Appendix :

Data Definitions and Sources		
Variable	***Definition***	***Source***
E_b	Free (black) market Exchange rate of Iran (average annual rate: Rials per US Dollar)	1965-1987: Currency Yearbook. For 1960-64 and 1988-1990, observations have been provided by Bahmani-Oskooee.
P^d	Consumer Price Index for Iran (Calculated for 1990=100)	Original data from: IFS several issues
P^f	Consumer Price Index for US (Calculated for 1990=100)	Original data from: IFS several issues
E_o	Official Exchange rate of Iran (1960 1990)	IFS several issues

Source: IFS = International Financial Statistics (IMF)

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Endnotes:

[1] In the pre-revolution period the Rial was devalued in 1968, 1969, 1975 and 1976 and revalued in 1967, 1973 and 1977. After the revolution devaluations occurred in 1980-1984, 1988 and 1989 and revaluations in 1985, 1986, 1987 and 1990.

[2] There are 7 non-zero values of Δe_{ot} before the revolution, and so we have only 5 degrees of freedom when we estimate equation 2. Including the zero values of Δe_{ot} would greatly increase in the degrees of freedom, but at the same time will bias λ_0 toward zero.

[3] We originally used the Augmented Dickey Fuller test (of order 2) but the lags were insignificant and their removal did not induce serial correlation of the residuals of the test equations.

[4] If we estimate an equation such as (1) for Δe_0 over the entire pre-revolution period, the downward bias on λ_0 is confirmed as we then estimate λ_0 to be -0.08 with a t-ratio of -1.17.

[5] Dornbusch (1987) reports that when inflation differentials are high then strong support is found for PPP. In terms of cointegration studies this is consistent with a more rapid adjustment to equilibrium.

[6] These results are robust to the inclusion of re_{jt-1} as an explanatory variable.

[7] This holds for the official exchange rate even if we add the first lag of the inflation differential to take into account the evidence previously reported in support of relative PPP.

5- Conclusion

We have shown that Purchasing Power Parity (PPP) is a relevant model of the determination of the black market exchange rate in Iran both before and after the revolution. But PPP in it's strong form is only relevant to the official exchange rate before the revolution, after the revolution it is relative PPP that determined the official exchange rate. Before the revolution both rates appear to have responded to movements in the other, but after the revolution no such relationship seems to have existed.

Our findings go some way to explaining the rise in the black market premium over the 1980s. The black market premium appears to be stationary before the revolution because both rates responded to similar stimuli. The premium would occasionally rise as the fixed official rate became mispriced, but realignments of the official rate would then reduce the premium. After the revolution the black market still moved in line with PPP, though the equilibrium real exchange rate may have been somewhat higher. But in this period the real official rate had no influence on the nominal official exchange rate; and the official rate was also unresponsive to the depreciation of the black market rate. Thus, the two exchange rates began to widely diverge after the revolution, which created a rising black market premium.

can not be rejected. Over the pre-revolution period we find that the fall in value of one exchange rate causes the other exchange rate to fall in value. For the official exchange rate a unit response cannot be rejected [$\psi_o = 1$, $\chi^2(1)= 0.25$]. For the black market $\psi_b / 1-\beta_b = 1$ cannot be rejected [$\chi^2(1)= 0.02$], thus e_b depreciates one to one for official devaluations. This is consistent with a number of studies (e.g. Dornbusch et al (1983) and Agenor (1991)) that report that official devaluations cause the black market rate to depreciate. In the post revolution period we find no evidence of spillovers from the official rate to the black market rate or vice versa.[7]

This change in the behavior of both exchange rates could be explained by the government's desire to profit from the high post-revolution black market premium. Thus, they chose to not devalue the official rate following the black market depreciations; and as the real official exchange rate became hugely overvalued, that is exchange from official sources increasingly scarce, so movements of the official rate ceased to influence the black market.

4-3-1- Pre-revolution:

$$\Delta e_{bt} = 0.83 + 0.42\,\Delta e_{bt-1} + 0.53\,\Delta e_{ot} - 0.14\,(e_b - p^d + p^f)_{t-1} \quad (16)$$
$$(2.12) \quad (2.52) \quad (2.00) \quad (-2.12)$$

$\overline{R}^2 = 0.47$; LM(1) = 0.35; 1960 - 1978; N.= 19

$$\Delta e^{+}_{ot} = -0.01 + 0.85\Delta e_{bt} \quad (17)$$
$$(-.72) \quad (2.85)$$

$\overline{R}^2 = 0.54$; 1960 - 78; N.= 7; DW = 1.14; N.= 7

4-3-2- Post-Revolution:

$$\Delta e_{bt} = 2.49 - 0.50\,\Delta e_{ot} - 0.33\,(e_b - p^d + p^f)_{t-1} \quad (18)$$
$$(3.41) \quad (-0.74) \quad (-3.09)$$

$\overline{R}^2 = 0.41$; LM(1) = 3.15; 1979 - 1990; N.= 11

sample, there is some support for relative PPP in the official market after the revolution.

It seems that prior to the revolution movements in both exchange rates could be explained by movements in the real exchange rates. After the revolution, this only applies to the black market, the official rate seems to respond to short term inflation movements but not to long run movements in the real exchange rate. One other mechanism that could prevent the exchange rates from systematically moving apart is if movements in one market cause similar movements in the other. We consider such spillovers in the next section.

4-3- Spillovers

The spillovers we consider are that the real exchange rate or change in the nominal value of an exchange rate may spillover onto the other exchange rate. Theoretically, we should expect some sort of spillovers, as disequilibrium in one market implies disequilibrium in at least one other market. For example, if the official exchange rate is overvalued, we may expect that the higher demand for foreign currency in the black market will tend to depreciate the black market rate. We estimate equations such as (14) to test for spillovers from devaluations/depreciations of one rate to the other:

$$\Delta e_{jt} = \alpha_j + \beta_j \Delta e_{jt-1} + \lambda_j (e_j - p^d + p^f)_{t-1} + \psi_j \Delta e_{kt-i} + \mu_{jt} \quad (14)$$

We estimate the following equation to test for spillovers from the real exchange rate:

$$\Delta e_{jt} = \alpha_j + \beta_j \Delta e_{jt-1} + \lambda_j (e_j - p^d + p^f)_{t-1} + \delta_j (e_k - p^d + p^f)_{t-i} + \mu_{jt} (15)$$

where $k \neq j$. We again only use non-zero values of Δe_o in the pre-revolution period,

and constrain β_o and λ_o to equal 0 in the pre-revolution period.

In neither period do we find evidence of spillovers from one real exchange rate onto the other exchange rate, in all cases $\delta_j = 0$

Relative PPP requires that $\phi_{ij} > 0$, and $\phi_{ij} / (1-\beta_j) = 1$ in the case of equation (9) and $\phi_{ij} = 1$ in equation (10). Our preferred equations are reported below:

4-2-1- Pre-Revolution

$$\Delta e_o^+ = -0.008 - 0.25\Delta(p^d - p^f)_{t-1} \quad (10)$$
$$(-0.37 \quad (-0.42)$$
$$\overline{R}^2 = -0.16;\ 1960-78;\ N.=7$$

$$\Delta e_{bt} = -0.007 + 0.41\Delta e_{bt-1} + 0.12\Delta(p^d - p^f)_{t-1} \quad (11)$$
$$(-0.65)\ (1.87) \qquad (0.57)$$
$$\overline{R}^2 = 0.12;\ 1960-1978;\ N.=17$$

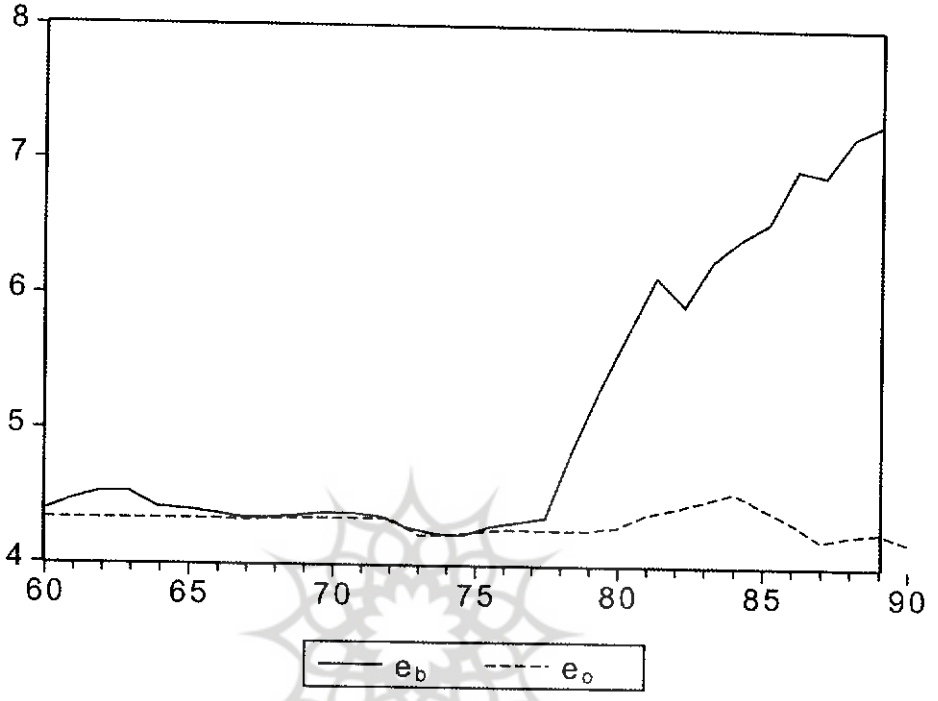
4-2-2- Post-Revolution

$$\Delta e_{ot} = -0.05 + 0.64\Delta e_{ot-1} + 0.43\Delta(p^d - p^f)_t \quad (12)$$
$$(-1.14)\ (1.77) \qquad (1.15)$$
$$\overline{R}^2 = 0.09;\ 1979-90;\ N.=12$$

$$\Delta e_{bt} = 0.35 - 1.03\Delta(p^d - p^f)_{t-1} \quad (13)$$
$$(3.11)\ (-1.17)$$
$$\overline{R}^2 = 0.03;\ 1979-90;\ N.=12$$

Before the revolution relative PPP is clearly rejected in the official market, devaluations appear to be negatively related to relative inflation. In the black market the coefficient on relative inflation is correctly signed but insignificantly different from zero and $[\phi_b/1-\beta_b\ ]$ is significantly less than 1 $[\chi^2(1)=5.99]$. Thus, before the revolution relative PPP is strongly rejected in both markets. After the revolution PPP is strongly rejected in the black market, as ϕ_b is negative. For the official exchange rate ϕ_o is correctly signed, but insignificantly different from 0, but $\phi_o/(1-\beta_o)$ is also insignificant from 1 $[\chi^2(1)=0.01]$.[6] Thus, given our small

Figure 2: Black Market and Official Exchange Rates (logarithm)



Relative Purchasing Power Parity

Realtive PPP proposes that even if PPP does not hold in the levels of exchange rate and relative prices it may hold for the growth rates. We test for relative Purchasing Power Parity by running regressions such as:

$$\Delta e_{jt} = \alpha_j + \beta_j \Delta e_{jt-1} + \phi_j \Delta (p^d - p^f)_{t-i} + \mu_{jt}\,, \qquad (8)$$

and for the pre-revolution official exchange rate:

$$\Delta e^{+}_{ot} = \alpha_o + \phi_o \Delta (p^d - p^f)_{t-i} + \mu_{ot}\,, \qquad (9)$$

higher post revolution inflation rate (the inflation rate averaged 6% before the revolution and 16% after) which raises the costs of slowly adjusting the price of foreign currency.[5] The post revolution equation implies a higher value of the real exchange rate (α_b / λ_b) 7.5 against 5.8 after the revolution, and this increase in the real rate is statistically significant [$\chi^2(1) = 31.9$].

It would seem that the determinants of the two exchange rates were similar before the revolution, but have greatly diverged since. The change clearly relates to how the official rate has been adjusted. Whilst adjustments were rare in the pre-revolution period, they did correct the real exchange official towards the PPP level. But in the post-revolution period, though more frequent adjustments occurred to the official rate, they were not towards PPP. This is consistent with the view that post-revolution governments have used an over valued real official exchange rate as a means to generate revenue (see Karshenas and Pesaran, 1995). Figure 2 shows that relative to the rapid depreciation in the black market since the revolution, the official exchange rate has been almost constant. Even if strong PPP is not relevant to the post revolution official market for foreign exchange, relative PPP might be relevant. We consider this issue next.

where numbers in brackets are t-ratios, N is the number of observations and LM(1) is a test for first order serial correlation, distributed as χ^2 (1).

Before the revolution, the adjustments to both exchange rates are to restore purchasing power parity, and λ_b is significant from zero at the 10% level.[4] According to the point estimates, deviations from PPP are initially corrected almost twice as fast in the official market as in the black market. But, of course, the slower initial adjustment in the black market reflects the continuous nature of the adjustment in the black market. The long run value of the real exchange rate (α_j/λ_j) is similar in both equations, 5.71 in equation (4) and 5.84 in equation (5).

Whilst the lags and timing of adjustment differ, the long run adjustments are not that different. This suggests that whilst revisions to e_o were infrequent they did tend to mimic the longer run behavior of e_b.

4-1-2- Post-Revolution:

$$\Delta e_{ot} = \underset{(-0.9)}{-0.26} + \underset{(0.88)}{0.05}\,(e_o - p^d + p^f)_{t-1} \qquad (6)$$

$$\bar{R}^2 = -0.02;\ \text{LM(1)} = 0.80;\ 1980 - 1990;\ \text{N.} = 11$$

$$\Delta e_{bt} = \underset{(3.4)}{2.33} - \underset{(-3.07)}{0.31}\,(e_b - p^d + p^f)_{t-1} \qquad (7)$$

$$\bar{R}^2 = 0.43;\ \text{LM(1)} = 1.83,\ 1979 - 1990;\ \text{N.} = 12$$

After the revolution a very different picture emerges. The value of λ_o is positive, but insignificant from zero, indicating no adjustment to restore a PPP equilibrium in the official market. However, there is still evidence of PPP being restored in the black market, and λ_b is significantly different from zero at the 5% level. The point estimate of the rate of adjustment in the first year is almost twice the pre-revolution rate, this is possibly due to the

official rate test equation (t-ratio = -0.46). The real black market rate is now found to be stationary, the Dickey Fuller statistic is -5.16, but the real official exchange rate is found to be non-stationary, the DF statistic is 1.95.

On this evidence PPP is accepted for the black market and rejected for the official market. However, the Dickey Fuller statistic is known to have a number of problems, which may explain the rejection of PPP for the official market. Also these tests do not tell us whether the exchange rate or prices adjust to maintain a stationary real rate in the black market. Moreover, these tests cannot tell us whether the rejection of stationarity for the real official rate applies to both periods. To proceed further we must estimate the error correction models. Banerjee et al have shown that in small samples estimating the error correction model can be a superior test for cointegration compared with Engle and Granger's (1987) method or even Johansen's method. Significantly negative values of λj are indicative of cointegration, but in the presence of non-stationary variables the distribution of the t-ratio on λj is not standard, critical values are produced by Mackinnon (1991). Our preferred error correction equations are reported below.

4-1-1- Pre-Revolution:

$$\Delta e^{+}_{ot} = 2.0 - 0.35(e_o - p^d + p^f)_{t-1} \qquad (4)$$
$$(1.71)\ (-1.7)$$

$$\bar{R}^2 = 0.24;\ 1960 - 1978;\ N.=7$$

$$\Delta e_{bt} = 0.992 + 0.44\ \Delta e_{bt-1} - 0.17\ (e_b - p^d + p^f)_{t-1} \qquad (5)$$
$$(2.35)\quad (2.4)\quad (-2.36)$$

$$\bar{R}^2 = 0.35;\ LM(1) = 0.02;\ 1960 - 1978;\ N.=17$$

4- Results

4-1- Strong Purchasing Power Parity

If the exchange rate adjusts to restore the real rate to the equilibrium value, then e^* is given by the ratio of domestic to foreign prices, p^d - p^f. Thus we estimate equations of the form:

$$\Delta e_{jt} = \alpha_j + \beta_j \Delta e_{jt-1} + \lambda_j [e_j - (p^d - p^f)]_{t-1} + \mu_{jt}, \qquad (3)$$

There is considerable debate about the appropriate price series to use in estimation of PPP models. Ideally, the series should reflect the price of tradable goods, as the prices of non-tradables will reflect domestic factors. For our purposes this debate is unhelpful as we have no choice but to use the consumer price index. Any rejection of PPP may then reflect the use of an inappropriate price index.

Table 1 includes the results of stationarity tests performed on the real official and black market exchange rates ($re_j = e_j - (p^d - p^f)$), we find each to be I(1). Given the non-stationarity of e_o, e_b, p^d and p^f, a weak test of PPP is the stationarity of the real exchange rate. If the simple PPP model is a valid long-run relationship, then the exchange rate and price differential should not systematically depart from each other and so the real exchange rate should be stationary (see, for example, Taylor 1995). Hence, our evidence rejects the strong form of PPP.

The rejection of stationarity in the real exchange rates may reflect small sample problems of the test and problems of applying unit root tests in a multivariate context (see Banerjee et al 1993), but also could be due to a shift in the real exchange rate after the revolution. Perron (1989) discusses the problems of testing for a unit root in the presence of structural breaks. To take account of this possibility we performed a Dickey Fuller[3] test on the real exchange rates with the addition of a post-revolution intercept dummy in each test equation. The dummy is highly significant in the test equation for the black market rate (t-ratio on the dummy = 6.20), but the dummy is not significant in the

Table 1: Phillips-Perron Tests for Unit Roots (1962-90)

Varible	Z(α)	Z(t)
e_h	1.51	1.28
e_o	-8.79*	-1.99
p^d	1.71	4.01
p^f	0.41	0.85
re_h	-0.76	-0.36
re_o	3.27	3.21
Δe_h	-20.58*	-3.93*
Δe_o	-19.59*	-3.72*
Δp^d	-7.87*	-2.24
Δp^f	-7.72*	-2.22
Δre_h	-25.18*	-4.66*
Δre_o	-10.67*	-2.57

Notes:
Lag length = 2, Z(α) is the Phillips-Perron test statistic for a unit root, Z(t) is the Phillips-Perron test statistic when a deterministic trend is included.

* indicates significant at 5% level.

permits slow adjustment through inertia captured by β_j and an adjustment towards equilibrium. If the exchange rate exceeds the equilibrium value, then we expect an appreciation to restore equilibrium, hence $\lambda_j < 0$.

Our data is annual for the period 1960 to 1990, so that we have at the most 19 observations in the pre-Revolutionary period and 12 in the post-revolutionary period. For this reason we do not employ either Johansen's (1988) methodology or the general to specific methodology, but simply test a number of simple models and report the best OLS estimates.

Modeling the official exchange rate presents a further problem. In the official market adjustments of the nominal exchange rate were rare in the pre-revolution period, and so data on Δe_{ot} will be dominated by zeros[1]. So that we obtain a clearer picture of the adjustment process we choose to model the official market exchange rate only in the periods when a change in the nominal exchange rate took place. For the post-revolution period this simply means starting our estimation from 1980. For the pre revolution period we estimate:

$$\Delta e_{ot}^{+} = \alpha_o + \lambda_o (e_o - e_o^*)_{t-1} + \mu_{ot} \qquad (2)$$

where + indicates non-zero values.[2]

Generally the first step in estimating error correction models is to test for stationarity, and if the data are not stationary, then to test for cointegration. However, our small samples make testing for stationarity and cointegration problematic, as tests for these properties rely on asymptotic results. Generally, prices are regarded as being non-stationary and clearly the rapid depreciation of the rial in the black market would imply that this variable is non-stationary. The Phillips - Perron tests indicate that e_o *and* e_t are I(1) and that p^d and p^f could be I(2) (see Table 1).

2- Theory

There are numerous mechanisms that could determine equilibrium exchange rates. One is *purchasing power parity* which follows from the assumption that in equilibrium it should not be possible to profit from buying a good in one country and selling it in another. In this case, the exchange rate adjusts to maintain a constant real exchange rate in the long run. Either trading in the free market forces an incorrectly valued exchange rate back to the equilibrium value, or flows of foreign reserves force the authorities to correct the official exchange rate. In the first case, when the currency is overvalued falling demand for net exports creates an excess supply of currency which depreciates the exchange rate. In the second case, the drain on reserves due to intervention to support an overvalued currency eventually forces a devaluation. In either case in the long-run $e = k + p^d - p^f$, where k is a constant, e, p^d and p^f are, respectively, the exchange rate, the domestic price level and the foreign price level, all measured in natural logarithms. Despite a number of objections to the simplistic theory of PPP, the model has a good empirical record, especially in high inflation countries (Dornbusch, 1987). A weaker formulation is known as relative PPP. This postulates that whilst PPP may not hold for the levels of the exchange rate and prices it may hold for their growth rates. In this case a unit relationship exists between the rate of depreciation of the currency and the inflation differential (see for example Frenkel, 1978).

3- Econometrics

We employ simple error correction models to test the alternative exchange rate models, that is:

$$\Delta e_{jt} = \alpha_j + \beta_j \Delta e_{j_{t-1}} + \lambda_j (e_j - e_j^*)_{t-1} + \mu_{jt} \qquad (1)$$

Where e^* is the equilibrium value of the exchange rate, Δ is the difference operator, μ_{jt} is an error term and $j = o$ denotes the official rate and $j = b$ denotes the black market rate. Such a model

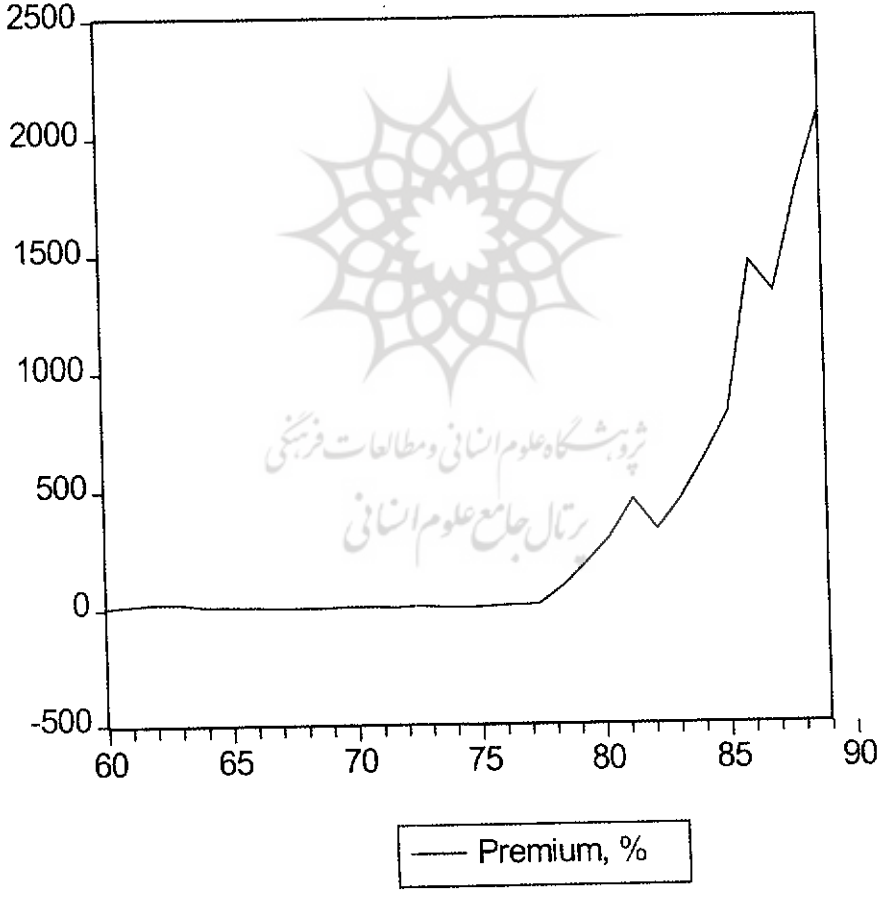
Bahmani-Oskooee (1993) reports that purchasing Power Parity appears to be a valid model of the black market rate but not of the official exchange rate. Bahmani-Oskooee tests for cointegrating relationships over the pre- and post-revolution period together. As the economy of Iran has changed so fundamentally since the revolution, an issue we consider is whether or not the findings of Bahmani-Oskooee apply to these periods separately. Given that prior to the revolution the black market premium was at times near to zero, it would appear that the official rate must have been adjusted towards the black market rate. If Purchasing Power Parity holds for the black market rate before the revolution, then it should be the case that the official rate was adjusted towards the PPP rate. As the premium widened after the revolution then we would expect the determination of the official exchange rate to be very different to that of the black market rate. We also consider whether movements of one exchange rate may have spillover effects on the other exchange rate. The widening of the premium could be explained by changes in any of these relationships after the revolution.

Section I briefly reviews the theory of PPP. Section II discusses our econometric methodology. Our results are presented in section III and section IV concludes. We find that PPP in its strong form applies to the black market rate over both periods, but only applies to the official rate before the revolution. After the revolution relative PPP applies to the official exchange rate, but otherwise we find no evidence of relative PPP explaining either exchange rate. Changes in the value of one nominal exchange rate appear to trigger a similar movement in the other rate before the revolution, but after the revolution there is no such response in either market. Clearly, these differences in the behavior of the official rate over the two periods help to explain the systematic rise in the premium since the revolution.

revolution to over 2000% by 1990 (see figure 1). The purpose of this paper is to consider whether or not purchasing power parity has influenced either the black market or official exchange rates; to see if there are any links between the two exchange rates and to use these findings to explain how the black market premium became so great.

Figure 1: The Black Market Premium (%)

[(Eb-Eo)/Eo]



Determinants of the Official and Free Market Exchange Rates of Iran: An Explanation of the Black Market Premium

Aziz Arman (Ph.D.)*

Abstract:
In this study validity of purchasing power parity (PPP) to the official and black market exchange rates in Iran for the pre and post revolution periods is investigated. We find that strong PPP applies to the black market over both periods, but only applies to the official market before the revolution. After the revolution relative PPP can apply to the official market, but otherwise growth in either exchange rate seems unrelated to inflation differentials. The systematically rising black market premium since the revolution is explained by the failure of official rate which is in allignment with PPP and that there appears to be no relationship between the official and black market rates after the revolution.

Keywords: *Middle East, Iran, exchange rates, purchasing power parity, black market premium.*

1- Introduction

In Iran a free market for foreign exchange has existed for many years alongside the official market for foreign exchange. The official exchange rate has been fixed and subject to infrequent changes of nominal value. Sometimes the free market has been almost dormant, at such times the premium that could be earned in the free market has been almost zero. But at other times, most notably since the revolution of 1979, the free market has been the dominant source of foreign exchange. The social and political unrest starting shortly before the revolution initiated a rapid depreciation of the black market exchange rate as the demand for foreign currency exceeded the official supply. In the post-revolution period, the premium on foreign currency sold in the black market over currency sold in official markets has been rapidly increasing, from near to zero shortly before the

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