DECLINE OF THE IRANIAN RIAL DURING THE POST REVOLUTIONARY PERIOD: PRODUCTIVITY APPROACH

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THE DECLINE OF THE IRANIAN RIAL DURING THE POST REVOLUTIONARY PERIOD: PRODUCTIVITY APPROACH*

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Abstract

Since the advent of revolution in Iran, the Iranian rial has lost its nominal and real values by more than 40 times. What could explain this decline? In this paper, I identify the decline in relative productivity between Iran and her seven major trading partners as the major cause of the decline in the real rial. Engle-Granger cointegration and error-correction modeling along with Johansen-Juselius cointegration technique are used to establish the long-run relation between real exchange rates (seven) and differential productivity. Additionally, the empirical methodologies are supplemented with a graphical exposition to add more intuition to the analysis. Finally, several policy recommendations are outlined.

ملخص

فقد الريال الايراني منذ قيام الثورة في ايران أكثر من ٤٠ ضعف من قيمتيه الاسمية والفعلية. فما هو تفسير هذا الانخفاض؟ في هذه الورقة أسعى إلى توضيح الانخفاض في الانتاجية النسبية بين ايران وشركائها التجاريين السبعة الأهم كسبب رئيسي وراء انخفاض قيمة الريال الفعلية. ويتم استخدام نموذج انجل-جرانجر للتكامل المشترك وتصحيح الخطأ مع أسلوب جوهانسن-جوسيليوس لطريقة التكامل المشترك وذلك لتحديد العلاقة طويلة الأجل بين أسعار الصرف الفعلية (السبعة) والانتاجية المتباينة. بالاضافة إلى ذلك، يستكمل عرض بياني المناهج التطبيقية ليضفي مزيداً من التوضيح للتحليل. وأخيراً يتم عرض عدد من التوصيات الخاصة بالسياسات الاقتصادية.

I. INTRODUCTION

The long-run theory of nominal exchange rate determination has come under the heading of Purchasing Power Parity (PPP here after) according to which the nominal exchange rate between two currencies is defined as the ratio of corresponding national price levels. Applied between, say, the Iranian rial and the United States dollar, the PPP claims that in the long-run:

$$R_t = (P_{IRAN}/P_{U.S.})_t \quad (1)$$

where R is number of rials per dollar, P_{IRAN} is the price level in Iran; and $P_{U.S.}$ is the price level in the U.S.

Recent studies such as Taylor (1988), Karfakis and Moschos (1989), Layton and Stark (1990), McNown and Wallace (1989), Bahmani-Oskooee and Rhee (1992) and Bahmani-Oskooee (1993a) who used cointegration analysis, mostly rejected the PPP.[1] As far as the experience of Iran is concerned, Bahmani-Oskooee (1993b) has provided partial support for the PPP. Using the black market value of the rial, he has shown that although there is a long-run relation between exchange value of the rial and the price ratio, the slope coefficient in equation (1) is not unity, an example of imperfections in PPP. What may cause imperfections in PPP (in case of Iran) or its total failure in case of many other countries? First, the assumptions behind the PPP, such as free trade and zero transaction cost are violated in many instances. Many countries do have trade restrictions such as tariff or quota and there is always cost associated with any international transaction. Second, because of high transaction costs there are always goods that are nontradeables. Prices of nontradeables (such as a hair cut) are not usually equalized across countries. As a result, relation (1) or PPP could hold if prices included in (1) are those of tradeables. However, when prices of nontradeables are incorporated in equation (1), the PPP could fail. Third, imperfections in PPP, i.e., a slope coefficient of less than unity could be the result of what is known as simultaneity problem. In equation (1) neither exchange rate nor relative prices could be exogenous. Fourth, another assumption behind equation (1) is that the weights used in constructing price indexes for both countries are the same. This assumption could easily be violated due to the fact that two countries use different basket of goods to construct their price index. Fifth, there are variables other than relative prices (such as money or asset prices) which may determine the exchange rate. Finally, there could be real factors or real variables that may cause the PPP (the right hand side variable in equation 1) to deviate from equilibrium exchange rate (the left hand side variable in equation 1). Among the real variables, the productivity differential between two countries has received the most attention in the literature and indeed, has resulted in its own literature under the heading of "productivity bias hypothesis in PPP". As it will be shown later, testing the productivity bias hypothesis amounts to testing and identifying the productivity differential between two countries as a determinant of real exchange rate between two countries.

Since the advent of the Islamic revolution in 1979, the Iranian rial has lost its nominal and real value substantially. Could the productivity differential between Iran and its major trading partners, i.e., Canada, France, Germany, Italy, Japan, U.K., and the U.S. be the source of the decline? It is the

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[1]. For a comprehensive review of the literature on PPP see Officer (1976a).

purpose of this paper to investigate this question. To this end, in section II, we provide a review of related literature. Section III introduces a model of real exchange rate determination and discusses the methodologies employed to estimate the model. Since the models will be estimated using time series data over the 1960-1990 period, the estimation methods are based on cointegration and error-correction techniques of Engle-Granger (1987) and Johansen-Juselius (1990). In section IV we present the empirical results. Section V discusses macro economic policy implications of our findings. The study is summarized in section VI. Data definition, construction and sources are cited in section VII. Finally, the literature used in the study is cited in section VIII.

II. REVIEW OF THE LITERATURE

Before discussing the relevant literature, let us first learn more about the relation between exchange rate and relative prices. By relying upon equation (1) we can measure the deviation of PPP which is equal to $(P_{IRAN}/P_{U.S})$ from equilibrium exchange rate R by the following ratio:

$$\frac{(P_{IRAN}/P_{U.S})}{R} \qquad (2)$$

which could also be written as

$$\frac{P_{IRAN}}{P_{U.S.}\,R} \qquad (3)$$

In (3) if we substitute definition of each variable,i.e., number of rials per Iranian output for P_{IRAN}; number of dollars per U.S. output for $P_{U.S.}$; and number of rials per dollar for R, we obtain

$$\frac{(\text{Rial/Iranian Output})}{(\text{Dollar/U.S. Output})(\text{Rial/Dollar})} = \frac{\text{U.S. Output}}{\text{Iranian Output}} \qquad (4)$$

which is number of U.S. output per unit of Iranian output, i.e. the real exchange rate. Therefore, an increase in (3) will be an indication of the real appreciation of the rial and a decrease in it an indication of real depreciation. The implication is that the measure of deviation of PPP from equilibrium nominal exchange rate outlined by relation (2) is really nothing but a measure of real exchange rate outlined by relation (3). Thus, they could be used interchangeably, as it has been done in the literature to which we turn next.

The most path breaking article in the literature that tries to identify productivity differential as a factor that causes the PPP to deviate from equilibrium exchange rate or as a determinant of real exchange rate belongs to Balassa (1964). In one instance Balassa (1964, p. 586) argues that if international productivity differences are greater in the production of traded goods than non-traded goods, the country with higher productivity will experience on overvalued currency in terms of purchasing power parity. This implies that relation (3) should be positively dependent upon the ratio of Iranian productivity over U.S. productivity. In another instance Balassa (1964, p. 586) writes:

> If per capita incomes are taken as representative of levels of productivity, the ratio of purchasing power parity to the exchange rate will thus be an increasing function of income levels.

In the above quote, Balassa actually is referring to relation (2) as a positive function of income ratios. A major reason for the productivity bias in PPP, as provided by Balassa, is that greater productivity differentials between countries contribute to a greater wage differentials, thus, to a greater price differentials in services and non-traded goods. This will make the gap between PPP and the equilibrium exchange rate wider.

In attempting to verify empirically the above proposition concerning the relationship of PPP, exchange rates, and income levels, Balassa plotted the PPP as a percent of exchange rate against per capita GNP of 12 industrial countries using data from 1960. The graph showed a close association between the two variables. The correlation coefficient between the two variables with 12 observations was 0.92 which provided evidence for the validity of Balassa's proposition regarding the productivity bias hypothesis.

De Vries (1968) in a comprehensive study considered the magnitude of depreciation of nominal and real exchange rates of 109 members of International Monetary Fund from 1948 till 1967. The main conclusion was that number of less developed countries that devalued their currencies or experienced depreciation in their currencies were much higher than number of developed countries. Several explanation for this finding was provided among which one has to do with productivity. As de Vries (1968, p. 572) writes:

> Productivity advances in the more developed countries could often run ahead of their exchange rates, preventing damage to their export positions. Because of productivity advances in export production, prices of export goods in the more developed countries may well have gone down despite advances in the cost of living index. This has probably occurred much less frequently in the less developed countries.

Although de Vries did not provide neither theoretical nor empirical justification for his argument, it is apparent that he cites productivity advances in developed countries relative to less developed countries as a source of fewer devaluations or depreciation in the former group relative to the latter group. Another reason for rapid depreciation in less developed countries was that less developed countries use exchange rate adjustment as a policy tool more than developed countries do. More developed countries do rely heavily on the use of fiscal and monetary policies and other domestic measures. Finally, it was noted that less developed countries that eliminated multiple exchange rates, experienced a rapid depreciation of their currencies in excess of internal inflation.

As indicated in the introduction, one reason for the failure of the PPP is the exclusion of other variables. Using data from 1960 for the same 12 OECD (Organization for Economic Corporation and Development) countries and 19 Latin American countries, Clague and Tanzi (1972) examined the relevance of other variables in addition to per capita income in determining the deviation of PPP from the equilibrium exchange rate. Major conclusions of Clague and Tanzi's study were that in the case of 12 OECD countries, the Balassa effect received strong support, however, in the case of Latin American countries it did not. Grunwald and Salazar-Carillo (1972) is another study which tested the productivity bias hypothesis for Latin American countries with no success. As they conclude:

> It appears that without further manipulation Latin American data are not consistent with the Balassa hypothesis and that therefore there are, in this respect, significant differences between the developing and developed countries which Balassa examined. (p. 264).

The first criticism of Balassa's work has come from Officer (1974) where he criticizes Balassa's results on statistical grounds. In his comment on Officer's work, Balassa (1974, p. 882) discounts Officer's criticisms of his 1964 work and concludes that:

> Whatever the statistical validity of this result, it provides no justification for the absolute purchasing power parity theory as Officer alleges. The result only shows the existence of a broad correspondence between international wage differences in productivity levels I pointed out in my 1964 paper.[2]

Officer (1976b) does not give up the issue and conducts a comprehensive study in which he focuses on econometric testing of the productivity bias hypothesis. The model tested by Officer takes the following form:

$$PPP_i/R_i = \alpha + \beta PROD_i + \epsilon_i \quad (5)$$

where
PPP_i = purchasing power parity of country i, number of unitsof domestic currency per unit of standard currency,
R_i = exchange rate of country i, number of units of domestic currency per unit of standard currency,
$PROD_i$ = ratio of productivity in country i to productivity in the standard country,
ϵ_i = error term.

If the productivity bias hypothesis is to hold, the estimate of β should be positive and significantly different from zero.

All studies reviewed above estimated a variant of equation (5) for only one year. Officer estimates different variants of (5) for different years. First $PROD_i$ is replaced by (GDP/POP) where

2. Another statistical deficiency of Officer's work is that since he pooled time-series data from 10 countries, the residuals could have been serially correlated over time and heteroskedastic across countries. In this case it would be necessary to make corrections for serial correlation and heteroskedasticity. On how to test and correct for serial correlation and heteroskedasticity when data are pooled see Bahmani-Oskooee (1987).

$(GDP/POP)_i$ is the ratio of per capita GDP (at current prices) in country i to per capita GDP (at current prices) in the standard country. The numerator is converted from domestic currency to the standard currency by means of the PPP between the two countries. The resulting model is estimated annually for each year starting from 1950 and ending at 1973. Fifteen industrial countries are involved with Germany serving as the standard country.[3] The result of this experiment reported in Officer's Table 2 (1976b, p. 556) did not support the Balassa's hypothesis. In the second variant $PROD_i$ in equation (11) is replaced by $(GDP/EMP)_i$. This new ratio is defined as the ratio of GDP (at current prices) per employed worker in country i to GDP (at current prices) per employed worker in the standard country, where the numerator is converted from domestic currency to the standard currency by means of the PPP between the two countries. The resulting model was estimated for the same years using data from the same 15 industrial countries. The results reported in Officer (1976b, Table 3), again, did not support the productivity bias hypothesis. Finally, in the third case $PROD_i$ in equation (11) is replaced by $(PRODT/PRODNT)_i$ where for each country PRODT/PRODNT is the ratio of productivity of the traded sector of that country to the productivity of her nontraded sector. In turn each sector's productivity is defined as GDP (at constant prices) originating in that sector per employed worker in that sector. Constructing this same measure for the standard country and taking the ratio of country i's PRODT/PRODNT to that of the standard country yield the definition of $(PRODT/PRODNT)_i$ employed by Officer. Like other variants of equation (11) the resulting model was estimated for the same years using data from the same 15 industrial countries. Again no significant results were obtained in this case either.[4] Officer (1976b, p. 575) then concludes:

> The evidence provided by this study indicates that the productivity bias hypothesis lacks a firm empirical foundation, suggesting that the general acceptance of the hypothesis is unwarranted. With careful attention paid to the experimental design of the test, the productivity bias was found to have no operational impact on the PPP over exchange rate relationship, except in extremely rare cases.[5]

Thus far, studies reviewed above have mostly rejected the productivity bias hypothesis except Balassa. However, more recent cross-sectional studies such as Kravis and Lipsey (1978, 1983) and Clague (1986, 1988) have supported the hypothesis. A common feature of all studies mentioned above is that they have all used cross-sectional data and have provided mixed conclusions. We are

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[3]. The countries included were Canada, the United States, Australia, New Zealand, Austria, Belgium, Denmark, Finland, France, Italy, the Netherlands, Norway, Sweden, Switzerland and the United Kingdom.

[4] In another attempt, Officer (1976, p. 557) constructed a new "ideal-index PPP" for each country which was then used in re-estimating equation (11). The reported results in his Tables 5, 6, and 7 were not supportive of the hypothesis.

[5]. Officer's findings received further support from Bahmani-Oskooee and Niroomand (1996) when they extended number of countries from 15 to more than 100 and the years within which cross-country data were used from fixed to flexible exchange rate era.

now left with three studies that have used time-series data and have provided evidence supporting the productivity bias hypothesis. The first study in this group is by Hsieh (1982) who tried to identify the determinant of real exchange rate using productivity approach. After going through theoretical derivations, Hsieh (1982, p. 358) subjected the following equation to empirical testing.

$$r = c_0 + c_1[a_T - a_N] - c_2[a^*_T - a^*_N] + c_3[w - s - w^* + a^*_T - a_T] + u \quad (6)$$

where
r = rate of change of real exchange rate;
a_T = rate of change of average product of labor in the traded industries;
a_N = rate of change of average product of labor in the nontraded industries;
w = rate of change of nominal wage rate measured in local currency;
s = rate of change of nominal exchange rate (# domestic currency per unit of foreign currency);
a^*_T, a^*_N, and w^* carry the same definitions as above, but for foreign country.

Hsieh estimated equation (6) for Germany and Japan using time series data over 1954-76 period. In each case the "foreign" country's variables were geometric average of variables of the trading partners.[6] The empirical results were somewhat significant which made Hsieh (1982, p. 361) to conclude that:

> Nevertheless, these results represent a more favorable confirmation of the productivity differential model that the cross section regressions of Officer (1976b). An explanation may be that cross section regressions do not account for factors which are specific to each country, e.g. tastes are different across countries. In a time series these factors are held constant. To the extend that the changes in tastes are small over time, time series regressions will be able to explain the variance of the real exchange rate better than cross section regressions.

The second study which has used time series data in addition to cross-sectional data is by Villani (1985) who mostly adhered to a graphical approach to test a variant of the productivity bias hypothesis. Villani tries to test two hypotheses. The first hypothesis is that the international price ratio, IPR defined as the ratio between prices of non-traded goods and of traded goods is an increasing function of per capita income or productivity. The second hypothesis tested is whether productivity has any impact on the share of two sectors (non-traded and traded sectors) in GNP. These two hypotheses are tested together using a functional relation to link the productivity index to the ratio between the general price index (since it uses weights from both sectors) and the index of prices in the manufacturing sector. In the empirical analysis the ratio of the general index of consumer prices and the index of wholesale prices of manufactures is used as the dependent variable and the index of productivity per man-hour in the manufacturing sector as the independent variable. The cross-sectional data are plotted using data from Canada, United States, Germany, United Kingdom, Italy, France, Netherlands and Japan. While for the period 1955-63 the data were more

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[6]. For Germany the trading partners were Canada, U.S., Japan, France, Italy, Netherlands, and U.K. For Japan the trading partners were the same where Japan was replaced by Germany.

highly concentrated, for the period 1963-72 they were not. In the time series graphs the results confirm the theory only in the case of Italy.

The last time series study is that of Bahmani-Oskooee (1992). He modifies the model used by Officer (1976b, equation 5 above) so that it could be used for time-series analysis. Bahmani-Oskooee's model reads as follows:

$$(PPP/R)_t = \alpha + \beta(PROD^*/PROD)_t + \epsilon_t \qquad (7)$$

where

PPP = purchasing power parity defined as number of units of domestic currency per unit of standard currency,

R = exchange rate defined as number of units of domestic currency per unit of standard currency,

$PROD^*$ = measure of productivity in domestic country,

PROD = measure of productivity in standard country,

ϵ_t = error term.

One controversial issue in testing the productivity bias hypothesis is that the exchange rate employed in the empirical analysis must be the equilibrium rate. While this assumption may not be satisfied in cross-sectional studies, it may be satisfied in time series studies. In cross-sectional studies usually the exchange rate for each country belongs to a specific year which may or may not be the equilibrium rate. However, in time-series analysis Bahmani-Oskooee (1992, p. 229) has argued that

> The use of time series data over a longer period of time may resolve part of this controversy due to the fact that at least some of the observations on the exchange rate may reflect the equilibrium rate.

The second controversial issue in testing the productivity bias hypothesis concerns the use of PPP versus R in converting the income of an individual country (to be used in the productivity variable) from domestic currency to the currency of the standard country. Bahmani-Oskooee argues that in a time-series analysis this issue could be resolved by using the indices of productivity rather than the levels of productivity. Productivity indices are usually unit free and their use will change neither the sign nor the statistical properties of the estimated coefficients.

After selecting the U.S. as the standard country, Bahmani-Oskooee estimates equation (7) using Engle-Granger's (1987) cointegration technique over 1960-88 period for Canada, France, Germany, Italy, Japan, and the U.K. The results showed that the two variables were cointegrated, thus do have a long-run relationship in the cases of Italy, Japan, and the U.K., a result that supports the productivity bias hypothesis.

As the above review of the literature indicates, time series studies on the productivity bias hypothesis are rare and there is more room in the literature for such studies, specially, for a developing nation such as Iran. Thus, in the next section the model and methodologies are introduced for testing the long-run and short-run properties of the model.

III. THE MODEL AND METHODOLOGY

To determine whether the productivity differential between Iran and each of its major trading partners is a factor that contributes to the deviation of PPP from equilibrium exchange rate or is a determinant of real exchange rate we adopt a time-series model from Bahmani-Oskooee (1992). Let R now (defined as number of rials per unit of trading partner i's currency) be the equilibrium exchange rate. Using quantity (2) and (3), we measure the deviation of the purchasing power parity, PPP, from equilibrium exchange rate R, by

$$\frac{(P_{IRAN}/P_i)}{R} = \frac{P_{IRAN}}{R.P_i} \tag{8}$$

In (8) $(P_{IRAN})/(R.P_i)$ is nothing but the real exchange rate between Iran and trading partner i. As indicated before an increase in this ratio will be an indication of the appreciation of the rial in real terms. If the productivity differential between Iran and country i has to contribute to the deviation of PPP from R, or if it is to be a determinant of real exchange rate, we can employ the following time-series model:

$$\frac{(P_{IRAN}/P_i)_t}{R_t} = \alpha + \beta(PROD_{IRAN}/PROD_i)_t + \epsilon_t \tag{9}$$

where
P_{IRAN} = price level in Iran;
P_i = price level in country i;
R = nominal exchange rate (number of rials per unit of country i's currency;
$PROD_{IRAN}$ = index of measure of productivity in Iran;
$PROD_i$ = index of measure of productivity in country i;
ϵ = an error term.

If the productivity bias hypothesis is to receive support, estimate of β should be positive and significant. How are we going to estimate the model outlined by equation (9)? As indicated before, the methodology to estimate the model is based on cointegration analysis. The first step in the cointegration analysis is to learn about the degree of integration of each time-series variable, i.e., whether a variable is stationary or not. A common practice to determine the degree of integration of each variable is the application of the Augmented Dickey-Fuller test. For a variable Z, it is formulated by the following equation:

$$Z_t = \alpha + \beta t + \sigma Z_{t-1} + \sum_{i=1}^{k}\tau_i \Delta Z_{t-i} + w_t, \tag{10}$$

where t is a trend term and w is an error term. To test whether $\sigma = 1$, we calculate the ADF test statistic as the ratio of the estimate of σ-1 to its standard error. The cumulative distribution of the ADF test statistic is provided by Mackinnon (1991). If the calculated statistic is less than its critical value, then the null hypothesis of $\sigma = 1$ is rejected and Z_t is said to be stationary or I(0).[7] If a variable achieves stationarity after being differenced once, that variable is said to be integrated of order one denoted by I(1).

However, as it will be shown in the next section, the plot of all variables indicated a structural break in the data a year before the Iranian revolution, i.e., 1978. When there is a structural break in the data, the ADF test is modified by Perron (1989) who included two dummy variables. The Perron test involves estimating the following modified ADF formulation:

$$Z_t = \alpha + \phi D_t + \Gamma DT_t + \beta t + \sigma Z_{t-1} + \sum^{k}_{i=1}\tau_i \Delta Z_{t-i} + w_t, \quad (11)$$

where D is a dummy variable that equals 1 in post 1978 period (including 1978 itself) and zero in pre 1978 period. DT is a dummy variable that equals 1 only in 1978 and zero before and after 1978. The test of $\sigma = 1$ is basically an ADF test with different critical values provided by Perron (1989).

To establish the long run relationship between real exchange rate and productivity differential we first rely upon Engle-Granger (1987) cointegration analysis. Behind the cointegration analysis lies the idea that two variables such as the dependent and independent variables in equation (9) may drift apart in the short-run. But economic forces will make them converge toward an equilibrium in the long-run. The essence of Engle-Granger method for cointegration is that two I(1) variables are cointegrated if in the simple OLS regression of one on the other, the residuals (as a proxy for linear combination) are integrated at any order less than d.

Once the long-run relationship between real exchange rate and the productivity differential is established, we are left with one important question, i.e., which variable in equation (9) causes the other one and provides the short-run dynamics to achieve the long-run equilibrium. Before the appearance of cointegration literature many researchers relied upon simple Granger causality tests. Simple Granger causality test would be valid only if the variables are not cointegrated. If variables are cointegrated, then some long-run information is missing from simple Granger causality test. Thus when variables in (9) are cointegrated, error-correction models are used to detect the causality between real exchange rate and productivity differentials. Assuming both variables in (9) are I(1), error-correction models are formulated as equations (12) and (13):

$$\Delta(P_{IRAN}/P_i.R)_t = a + b\epsilon_{t-1} + \Sigma^{M}_{i=1}c_i\Delta(P_{IRAN}/P_i.R)_{t-i} + \Sigma^{n}_{i=1}d_i\Delta(PROD_{IRAN}/PROD_i)_{t-i} + \omega_t \quad (12)$$

and

$$\Delta(PROD_{IRAN}/PROD_i)_t = a' + b'\epsilon'_{t-1} + \Sigma^{M}_{i=1}c'_i\Delta(PROD_{IRAN}/PROD_{U.S})_{t-i} + \Sigma^{N}_{i=1}d'_i\Delta(P_{IRAN}/P_i.R)_{t-i} + \omega'_t \quad (13)$$

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[7]. Number of lags are usually selected by relying upon the level of significance of lagged first differenced variables.

where Δ is the first difference operator and ϵ' is the stationary residuals when the cointegration equation (9) is estimated in reverse order (switching the dependent variable with the independent variable). In error-correction models since all variables are stationary, the t-ratios are usually used to establish the significance of estimated coefficients. Equations (12) and (13) are not only used to investigate the short-run dynamics, but also the causality between the dependent and independent variables. For example in (12), the idea is whether current values of real exchange rate could be explained by the past values of productivity ratio in addition to its own past values. Therefore, one channel through which productivity ratio causes the real exchange rate, is through the significance of d_i's. There is a second channel through which productivity ratio could cause the real exchange rate. This second channel is through the significance of lagged error term. This is because the lagged error term includes the lagged value of productivity ratio in addition to the lagged value of real exchange rate. Similarly in equation (13) real exchange rate Granger causes the productivity ratio if either b is significant or d_i's are significant.

Finally, to enrich our findings from Engle-Granger method, we will also use Johansen's (1988) technique which establishes whether there is a long-run equilibrium relationship between a set of variables.[8] Actually, Engle-Granger method has been criticized due to its inability to identify multiple cointegrating vectors that may exist among set of variables. Johansen (1988) and Johansen and Juselius (1990) define a distributed lag model of a vector of variables, X as

$$X_t = \pi_1 X_{t-1} + \pi_2 X_{t-2} + \dots + \pi_k X_{t-k} + \epsilon_t \quad (14)$$

where X is a vector of p <u>stationary</u> variables and ϵ_t is an independently and identically distributed p dimensional vector with zero mean and Ω variance matrix.[9] However, since most economic variables are non-stationary, Johansen and Juselius suggest rewriting (14) in first difference form in a fashion similar to the Augmented Dickey Fuller (ADF) test as:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} - \pi X_{t-k} + \epsilon_t \quad (15)$$

where

$$\Gamma_i = -I + \pi_1 + \pi_2 + \dots + \pi_i \quad (i=1, \dots k)$$

and

$$\pi = -(I - \pi_1 - \pi_2 - \dots - \pi_k).$$

In (15) the only level term is πX_{t-k}. Thus, the long-run or cointegrating matrix is given by π which is a pxp matrix and includes number of r cointegrating vectors between the variables in X. Usually r is the rank of π. If we define two matrices α and β (both pxr) such that $\pi = \alpha\beta'$, the rows of β will form the r cointegrating vectors. Johansen and Juselius (1990) demonstrate that β, the cointegrating vector can be estimated as the eigenvector associated with the r largest and significant eigenvalues found by solving

8. For an step by step application of Johansen's technique see Hall(1989).

9. In our case $X = [\ (P_{IRAN}/P_i.R)_t\ \ (PROD_{IRAN}/PROD_i)_t\ ]$.

$$| \lambda S_{kk} - S_{k0}S_{00}^{-1}S_{0k} | = 0 \quad (16)$$

where

$$S_{ij} = T^{-1}\sum_{t=1}^{T} R_{it}R'_{jt} \quad i,j = 0, k$$

In turn, R_{0t} is a set of residuals from regressing ΔX_t on the lagged differences of ΔX_t and R_{kt} is set of residuals from regressing X_{t-k} on the lagged differences. Using the eigenvalues obtained from solving (16), Johansen and Juselius prove that one can test the hypothesis that there are at most r cointegrating vectors by calculating two likelihood test statistics known as the trace and the λ-max statistics outlined by equations (17) and (18) respectively:

$$\text{trace} = -T \sum_{i=r+1}^{N} Ln(1-\lambda_i) \quad (17)$$

and

$$\lambda\text{-max} = -T \ln(1-\lambda_{r+1}) \quad (18)$$

where $\lambda_{r+1}, \ldots, \lambda_p$ are the estimates of p - r smallest eigenvalues. Fortunately, all calculations are now built into computer packages. MFIT.3 by Pesaran and Pesaran (1991) will be employed to carry out these tests.

IV. EMPIRICAL RESULTS

In this section we try to apply the three methodologies described in the previous section to investigate the long-run and short-run relationship between the real exchange rate and the productivity differential between Iran and her seven major trading partners, i.e., Canada, France, Germany, Italy, Japan, U.K., and U.S. For example the model outlined by equation (9) will read as follows when the trading partner i is Canada.

$$\frac{(P_{IRAN}/P_{CANADA})_t}{R_t} = \alpha + \beta(PROD_{IRAN}/PROD_{CANADA})_t + \epsilon_t \quad (19)$$

where R is number of rial per Canadian dollar.

While definition, construction and sources of the data are provided in section VII, it should be mentioned that annual data are used over 1960-1990 period for a total of 31 observations. The choice of the period is due to availability of data on all relevant variables. Hakkio and Rush (1991) have demonstrated that the ability of cointegration tests to detect cointegration is a function of total sample length rather than the frequency of the data. Therefore, using annual data over the 1960-90 period in this project is as good as using quarterly or monthly data over the same period.

Before we proceed with the cointegration analysis, it may help us gain some insight into the relation between real exchange rate and productivity differential (as dependent and independent variables in equation 9) between Iran and its seven trading partners by plotting the variables as in figures 1-7(at the end of the paper). Thus in figure 1 the real exchange rate is the left hand side variable in equation

(9) and productivity ratio is the right hand side variable. By replacing Canadian data by the French data we move to figure 2 and so on. As defined before, an increase in real exchange rate in each graph is an indication of appreciation of rial in real terms.

Two observations from figures 1-7 deserve mention. First, there seems to be a turning point in both variables in almost all graphs. On the average, both variables are rising before 1978 and falling there after. The explanation lies behind political events led by the fall of the Shah, the Islamic revolution, and rhetorical war between Iran and Iraq. Thus, there seems to be a structural break in the relations. Second, in the post-revolutionary period, there is indication in all figures that as Iranian productivity relative to her trading partner declines, so does the value of real rial, a graphical support for the productivity bias hypothesis. Finally, we may conjecture that the comovement in two variables could be due to a third factor like oil revenues. On the one hand an increase in oil revenues increases per capita income or productivity. On the other hand, since oil revenues in dollars constitute supply of dollars to the foreign exchange market, its increase increases the dollar supply, resulting in an appreciation of the rial. For more on this point see Bahmani-Oskooee (1995b, p. 282).

We are now in a position to carry out the cointegration and error-correction modeling. As we indicated before, the first step in the cointegration analysis is to test for the stationarity of each variable. Due to evidence from figures 1-7 we employ the Perron (1989) test outlined by equation (18). We apply the Perron test for the level as well as for the first differenced variables and report the results in Table 1.

As can be seen from Table 1 the calculated perron statistic is less than its critical value (reported at the bottom of Table 1) only in the case of first differenced variables. These results indicate that while the level of each variable is non-stationary, the first differenced variables are stationary. Thus, all variables are integrated of order one or they are I(1).

We are now in a position to apply the Engle-Granger method. Note that as indicated before, if two I(1) variables are to be cointegrated, the residuals in the regression of one variable on the other must be I(0). Thus, we apply the OLS by regressing the real exchange rate on the productivity ratio and a trend term, and then test for the stationarity of the residuals using the ADF test outlined by equation (11) where the trend term is excluded. We repeat this procedure by changing the position of the real exchange rate and productivity ratio. The results are reported in panels A and B of Table2.

It is obvious from either panel that the calculated ADF statistics of the residuals are not less than the critical value, indicating that in none of the cases the residuals are I(0). The implication is that in all seven cases the real exchange rate and productivity ratio are not cointegrated and have no long-run relationship. However, the failure to find cointegration could be due to the ignorance of structural break in 1978. Thus, we thought to carry out the analysis once more after including the dummy variable in the so called cointegration equations. The results are reported in Table 3.

Note that Ireland and Wren-Lewis (1992, p. 221) have argued that the dummy variable is not a stochastic variable, thus, it could be interpreted as a modification to the intercept term which enables us to assume that still the cointegration equations have two variables and we can use the same critical values as in Table 2 where the dummy variable D was excluded. From panel A in Table 3 we gather that our calculated ADF statistic is less than its critical value in the cases of Canada, Italy, and the United States and marginally less in the case of Germany. Thus, at least in four cases cointegration is confirmed. Furthermore, the slope coefficients in all cointegration equations are positive, supporting the productivity bias hypothesis.

Now that we have established the long-run relationship between real exchange rate and productivity ratio, at least in four cases, the question that remains to be answered is which variable causes the other one and provides the short-run adjustment toward the long-run equilibrium. The answer is provided by estimating the error-correction models. Several points deserve mention. First, in estimating the error-correction models, the lagged error-correction term denoted by EC_{t-1} should have been excluded whenever there was lack of cointegration. However, to have uniform results we retained it in all error-correction models. Second, the lagged error-correction term in each case is from cointegration equation which includes the dummy variable D. Finally, in selecting the optimum number of lags in each error-correction model, we first estimated all possible lag combinations with the maximum of four lags on each variable and then, following Bahmani-Oskooee et. al. (1991) or Bahmani-Oskooee and Payesteh (1993) selected the one that minimized Akaike's Final Prediction Error (FPE) statistic. The optimum models for all seven cases are reported in Tables 4-10.

Note that in each case causality from the dependent to independent variable is established if either the lagged error-correction term is significant or if the lagged first differences of the independent variable is significant.

Table 4 reports the results between Iran and Canada. Concentrating on the model that has the real exchange rate as the dependent variable, we notice that the lagged error-correction term carries a significant coefficient (absolute value of the t-ratio is 3.36) indicating that productivity ratio causes the real exchange rate. We also notice that the third lag of productivity ratio carries significant coefficient (absolute value of the t-ratio is 3.19), again indicating that productivity ratio causes the real exchange rate. However, in the model that has the productivity ratio as the dependent variable, neither the error-correction term nor the lagged real exchange rate carry significant coefficients indicating that the real exchange rate does not cause the productivity ratio. Exactly similar conclusions are reached in the results for France in Table 5, for Germany in Table 6, for Italy in Table 7, for Japan in Table 8, for U.K. in Table 9, and for the U.S. in Table 10. Only in the case of Japan we notice bidirectional causality, i.e., not only productivity ratio causes the real exchange rate, but the real rate causes the productivity ratio as well. All in all, from the error-correction models we infer that the short-run causality is from productivity ratio to real exchange rate. The policy implication of this finding, as will be discussed later, is that to make the rial to regain its real value, macroeconomic policies must be aimed at improving productivity.[10]

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[10]. Although the simple model show that in most cases the causality is from productivity ratio to exchange rate, we should not forget the macroeconomic consequences of changes in nominal and real exchange rates. For the inflationary effects of depreciation of the rial see Bahmani-Oskooee (1995a) and for its stagflationary effects see Bahmani-Oskooee (1996).

To enhance our cointegration results, as was indicated, we also applied the Johansen-Juselius cointegration technique. In applying Johansen-Juselius technique we need to decide about the order of VAR. Due to limited number of observations and annual data we impose only one lag. However, following Johansen-Juselius (1992, p. 219) we make sure that the residuals do satisfy the normality condition by calculating the Jarque-Bera statistic which is distributed as a χ^2 with 2 degrees of freedom.[11] The results of Johansen-Juselius maximum likelihood procedure for all seven cases are reported in Tables 11-17.

Like before, reported in these tables are two types of results, depending whether the dummy variable D is excluded (panel A) or included (panel B) in the procedure. As a general rule, the null hypothesis will be rejected if either λ-max statistic or the trace statistic is larger than their critical value using either 95% critical value of 90% critical value.

From Table 11 which reports the results between Iran and Canada it is obvious that the null hypothesis of no cointegration, i.e., $r=0$ is rejected by the λ-max test (13.639>12.91) but not by the trace test. However, the null of at most one cointegrating vector ($r<=1$) cannot be rejected in favor of $r = 2$. Thus, from panel A we can conclude that there is at most one cointegrating vector between real exchange rate and the productivity ratio between Iran and Canada. The results become somewhat stronger when the dummy variable D is included in the procedure. Now, as panel B indicates both λ-max and trace tests support the null of $r=1$ (35.73>21.07 and 43.55>31.52). Exactly the same results are obtained for the case of France from Table 12. For Germany there is one cointegrating vector only when the dummy variable is included. For Italy there is one cointegrating vector only when the dummy variable is excluded from the procedure. For Japan the null of $r=0$ cannot be rejected neither in panel A nor in panel B. For U.K. the null of no cointegration is rejected in favor of $r=1$ either from panel A or from panel B. Finally, for the U.S. there is evidence of one cointegrating vector from panel B. As can be seen, except for Japan, there is evidence of at most one cointegrating vector in the remaining cases, a somewhat stronger result than the Engle-Granger method.

The next step is to report the cointegrating vectors for each case. Usually, it is a common practice to normalize on one of the variables by setting the coefficient of that variable at -1.00. We normalize on the real exchange rate and report the normalized value inside the parenthesis beneath each coefficient, in Table 18.

Reported in Table 18 are two vectors for each case. The first vector corresponds to panel A where the dummy variable D was excluded. The second vector corresponds to panel B where the dummy variable D was included. Concentrating on the normalized values, we gather that the normalized coefficient of productivity ratio in each case is positive except in the case of Japan for which there was evidence of no cointegration. These are similar in sign and in size to the slope coefficients

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[11]. The Jarque-Bera statistics = $n\{(1/6)s^2+ (1/24)(k-3)^2\}$ where s is the measure of skewness and k is the measure of kurtosis of the residuals. Johansen and Juselius (1992, p. 219) also employed Jarque-Bera test.

obtained by OLS that were reported in panel A of Table 2, providing strong support for the productivity bias hypothesis.[12]

V. POLICY IMPLICATION OF THE RESULTS

In the previous section we showed that a decline in Iranian productivity relative to that of its major trading partners, has caused a depreciation of the rial in real terms. This was especially pronounced during the post-revolutionary period, as was observed from figures 1-7. Therefore, if policy makers are to reverse the decline of the rial, they must aim at macroeconomic policies that are designed to increase Iranian productivity over time. An increase in productivity will not only help the rial gain its real value, but will also increase living standards. What policies are available? Below we discuss those policies that are mostly recommended in the literature.

1. Many monetarist economists argue that countries that are committed to fight inflation and provide price stability, will end up having a market system which functions better and provides a better environment to promote productivity growth. This is due to the fact that stable prices allocate economic resources more efficiently. To achieve price stability, monetary policy should be implemented without political pressure which implies that the central bank should be independent of the central government. Indeed, after constructing an index of "central bank independence" for 16 OECD countries and measuring their rates of inflation over the 1955-90 period, De Long and Summers (1992, p. 105) provide strong evidence for the hypothesis that countries with more independent central banks enjoy relatively low rates of inflation. The implication is that perhaps it is about time to grant the Bank Markezi independence so that it can better fight the recent surge in inflation. Independent central bank will adhere to price stability and use monetary policy to fight inflation and not to finance government spending.

2. Fiscal policy should be aimed at balancing the budget and not running any deficit. Rather than using private saving to finance government spending, it could be used to finance private or public investment that contributes to economic growth and productivity increase. To raise revenue, we must rely on tax policies. We must simplify our tax system and reorganize or create tax administration so that our tax efforts could be effective.

3. One of the fundamental economic decisions that any government must make is to how to allocate its resources between consumption and investment. For example, one major resource in Iran is oil. Should Iran allocate its oil income to present consumption or future long-term investment? All economists would agree that investment should be given priority over present consumption. Oil dollars should not be spent on foreign luxury goods. Rather, they should be channeled toward more productive equipment investment or direct investment. Government should have policies that give incentive for private parties to invest.

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[12]. To get more insight about the behavior of Iranian rial alternative exchange rate theories must be considered. Actually, the monetary model is examined by Bahmani-Oskooee (1995b) and supports the finding of this paper.

4. The Government must also pay attention to incentive structure for financial capital. It must provide an economic environment which provides incentive for people to invest in financial assets. It is through such investments that firms can raise revenue to be engaged in direct investment.

5. Investing in human capital is also essential for long-run growth. Specially, a developing country such as Iran must take steps in increasing its skilled labor force. Many Iranian students that went abroad for higher education did not return to their homeland. Even many educated Iranians fled the country after the revolution, making Iran suffer from the so called "Brain Drain" problem. By relying upon some policies to attract this group back, Iran can increase its pool of skilled labor force.

6. At present the Iranian economy could be characterized as suffering from stagflation. The economy is so complicated that every day there is a new regulation that may kill people's incentive to invest. Thus, some reorganization is perhaps required to increase the efficiency of the system and make the system move toward an economy with simple and perhaps some automatic rules. Here are some suggestions.

a. In a paper published in the Proceedings of the Third Seminar on Monetary and Foreign Exchange Policies by the Monetary and Banking Research Institute of the Central Bank of Iran (1993) I showed that the depreciation of the rial contributes to domestic inflation without having any expansionary effect on domestic production. Thus, one way to fight inflation and provide price stability under which we can expect increased productivity is to prevent the nominal value of the rial from going down. Depending upon oil revenues, the Central Bank should even try to revalue the rial by market intervention. By adopting a single exchange rate and abandoning the multiple exchange rate practice, the Central Bank has paved the way for such an intervention. At present, I will favor using some of the oil revenues for intervention to regain the value of the rial over even some long-term investment. As we make the dollar cheaper, many may try to take their capital out. Thus, the policy must be supplemented by contractionary monetary and fiscal policies. These polices combined will bring inflation down and provide an environment conducive to growth and productivity increase.

b. Eliminate all taxes on non-oil exports so that Iran can increase its non-oil exports. This will have two distinct effects. First increased exports will bring in more foreign exchange which will keep foreign currencies down and raise the value of the rial. Increased non-oil exports could also reduce Iran's dependency on oil so that in the long-run when we are out of oil, we do not experience an economic shock. Simplify import duties, simplify the paperwork requirement, eliminate any discriminatory treatment of foreign investment.

c. We need rapid and effective progress in the privatization of state companies; the elimination of any controls on prices and wages; the elimination of a complex network of subsidies.

7. There must be an industrial policy that supports Research and Development in public and private institutions.

8. As the appendix indicates, Iranian productivity is measured by per capita real Gross Domestic

Product. An increase in population could be one reason for the decline in Iran's productivity. Thus, a major secret to growth and increased productivity is to keep population growth down by appropriate policies.

VI. SUMMARY AND CONCLUSION

Part of the literature in international finance includes studies that have only one thing in common. They have all tried to test the productivity bias hypothesis. The hypothesis mostly advanced by Balassa implies that productivity differential between two countries could be one reason as to why the Purchasing Power Parity exchange rate could deviate from equilibrium rate or a more productive country should experience a real appreciation of its currency. Except Balassa, all other studies that have employed cross-sectional data to test the productivity bias hypothesis, have failed to support the hypothesis. However, two recent studies that have employed time series data from industrial countries, have supported the productivity bias hypothesis. There has been no confirmation of the hypothesis using data from a developing country.

In this project we used cointegration analysis of Engle and Granger as well as Johansen and Juselius and annual data for 1960-1990 period to reexamine the productivity bias hypothesis between Iran and its major trading partners (Canada, France, Germany, Italy, Japan, United Kingdom and the United States). The results showed that the deviation of PPP and the black market exchange rate between the Iranian rial and seven other major currencies has a long-run relationship with the productivity ratios in almost all cases. Estimates obtained from error-correction models show that in the short-run it is the productivity differential that causes real exchange rate.

A major policy implication of our finding is that while central bank intervention to drive up the nominal value of rial could in fact increase its real value, intervention cannot serve as a long-run policy. In the long-run economic fundamentals dictate the movement in real exchange rate. Among these fundamentals is the productivity. As shown graphically, Iran must try to increase its productivity and growth in order to help the rial gain back the real value it enjoyed before the revolution. Policies such as making the Iranian Central Bank independent so that it can pursue price stability; reducing budget deficits to stimulate physical capital; policies to increase human capital such as attracting educated Iranians from abroad or reforming the education system inside the Iran; etc. are all recommended policies to boost productivity in the long-run.

VII. DATA APPENDIX

Annual data over 1960-1990 period have been collected from the following sources.
a. International Financial Statistics of International Monetary Fund, different issues.
b. Pick's World Currency Yearbook.
c. Gordon (1993, Appendix A and B).

Definition of Variables:

P = Gross Domestic Product (GDP) deflator (1980=100). Iran's GDP deflator is from source a and those of other countries from source c.

R = Monthly black market exchange rate between rial and the dollar was available from source b. Average of monthly data are used as the annual exchange rate between rial and the dollar. Since no direct exchange rates between rial and other currencies were available, such rates were generated using cross exchange rate between dollar and other currencies.

PROD = Index of productivity in each country, 1980=100. For each industrial country this variable is collected from source c. For the U.S. it comes in index form with 1977=100. Thus, we had to change only the base year for the U.S. For other industrial countries, it came in terms of output per hour of employment. This figures were set in index form such that 1980=100. In the absence of hours of employment for Iran, following Balassa (1964) and Officer (1976b), we first constructed per capita real GDP. We then set it in index form so that 1980=100.

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Figure 1. Plot of Real Exchange Rate and Productivity Ratio: The Case of Iran vs. Canada

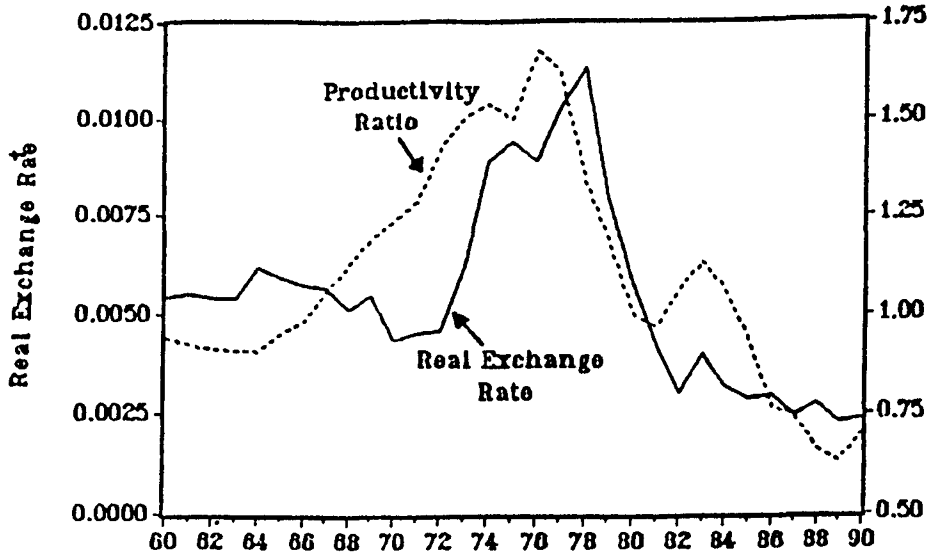

Figure 2. Plot of Real Exchange Rate and Productivity Ratio: The Case of Iran vs. France.

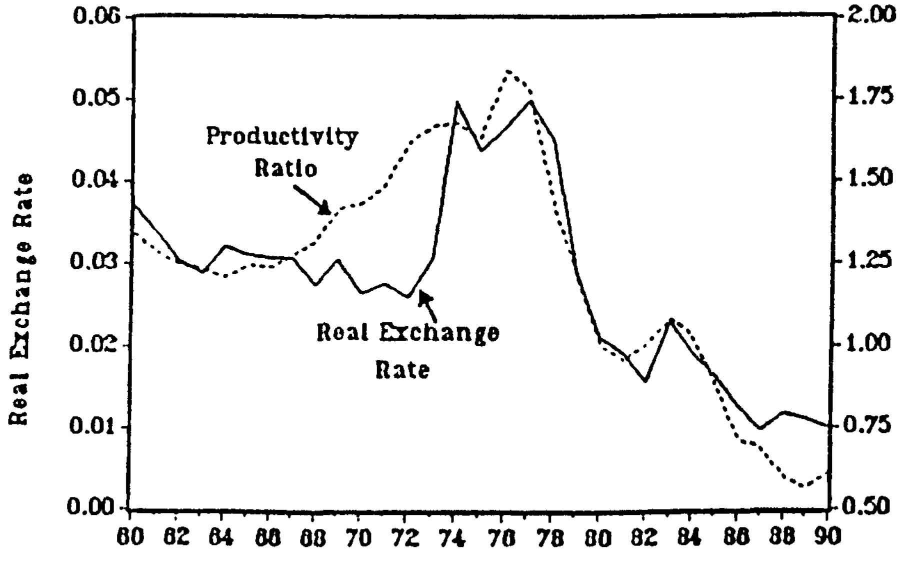

Figure 3. Plot of Real Exchange Rate and Productivity Ratio: The Case of Iran vs. Germany.

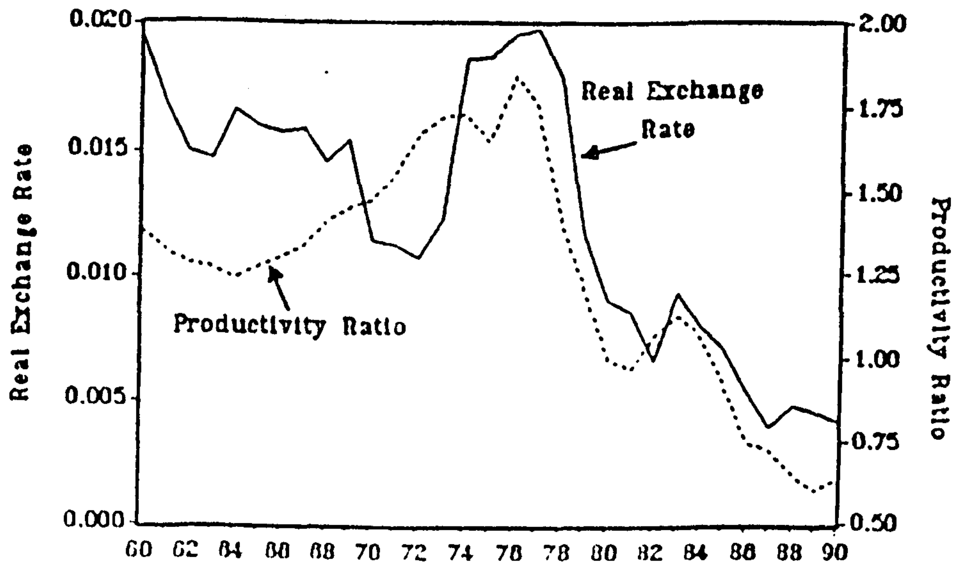

Figure 4. Plot of Real Exchange Rate and Productivity Ratio: The Case of Iran vs. Italy.

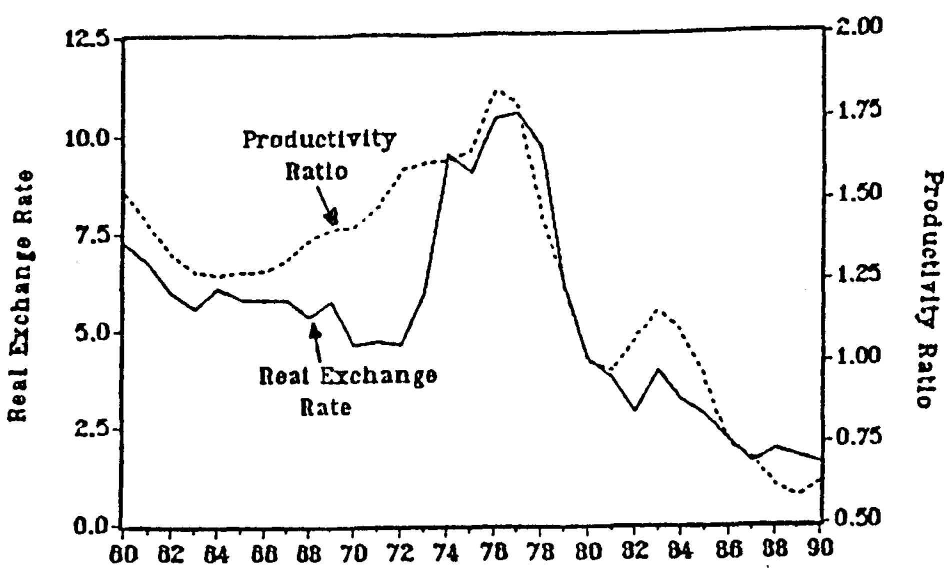

Figure 5. Plot of Real Exchange Rate and Productivity Ratio: The Case of Iran vs. Japan.

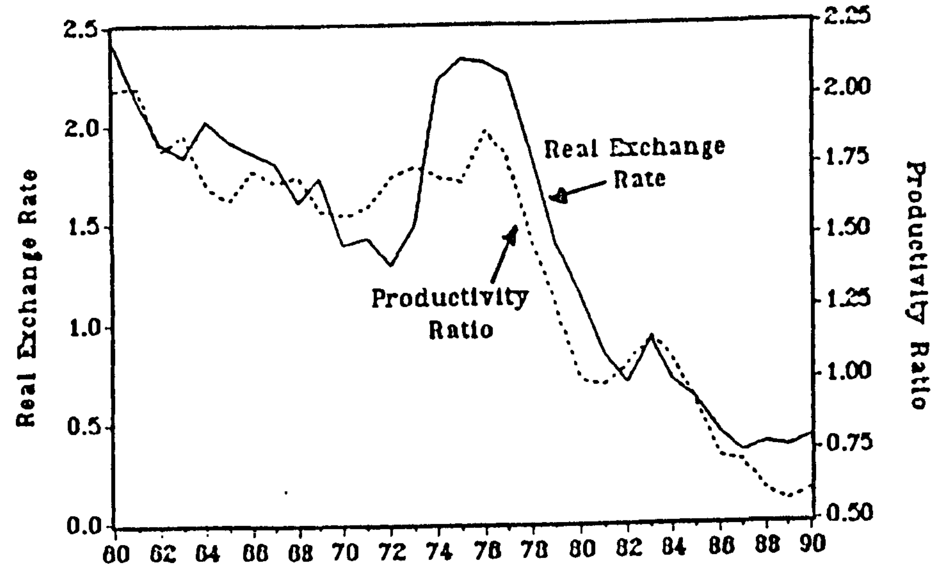

Figure 6. Plot of Real Exchange Rate and Productivity Ratio: The Case of Iran vs. U.K.

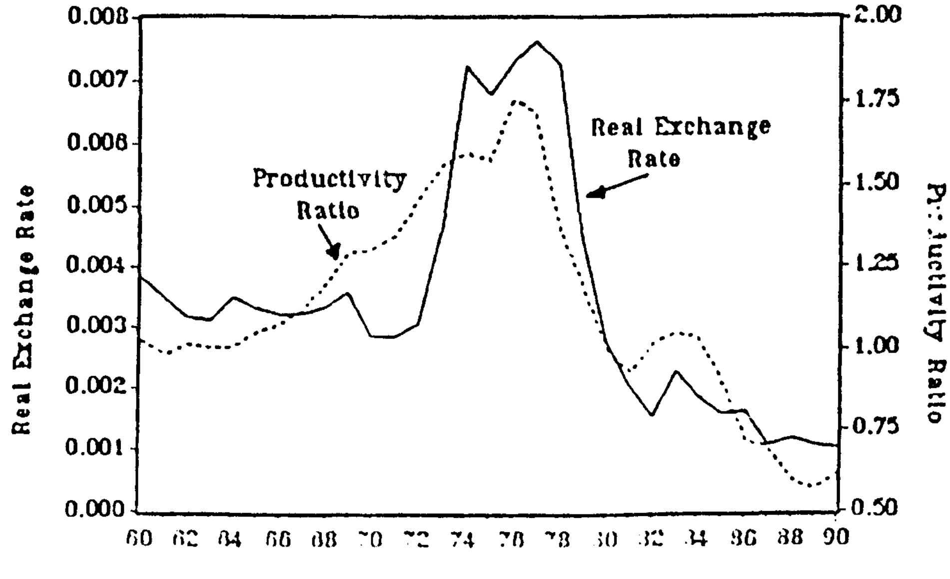

Figure 7. Plot of Real Exchange Rate and Productivity Ratio: The Case of Iran vs. The U.S.

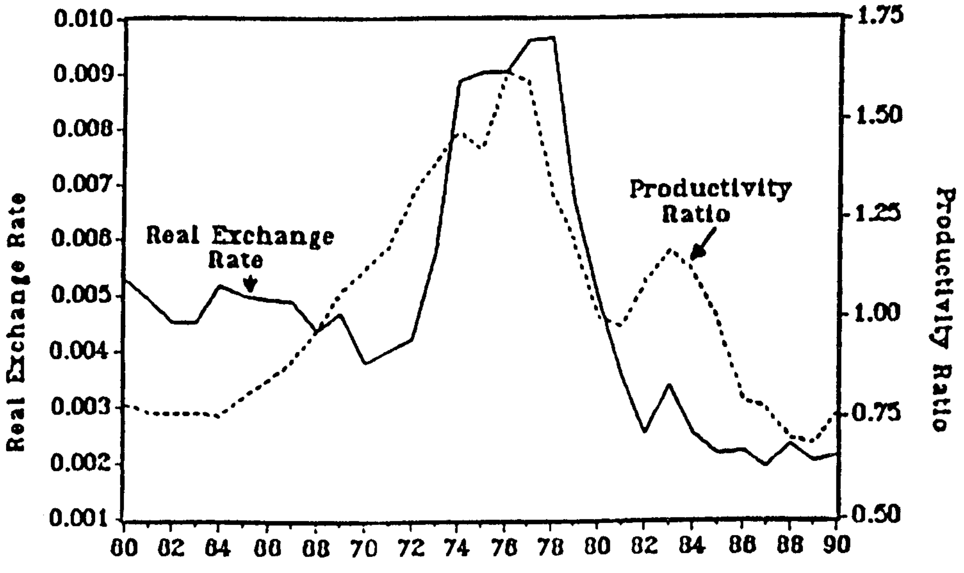

Table 1. The Results of Perro Test Applied to the Level as well as First Differenced Variables: 1960-1990.

i	Calculated Perron Statistic[a] Level $(P_{IRAN}/P_i)/R$	Level $PROD_{IRAN}/PROD_i$	First Difference $(P_{IRAN}/P_i)/R$	First Difference $PROD_{IRAN}/PROD_i$
Canada	-0.80[4][b]	-0.42[4]	-6.95[3]	-4.80[4]
France	-0.86[4]	-0.88[3]	-6.42[3]	-5.01[4]
Germany	-0.58[4]	-0.87[4]	-6.30[3]	-4.27[4]
Italy	-0.09[4]	-0.71[3]	-6.85[3]	-4.89[3]
Japan	-0.27[4]	-0.40[4]	-5.07[3]	-6.16[4]
U.K.	-1.06[4]	-0.66[4]	-6.64[3]	-4.85[4]
U.S.	-0.88[4]	0.28[4]	-6.70[3]	-5.43[3]

Notes: a. The critical value of Perron test at the 5% and 10% leve of significance are -3.76 and -3.47 respectively. These are from Perron (1989, table IV.B). Note that the ratio of pre-break sample size to total sample size is almost 0.6 in our case.

b. Numbers inside the brackets are the number of lags.

Table 2. Engle-Granger Cointegration Results

A-Cointegration Equation: $(P_{IRAN}/P_i)/R = f(t, PROD_{IRAN}/PROD_i)$

i	Slope	R^2	ADF[k][a]
Canada	0.006	0.57	-3.22[3]
France	0.027	0.78	-2.94[4]
Germany	0.008	0.77	-3.35[3]
Italy	6.982	0.76	-3.35[4]
Japan	1.585	0.86	-3.05[1]
U.K.	0.005	0.72	-3.27[4]
U.S.	0.006	0.63	-3.57[3]

B-Cointegration Equation: $PROD_{IRAN}/PROD_i = f[t, (P_{IRAN}/P_i)/R]$

i	Slope	R^2	ADF[k][a]
Canada	91.31	0.53	-2.63[3]
France	25.02	0.78	-1.68[2]
Germany	58.17	0.66	-2.07[3]
Italy	00.09	0.81	-2.42[3]
Japan	00.39	0.92	-3.00[1]
U.K.	136.6	0.73	-2.38[3]
U.S.	97.95	0.59	-2.76[3]

Notes: a. Mackinnon (1991) critical value of the ADF statistic (with a trend term in the equation)for 31 observations and two variables is -3.72 at the 10% level of significance.

Table 3. Engle-Granger Cointegration Results Including D.

A-Cointegration Equation: $(P_{IRAN}/P_i)/R = f(t, D, PROD_{IRAN}/PROD_i)$

i	Slope	R^2	ADF[k][a]
Canada	0.007	0.60	-3.83[3]
France	0.031	0.78	-3.04[3]
Germany	0.009	0.76	-3.65[3]
Italy	7.650	0.76	-3.74[4]
Japan	1.615	0.86	-3.10[1]
U.K.	0.005	0.72	-3.50[4]
U.S.	0.006	0.63	-4.00[3]

B-Cointegration Equation: $PROD_{IRAN}/PROD_i = f[t, D, (P_{IRAN}/P_i)/R]$

i	Slope	R^2	ADF[k][a]
Canada	78.66	0.68	-3.12[3]
France	21.00	0.84	-2.97[3]
Germany	44.81	0.76	-2.10[3]
Italy	00.08	0.85	-3.05[3]
Japan	00.33	0.93	-3.14[1]
U.K.	116.1	0.78	-3.02[3]
U.S.	85.40	0.66	-3.31[3]

Notes: a. Mackinnon (1991) critical value of the ADF statistic (with a trend term in the equation) for 31 observations and two variables is -3.72 at the 10% level of significance.

Table 4. Coefficient Estimates of The Error-Correction Models: The Case of Iran vs. Canada.

Independent Variables	Dependent Variable $\Delta[(P_{IRAN}/P_i)/R]_t$	$\Delta(PROD_{IRAN}/PROD_i)_t$
Constant	-0.0001	-0.0012
	(0.03)	(0.06)
EC_{t-1}	-0.6629	-0.1425
	(3.36)	(1.05)
$\Delta[(P_{IRAN}/P_i)/R]_{t-1}$	0.5046	-9.4511
	(2.49)	(0.39)
$\Delta[(P_{IRAN}/P_i)/R]_{t-2}$	0.5458	-
	(2.49)	
$\Delta[(P_{IRAN}/P_i)/R]_{t-3}$	0.3184	-
	(2.20)	
$\Delta[(P_{IRAN}/P_i)/R]_{t-4}$	0.2807	-
	(1.72)	
$\Delta(PROD_{IRAN}/PROD_i)_{t-1}$	0.0030	0.6234
	(1.57)	(2.88)
$\Delta(PROD_{IRAN}/PROD_i)_{t-2}$	0.0011	-0.0628
	(0.48)	(0.21)
$\Delta(PROD_{IRAN}/PROD_i)_{t-3}$	-0.0081	-
	(3.19)	
$\Delta(PROD_{IRAN}/PROD_i)_{t-4}$		-
Other Statistics		
Adj. R^2	0.64	0.17
D-W	2.3703	2.0083

Notes: a. Numbers inside the parentheses are the absolute values of the t-ratios.
EC in each equation denotes the error-correction term.

Table 5. Coefficient Estimates of The Error-Correction Models: The Case of Iran vs. France.

Independent Variables	Dependent Variable	
	$\Delta[(P_{IRAN}/P_i)/R]_t$	$\Delta(PROD_{IRAN}/PROD_i)_t$
Constant	-0.0006 (0.78)	-0.0095 (0.47)
EC_{t-1}	-0.8967 (3.47)	-0.1477 (0.91)
$\Delta[(P_{IRAN}/P_i)/R]_{t-1}$	0.4416 (1.68)	-5.5625 (1.35)
$\Delta[(P_{IRAN}/P_i)/R]_{t-2}$	0.5695 (2.50)	-
$\Delta[(P_{IRAN}/P_i)/R]_{t-3}$	0.4806 (2.44)	-
$\Delta[(P_{IRAN}/P_i)/R]_{t-4}$	-	-
$\Delta(PROD_{IRAN}/PROD_i)_{t-1}$	-0.0020 (0.17)	0.6445 (3.04)
$\Delta(PROD_{IRAN}/PROD_i)_{t-2}$	0.0049 (0.45)	-
$\Delta(PROD_{IRAN}/PROD_i)_{t-3}$	-0.0414 (3.79)	-
$\Delta(PROD_{IRAN}/PROD_i)_{t-4}$	-	-
Other Statistics		
Adj. R^2	0.56	0.19
D-W	1.8202	1.7987

Notes: a. Numbers inside the parentheses are the absolute values of the t-ratios.
EC in each equation denotes the error-correction term.

Table 6. Coefficient Estimates of The Error-Correction Models: The Case of Iran vs. Germany.

Independent Variables	Dependent Variable: $\Delta[(P_{IRAN}/P_i)/R]_t$	$\Delta(PROD_{IRAN}/PROD_i)_t$
Constant	-0.0002	-0.0113
	(0.99)	(0.56)
EC_{t-1}	-0.9294	-0.1167
	(4.34)	(0.91)
$\Delta[(P_{IRAN}/P_i)/R]_{t-1}$	0.4788	-7.7536
	(2.46)	(0.77)
$\Delta[(P_{IRAN}/P_i)/R]_{t-2}$	0.7743	-
	(4.11)	
$\Delta[(P_{IRAN}/P_i)/R]_{t-3}$	0.4602	-
	(2.77)	
$\Delta[(P_{IRAN}/P_i)/R]_{t-4}$	-0.0766	-
	(0.54)	
$\Delta(PROD_{IRAN}/PROD_i)_{t-1}$	-0.0018	0.5527
	(0.50)	(2.83)
$\Delta(PROD_{IRAN}/PROD_i)_{t-2}$	0.0008	-
	(0.22)	
$\Delta(PROD_{IRAN}/PROD_i)_{t-3}$	-0.0145	-
	(3.94)	
$\Delta(PROD_{IRAN}/PROD_i)_{t-4}$	-	-
Other Statistics		
Adj. R^2	0.64	0.16
D-W	1.8652	1.8352

Notes: a. Numbers inside the parentheses are the absolute values of the t-ratios.
EC in each equation denotes the error-correction term.

Table 7. Coefficient Estimates of The Error-Correction Models: The Case of Iran vs. Italy.

Independent Variables	Dependent Variable $\Delta[(P_{IRAN}/P_i)/R]_t$	$\Delta(PROD_{IRAN}/PROD_i)_t$
Constant	-0.2223	-0.0133
	(1.30)	(0.68)
EC_{t-1}	-0.8072	-0.1048
	(3.97)	(0.63)
$\Delta[(P_{IRAN}/P_i)/R]_{t-1}$	0.4991	0.0064
	(2.39)	(0.28)
$\Delta[(P_{IRAN}/P_i)/R]_{t-2}$	0.6928	-
	(3.33)	
$\Delta[(P_{IRAN}/P_i)/R]_{t-3}$	0.3793	-
	(2.13)	
$\Delta[(P_{IRAN}/P_i)/R]_{t-4}$	-	-
$\Delta(PROD_{IRAN}/PROD_i)_{t-1}$	-0.9243	0.7508
	(0.39)	(3.58)
$\Delta(PROD_{IRAN}/PROD_i)_{t-2}$	0.8119	-0.3813
	(0.36)	(1.67)
$\Delta(PROD_{IRAN}/PROD_i)_{t-3}$	-8.7218	-
	(3.51)	
$\Delta(PROD_{IRAN}/PROD_i)_{t-4}$	-	-
Other Statistics		
Adj. R^2	0.57	0.31
D-W	1.9222	2.0923

Notes: a. Numbers inside the parentheses are the absolute values of the t-ratios.
EC in each equation denotes the error-correction term.

Table 8. Coefficient Estimates of The Error-Correction Models: The Case of Iran vs. Japan.

Independent Variables	Dependent Variable: $\Delta[(P_{IRAN}/P_i)/R]_t$	Dependent Variable: $\Delta(PROD_{IRAN}/PROD_i)_t$
Constant	-0.0357	-0.0278
	(0.93)	(1.41)
EC_{t-1}	-0.6671	-0.4937
	(3.57)	(2.88)
$\Delta[(P_{IRAN}/P_i)/R]_{t-1}$	0.5098	-0.0329
	(2.68)	(0.41)
$\Delta[(P_{IRAN}/P_i)/R]_{t-2}$	0.2675	0.1144
	(1.58)	(1.43)
$\Delta[(P_{IRAN}/P_i)/R]_{t-3}$	-	-0.1516
		(1.84)
$\Delta[(P_{IRAN}/P_i)/R]_{t-4}$	-	-0.1314
		(1.69)
$\Delta(PROD_{IRAN}/PROD_i)_{t-1}$	0.0866	0.5579
	(0.23)	(3.04)
$\Delta(PROD_{IRAN}/PROD_i)_{t-2}$	-0.6912	-
	(2.03)	
$\Delta(PROD_{IRAN}/PROD_i)_{t-3}$	-	-
$\Delta(PROD_{IRAN}/PROD_i)_{t-4}$	-	-
Other Statistics		
Adj. R^2	0.47	0.47
D-W	2.0356	2.1569

Notes: a. Numbers inside the parentheses are the absolute values of the t-ratios.
EC in each equation denotes the error-correction term.

Table 9. Coefficient Estimates of The Error-Correction Models: The Case of Iran vs. U.K.

Independent Variables	Dependent Variable	
	$\Delta[(P_{IRAN}/P_i)/R]_t$	$\Delta(PROD_{IRAN}/PROD_i)_t$
Constant	-0.0001	-0.0036
	(0.13)	(0.18)
EC_{t-1}	-0.2931	-0.0971
	(2.07)	(0.64)
$\Delta[(P_{IRAN}/P_i)/R]_{t-1}$	0.2112	-11.578
	(1.32)	(0.45)
$\Delta[(P_{IRAN}/P_i)/R]_{t-2}$	-	-
$\Delta[(P_{IRAN}/P_i)/R]_{t-3}$	-	-
$\Delta[(P_{IRAN}/P_i)/R]_{t-4}$	-	-
$\Delta(PROD_{IRAN}/PROD_i)_{t-1}$	0.0039	0.5661
	(2.66)	(2.63)
$\Delta(PROD_{IRAN}/PROD_i)_{t-2}$	-	-
$\Delta(PROD_{IRAN}/PROD_i)_{t-3}$	-	-
$\Delta(PROD_{IRAN}/PROD_i)_{t-4}$	-	-
Other Statistics		
Adj. R^2	0.54	0.16
D-W	2.0059	1.8556

Notes: a. Numbers inside the parentheses are the absolute values of the t-ratios.
EC in each equation denotes the error-correction term.

Table 10. Coefficient Estimates of The Error-Correction Models: The Case of Iran vs. the U.S.

Independent Variables	Dependent Variable $\Delta[(P_{IRAN}/P_i)/R]_t$	$\Delta(PROD_{IRAN}/PROD_i)_t$
Constant	-0.0001	0.0020
	(0.42)	(0.11)
EC_{t-1}	-0.4153	-0.1595
	(3.09)	(1.21)
$\Delta[(P_{IRAN}/P_i)/R]_{t-1}$	0.4332	-12.731
	(2.36)	(0.67)
$\Delta[(P_{IRAN}/P_i)/R]_{t-2}$	0.4155	-
	(2.11)	
$\Delta[(P_{IRAN}/P_i)/R]_{t-3}$	-	-
$\Delta[(P_{IRAN}/P_i)/R]_{t-4}$	-	-
$\Delta(PROD_{IRAN}/PROD_i)_{t-1}$	0.0032	0.5689
	(1.94)	(2.83)
$\Delta(PROD_{IRAN}/PROD_i)_{t-2}$	-0.0009	-
	(0.49)	
$\Delta(PROD_{IRAN}/PROD_i)_{t-3}$	-0.0053	-
	(2.76)	
$\Delta(PROD_{IRAN}/PROD_i)_{t-4}$	0.0029	-
	(1.96)	
Other Statistics		
Adj. R^2	0.59	0.16
D-W	2.2792	2.0105

Notes: a. Numbers inside the parentheses are the absolute values of the t-ratios.
EC in each equation denotes the error-correction term.

Table 11. Johansen's Maximum Likelihood Procedure Results: Iran vs. Canada.

Panel A. Procedure Excluding Dummy Variable D

Eigenvalues in descending order: 0.36531 0.046253
Jarque-Bera's test statistic: 0.46
Order of VAR = 1

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	13.639	14.90	12.91
r<= 1	r = 2	1.420	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	15.06	17.95	15.66
r<= 1	r = 2	1.420	8.176	6.503

Panl B. Procedure Including Dummy Variable D

Eigenvalues in descending order: 0.69611 0.15321 0.090124

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	35.73	21.07	18.90
r<= 1	r = 2	4.99	14.90	12.91
r<= 2	r = 3	2.83	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	43.55	31.52	28.71
r<= 1	r>= 2	7.82	17.95	15.66
r<= 2	r = 3	2.83	8.176	6.503

Table 12. Johansen's Maximum Likelihood Procedure Results: Iran vs. France.

Panel A. Procedure Excluding Dummy Variable D

Eigenvalues in descending order: 0.44107 0.007369
Jarque-Bera's test statistic: 3.49
Order of VAR = 1

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	17.451	14.90	12.91
r<= 1	r = 2	0.222	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	17.67	17.95	15.66
r<= 1	r = 2	0.22	8.176	6.503

Panl B. Procedure Including Dummy Variable D

Eigenvalues in descending order: 0.56740 0.16684 0.09582

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	25.14	21.07	18.90
r<= 1	r = 2	5.48	14.90	12.91
r<= 2	r = 3	3.15	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	33.76	31.52	28.71
r<= 1	r>= 2	8.62	17.95	15.66
r<= 2	r = 3	3.15	8.176	6.503

Table 13. Johansen's Maximum Likelihood Procedure Results: Iran vs. Germany.

Panel A. Procedure Excluding Dummy Variable D

Eigenvalues in descending order: 0.27683 0.001387
Jarque-Bera's test statistic: 4.26
Order of VAR = 1

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	9.723	14.90	12.91
r<= 1	r = 2	0.042	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	9.76	17.95	15.66
r<= 1	r = 2	0.04	8.176	6.503

Panl B. Procedure Including Dummy Variable D

Eigenvalues in descending order: 0.55084 0.13045 0.09164

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	24.01	21.07	18.90
r<= 1	r = 2	4.19	14.90	12.91
r<= 2	r = 3	2.88	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	31.08	31.52	28.71
r<= 1	r>= 2	7.07	17.95	15.66
r<= 2	r = 3	2.88	8.176	6.503

Table 14. Johansen's Maximum Likelihood Procedure Results: Iran vs. Italy.

Panel A. Procedure Excluding Dummy Variable D

Eigenvalues in descending order: 0.35899 0.016153
Jarque-Bera's test statistic: 1.64
Order of VAR = 1

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	13.341	14.90	12.91
r<= 1	r = 2	0.488	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	13.82	17.95	15.66
r<= 1	r = 2	0.49	8.176	6.503

Panl B. Procedure Including Dummy Variable D

Eigenvalues in descending order: 0.44731 0.14780 0.083402

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	17.78	21.07	18.90
r<= 1	r = 2	4.79	14.90	12.91
r<= 2	r = 3	2.61	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	25.19	31.52	28.71
r<= 1	r>= 2	7.41	17.95	15.66
r<= 2	r = 3	2.61	8.176	6.503

Table 15. Johansen's Maximum Likelihood Procedure Results: Iran vs.Japan.

Panel A. Procedure Excluding Dummy Variable D

Eigenvalues in descending order: 0.28795 0.0028216
Jarque-Bera's test statistic: 0.41
Order of VAR = 1

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	10.188	14.90	12.91
r<= 1	r = 2	0.085	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	10.27	17.95	15.66
r<= 1	r = 2	0.08	8.176	6.503

Panl B. Procedure Including Dummy Variable D

Eigenvalues in descending order: 0.41408 0.28209 0.024729

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	16.03	21.07	18.90
r<= 1	r = 2	9.94	14.90	12.91
r<= 2	r = 3	0.75	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	26.73	31.52	28.71
r<= 1	r>= 2	10.69	17.95	15.66
r<= 2	r = 3	0.75	8.176	6.503

Table 16. Johansen's Maximum Likelihood Procedure Results: Iran vs. U.K.

Panel A. Procedure Excluding Dummy Variable D

Eigenvalues in descending order: 0.38960 0.025472
Jarque-Bera's test statistic: 0.72
Order of VAR = 1

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	14.809	14.90	12.91
r<= 1	r = 2	0.774	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	15.58	17.95	15.66
r<= 1	r = 2	0.77	8.176	6.503

Panl B. Procedure Including Dummy Variable D

Eigenvalues in descending order: 0.56248 0.18669 0.10003

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	24.79	21.07	18.90
r<= 1	r = 2	6.20	14.90	12.91
r<= 2	r = 3	3.16	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	34.16	31.52	28.71
r<= 1	r>= 2	9.36	17.95	15.66
r<= 2	r = 3	3.16	8.176	6.503

Table 17. Johansen's Maximum Likelihood Procedure Results: Iran vs. the U.S.

Panel A. Procedure Excluding Dummy Variable D

Eigenvalues in descending order: 0.17650 0.039053
Jarque-Bera's test statistic: 1.36
Order of VAR = 1

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	5.825	14.90	12.91
r<= 1	r = 2	1.195	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	7.02	17.95	15.66
r<= 1	r = 2	1.19	8.176	6.503

Panl B. Procedure Including Dummy Variable D

Eigenvalues in descending order: 0.59644 0.17477 0.098954

LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	λ-max Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	27.22	21.07	18.90
r<= 1	r = 2	5.76	14.90	12.91
r<= 2	r = 3	3.12	8.176	6.503

LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	trace Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	36.11	31.52	28.71
r<= 1	r>= 2	8.89	17.95	15.66
r<= 2	r = 3	3.12	8.176	6.503

Table 18. Estimated cointegrating vectors using Johansen's technique (normalized coefficients inside parentheses).

i	$(P_{IRAN}/P_i)/R$	$PROD_{IRAN}/PROD_i$	D
Canada	106.237	-0.90126	-
	(-1.00)	(0.008)	
	86.830	-0.42020	0.299660
	(-1.00)	(0.005)	(-0.003)
France	33.849	-1.08550	-
	(-1.00)	(0.032)	
	27.821	-0.56767	0.303790
	(-1.00)	(0.020)	(-0.011)
Germany	60.419	-0.86699	-
	(-1.00)	(0.014)	
	54.254	-0.20546	0.502830
	(-1.00)	(0.003)	(-0.009)
Italy	-0.1442	1.07960	-
	(-1.00)	(7.482)	
	0.1117	-0.48707	0.281560
	(-1.00)	(4.361)	(-2.521)
Japan	-0.7345	1.05650	-
	(-1.00)	(1.438)	
	-0.2627	-0.36262	-0.74776
	(-1.00)	(-1.38)	(-2.84)
U. K.	177.10	-1.08690	-
	(-1.00)	(0.006)	
	132.57	-0.56181	0.28468
	(-1.00)	(0.004)	(-0.002)
U.S.	95.506	-0.91422	-
	(-1.00)	(0.009)	
	93.540	-0.50760	0.38326
	(-1.00)	(0.005)	(-0.004)

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