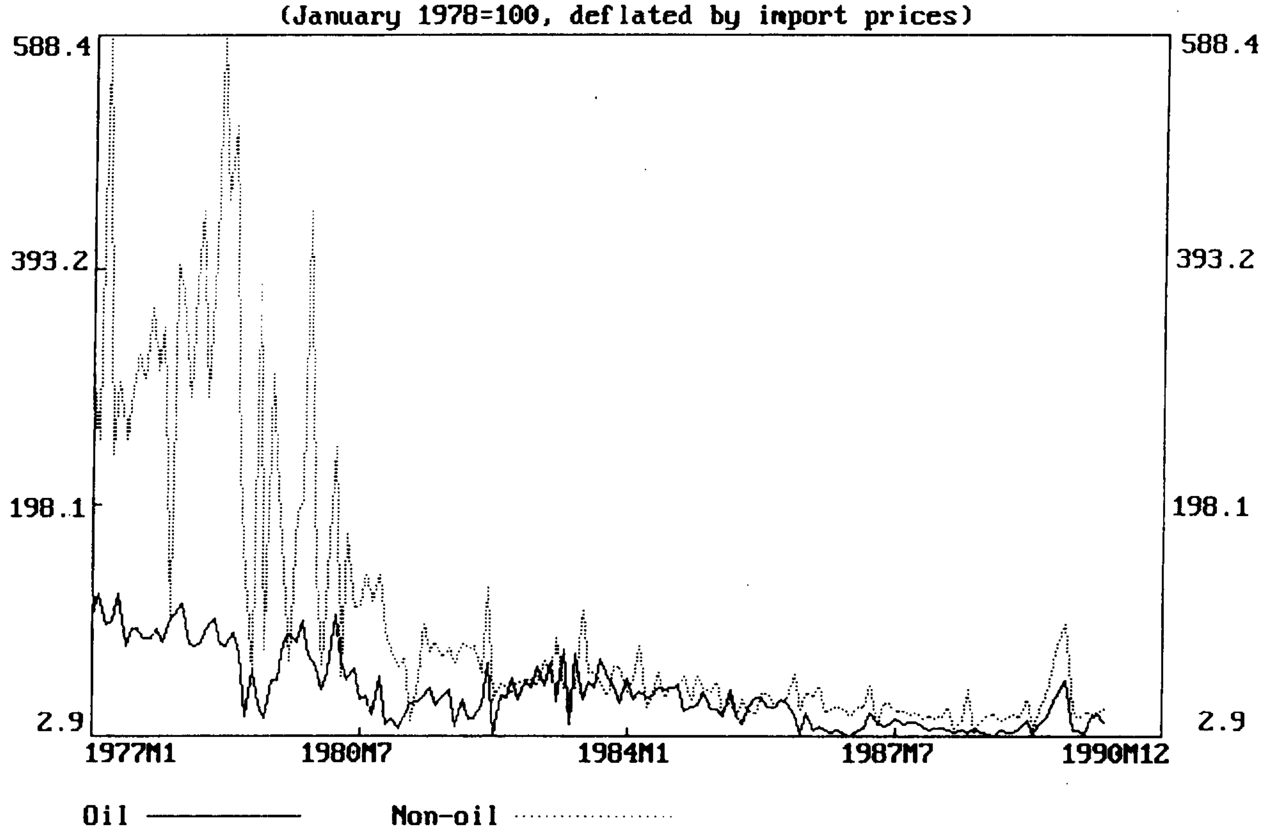
$$\Delta log(d_t) = \underset{(3.26)}{0.02} - \underset{(-2.93)}{0.24}\, \Delta log(d_{t-6}) - \underset{(-2.04)}{0.03}\, \Delta log(OX_{t-1}) - \underset{(-1.84)}{0.02}\, \Delta log(OX_{t-2})$$

$$+ \underset{(1.24)}{0.01}\, \Delta log(NOX_{t-1}) + \underset{(0.83)}{0.44}\, \Delta log(e_{t-1})$$

$$Adj\text{-}R^2 = 0.06,\ D.W. = 2.07,\ \hat{\sigma} = 0.09,$$

1/ Given that the official exchange rate remained largely stable throughout the period under study, the parallel market premium and exchange rate should have similar time series properties.

Chart 4: Indices of Real Oil and Non-oil Export Receipts
(January 1978=100, deflated by import prices)



where *d* is the parallel market premium, *OX* is real oil export receipts, *NOX* is real non-oil export receipts, e is the rial/dollar exchange rate, and σ is the standard error of the regression. The numbers in parentheses are *t*-statistics. While there is some evidence of the inverse relationship between oil exports and the premium, the coefficient of non-oil exports was of the wrong sign; however, it was statistically insignificant. The coefficient of changes in the official exchange rate was statistically insignificant. The sixth order lagged value of the change in the premium proved statistically significant; however, lower order lags of the same variable proved insignificant. Re-estimation of the above equation for shorter subperiods provided stronger support for the model, but the overall fit of the equation remained weak. The weakness of the results are likely to be due in part to the large volatility not only in the series on the parallel market premium, but also the series for oil and non-oil exports, as evidenced in Chart 4.

In addition to the paucity of data on pertinent variables, such as output of and government expenditures on nontraded goods, the poor overall fit of the equation may be due to several factors. First, the series for the parallel market exchange rate is very likely to contain considerable measurement error. Second, the poor statistical fit of the equation may be partly accounted for by differences in the calendars used for the measurement of the different variables. 1/ Third, the results might be due to the fact that the empirical analysis was done under the assumption that Iran has been operating under a system of dual exchange rates, when in fact the country operated under a multiple exchange rate system with frequent changes in the coverage of different exchange rates. Fourth, it is very likely that the movements in the parallel market exchange rate have been influenced by the numerous and significant political developments during the period under study. 2/

1/ All variables are recorded on the end-of-the-month basis. However, the parallel market premium is measured according to the Gregorian calendar, while all other variables are recorded according to the Iranian calendar. The Iranian calendar month runs from the twenty-first day of one Gregorian month to the twentieth day of the next month. Different weighted averaging schemes were tried in order to make the series compatible, but did not improve the empirical results.

2/ In order to examine the possibility of a long-run relationship between the parallel market premium and monetary factors, the existence of a cointegration relationship between the premium and the broad measure of money in real terms was tested using the Johansen procedure [Johansen (1988), and Johansen and Juselius (1990)]. Such a relationship could be established only at the $\alpha = 10$ percent level of confidence. Similar results were obtained when testing for the presence of a cointegration relationship between the parallel market premium and nominal stock of money.

IV. Concluding Remarks

In this paper we provided a simple model for the determination of the ratio of the parallel to the official exchange rate in an oil exporting economy. After examining some of the empirical properties of the rial/dollar parallel market exchange rate, we examined econometrically developments in the parallel market premium. While the econometric results did not provide strong support for the model, there is some evidence for the role played by oil exports on developments in the parallel foreign exchange market. It is important to emphasize that the model presented in this paper has abstracted from the wealth effects of oil resources. If the government of an oil producing country can readily resort to external borrowing against its oil reserves, indeed some of the motivation for the rationing of imports and the other exchange controls that engender a parallel market for foreign exchange will be attenuated. The model presented in this paper could be extended to provide for a framework for the analysis of such considerations.

The Evolution of the Iranian Foreign Exchange System Since 1974

Prior to the oil boom of the early 1970s, Iran operated a fixed exchange rate system under which the rial was pegged to the U.S. dollar. Between January 1974 and November 1978, Iran officially had a dual foreign exchange rate system comprising a fixed commercial and a "free" commercial rate. However, the central bank intervened frequently in support of the rial in the "free market," and the country operated under a virtually unified exchange rate system. In February 1975, the pegging of the rial to the dollar was abrogated in order to reduce the rial's sensitivity to fluctuations in the value of the U.S. dollar viz-à-viz the other major currencies, and an SDR peg was adopted at a par value of 82.2 rials per SDR. In addition, the commercial rate was allowed to float within a ± 2.25 percent band. The U.S. dollar, nevertheless, remained as the currency of intervention by the central bank. Throughout this period the parallel market exchange rate hovered closely above the official exchange rate.

With the escalation of domestic political tensions and of capital flight, the Central Bank of Iran discontinued its support of the rial in the free market in November 1978. In May 1979, the commercial and the noncommercial rates were replaced by two fixed exchange rates: an "official" and a devalued "unofficial" rate. Furthermore, surrender requirements on foreign transactions were reinstated. In May 1980, the official rate was devalued from 82.2 rials/SDR to 92.3 rials/SDR and became characterized by a multiplicity of exchange rates. The exchange system was further modified during the 1980s in response to domestic and external shocks. In some years, Iran operated under a system of over ten exchange rates. However, the actual structure and coverage of these rates had not been officially sanctioned.

Iran's exchange and trade system was partly liberalized following the end of the war with Iraq in 1988. In January 1991, the foreign exchange regime was drastically simplified and the existing seven exchange rates were replaced by three rates (Table A-1).

Table A-1. The Iranian Foreign Exchange System Prior to the January 1991 Reforms

Exchange Rate	Par Value	Coverage
1. Official	92.3 Rls./SDR	Oil exports, essential imports, public sector capital transfers
2. Incentive I	Official Rate + 350 Rls./US$	Non-oil exports (transactions in convertible currency)
3. Incentive II	Official Rate + 270 Rls./US$	Non-oil exports (transactions in non-convertible currencies or barter)
4. Preferential	420 Rls./US$	Imports of spare parts and some durable goods
5. Preferential Competitive	800 Rls./US$	Raw materials imports
6. Service	845 Rls./US$	Service imports
7. Free Market Rate	1,400 Rls./US$	All other transactions

The three rates included: the official rate (92.3 rials/SDR ≈ 70 rials/US$), the "competitive" rate (600 rials/US$), and a floating exchange rate. To complement these steps, the government reduced drastically the extent of exchange and trade restrictions. Numerous import items were moved from the official to the competitive rate and surrender requirements on non-oil exports were abrogated. 1/ Furthermore, foreign exchange receipts from non-oil exports were made convertible under the floating rate. After much anticipation, the multiple exchange rate system was virtually unified in March 1993. 2/ However, the unification was reversed in December 1993.

1/ It should be noted that prior to 1991 export surrender requirements were not always enforced.

2/ Although the exchange system was unified at the rate of Rls. 1,540 per U.S. dollar, a sizable amount of imports of essential goods and some current account transactions continued at the former basic official rate.

Mathematical Details

The Steady State Values of the Model

The steady state value of the parallel market premium was provided in the text. The equilibrium value for the real exchange rate, ρ, and the steady state values for holdings of foreign currency, f, and money, m, are given below:

$$\rho^* = \left[\frac{(1-\alpha)(1-\phi)q_x}{\alpha(1-\theta)q_n - (1-\alpha\theta)g_n}\right], \tag{A-1}$$

$$f^* = \frac{\phi q_x(1-\lambda)}{\alpha\theta\omega}, \tag{A-2}$$

$$m^* = \frac{\lambda\phi^{\alpha\theta}q_x^{\alpha}(1-\phi)^{\alpha(1-\theta)}(q_n-g_n)^{1-\alpha}}{(\alpha\theta)^{\alpha\theta}\omega(1-\alpha)^{1-\alpha}\left[\alpha(1-\theta)-(1-\alpha)\left(\frac{g_n}{q_n-g_n}\right)\right]^{\alpha(1-\theta)}}. \tag{A-3}$$

Stability Analysis

The dynamical system given by equations (7), (11), and (12) linearized around its steady state values is:

$$\begin{pmatrix} \dot{d} \\ \dot{f} \\ \dot{m} \end{pmatrix} = J \begin{pmatrix} d-d^* \\ f-f^* \\ m-m^* \end{pmatrix},$$

where J is the Jacobian matrix the elements of which, omitting the argument of the function $\lambda(0)$, are given below:

$$J_{11} = \frac{-\lambda(1-\lambda)(1-\alpha\theta)}{\lambda'} > 0,$$

$$J_{12} = \frac{-\lambda(1-\lambda)d^*}{\lambda' f^*} > 0,$$

$$J_{13} = \frac{(1-\lambda)^2}{\lambda' f^* \rho^{*(\alpha-1)} d^{*(1-\alpha\theta)}} < 0,$$

$$J_{21} = -(\alpha\theta-1)\alpha\theta\omega m^* \rho^{1-\alpha} d^{*(\alpha\theta-2)} > 0,$$

$$J_{22} = -\alpha\theta\omega < 0,$$

$$J_{23} = -\alpha\theta\omega\rho^{1-\alpha} d^{*\alpha\theta-1} < 0,$$

$$J_{31} = -\alpha\rho^{\alpha-1}d^{*-\alpha\theta-1}\left[\theta(1-\phi)+(1-\theta)\omega f^{*}d^{*-1}+\theta g_n\rho^{-1}\right] < 0,$$

$$J_{32} = -\alpha(1-\theta)\omega\rho^{\alpha-1}d^{*1-\alpha\theta} < 0,$$

$$J_{33} = -\alpha(1-\theta)\omega < 0.$$

The characteristic equation for the above system is:

$$\mu^3 + a_1\mu^2 + a_2\mu + a_3 = 0,$$

where:

$$a_1 = J_{11} + J_{22} + J_{33} \gtrless 0,$$

$$a_2 = (J_{11}J_{22}) + (J_{11}J_{33}) + (J_{23}J_{33}) - (J_{23}J_{32}) - (J_{12}J_{21}) - (J_{13}J_{31}) < 0,$$

$$a_3 = -(J_{11}J_{22}J_{33}) - (J_{12}J_{23}J_{31}) - (J_{13}J_{21}J_{32}) + (J_{11}J_{23}J_{32}) + (J_{12}J_{21}J_{33}) + (J_{13}J_{22}J_{31}) < 0.$$

The signs of the eigenvalues of the dynamical system could be obtained by using the following relationship among the roots of the system: 1/

$$a_1 = -(\mu_1 + \mu_2 + \mu_3),$$

1/ See Gandolfo (1971).

$$a_2 = \mu_1\mu_2 + \mu_1\mu_3 + \mu_2\mu_3,$$

$$a_3 = -\mu_1\mu_2\mu_3.$$

Given that the determinant of the system, a_3, is negative, at least one root must be negative. Furthermore, the total number of roots is three and, hence, the remaining two roots must be of the same sign. The negative sign of a_2 implies that the other two roots must be positive. Therefore, the system displays saddlepath stability.

Variable Definitions and Data Sources

PMP - simple parallel market premium ((*b*/*e*)-1);

d - ratio of the parallel market rate to the official exchange rate (*b*/*e*);

b - parallel market rial/U.S. dollar exchange rate (World Currency Yearbook);

e - official rial/U.S. dollar exchange rate (IFS);

OX - real foreign exchange receipts from oil exports, deflated by Iran's import price index (Bulletin, Central Bank of Iran);

NOX - foreign exchange receipts form exports of non-oil products and services, deflated by Iran's import price index (Bulletin, Central Bank of Iran).

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