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The Effect of Exchange Rate Uncertainty on Import: TARCH Approach

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ABSTRACT: This paper investigates the effect of exchange rate uncertainty on the Iran's import trade. The exchange rate uncertainty series were generated utilizing the TARCH model. This model analyzes the asymmetric effects. The analysis of uncertainty and asymmetry of the exchange rate shows significant TARCH effect on Iran's exchange rates. The findings of the study indicate that negative shocks (bad news) had greater impact on volatility during the period. In the next stage imports demand function is estimated. There was a long run relationship among, real import demand, real national income, real exchange rate and uncertainty of real exchange rate. Results show significant and negative impact of exchange rate uncertainty on Iran's imports, and import demand is positively affected by real national income. Furthermore significant and negative impact of real exchange rate on Iran's real imports is found.

Keywords: *Uncertainty, Real exchange rate, Real national income, Real import, TARCH*

INTRODUCTION

Since the adoption of the floating exchange rate system in the early 1970s, there has been an extensive debate about the impact of exchange rate volatility on international trade. The theoretical literature shows that the effect may be positive or negative. However, despite a large body of the literature, few papers provide statistically convincing evidence on whether exchange rate volatility affects trade flows between countries (see McKenzie (1998) for a comprehensive survey of the literature).

There are several channels through which exchange rate volatility could affect the trade flows. First, if traders are risk averse, they could reduce their activities due to exchange rate uncertainty in order to avoid any loss. Second, exchange rate uncertainty could directly affect the trade volume by making prices and profits uncertain, especially in countries where forward markets do not exist such as the developing world. Even if forward markets do exist in some industrial countries, some studies indicate that forward markets are not very effective in completely eliminating exchange rate uncertainty (Akhtar and Hilton, 1984).

Third, if exchange rate volatility persists over a longer period of time, it could induce domestic producers to switch buying from foreign sources to domestic sources, reducing the volume of trade, especially traded inputs. Finally, exchange rate uncertainty could also affect direct foreign investment decisions which in turn could lower the volume of trade. To reduce the price fluctuation due to exchange rate volatility, production facilities would be located near final markets, leading to change in pattern of trade.

A difficulty with this line of study is in measuring unexpected fluctuation in exchange rates. Traditionally, several different measures have been used in the literature, e.g., variances or standard deviations, average of absolute changes, and deviations from trend. However, these approaches do not well capture the

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main feature of higher moments in the exchange rate, which can be characterized as non-constantly varied with clustering. In recent years, with the usefulness of ARCH type models in representing this kind of "volatility clustering". (Chongcheul et al., 2004). In this line in the present paper the researcher have used TARCH model to generate the volatility of exchange rates and estimate a structural equation in the second stage with conventional OLS technique, by replacing the variable of unobserved volatility with the measured proxy, we can estimate real import equation.

Literature Review

There has been a considerable research concerning the impact of exchange rate volatility on the volume of international trade since the advent of flexible exchange rates in 1973. Interest in this field was incited by two main developments: (a) both the real and nominal exchange rates have undergone periods of substantial volatility since 1973; and (b) during the same period, international trade declined significantly among industrialized countries. Despite the large number of studies conducted, no real consensus has emerged regarding the impact of exchange rate volatility on trade flows.

The empirical literature reveals that the effects of exchange rate volatility on import are ambiguous. While a large number of studies find that exchange rate volatility tends to reduce the level of trade, others find either weak or insignificant or positive relationships. For example, Godwin and Benson (2009), Byrne et al. (2008), Chongcheul et al. (2004), Siregar and Rajan (2004), Bahmanee-Oskooee (2002), Sukar and Hassan (2001), Anderton and Skudelny (2001), Arize et al. (2000), Pugh et al. (1999), Ozbay (1999), Ariz (1998), Caporale and Doroodian (1994), Pozo (1992), Bahmanee-Oskooee (1991), Bini-Smaghi (1991), Perée and Steinheir (1989), Koray and Lastrapes (1989) find evidence for negative effects.

On the other hand, Agolli (2003), Doyel (2001), Ariz (1998), Samanta (1998), McKenzie and Brooks (1997), Kroner and Lastrapes (1993) find evidence for a positive effect for volatility on import and trade volumes of some developed countries.

In addition, Alam and Ahmed (2010), Aristotelous (2001), Bahmani-Oskooee and Payesteh (1993), Bahmani-Oskooee (1991), Hooper and Kohlhagen (1978) have reported no significant relationship between exchange rate volatility and import.

Ariz and Shwiff (1998), Gotur (1985), Cushman (1986) found mix results in their studies. Also Stavarek (2007), Jarko and Roman (2008), Yoon and Lee (2008), and Evzen and Juraj (2006) investigate the exchange rate volatility with TARCH approach, all of them find significant effect.

The majority of these studies have focused on the developed countries while developing countries have received little attention. Also the literature is replete with empirical evidence on the effect of exchange rate volatility on exports but sparse in regards to the effect on imports. The few existing studies on the impact of exchange rate volatility on imports are reviewed.

The empirical evidence and results depends on the choice of sample period, model specification, proxies for exchange rate volatility, and countries considered. (Chongcheul et al., 2004).

To summarize, the above discussion suggests that the impact of exchange-rate volatility on import demand is an empirical issue, because theory alone cannot determine the sign of the relation between imports demand and exchange-rate volatility.

There are only a few studies on effect of exchange rate volatility on Iran's import, for example Mohammadi and Taheri (2008), and Mohammadi and Mohammadzadeh (2007) investigates the influence of exchange rate volatility on Iran's trade and found a significant and positive effect in these researches with other approaches.

The present study investigates the effects of exchange rate volatility on Iran's import during the period 1959-2009.

RESEARCH METHOD

Theoretical Framework

The model by Clark (1973) is one of the earliest theories that examine the connection between exchange rate volatility and trade flows. It considers a competitive firm with no market power producing only one commodity, which is sold entirely to one foreign market and does not import any intermediate inputs. The firm is paid in foreign currency and converts the proceeds of its exports at the current exchange rate, which varies in an unpredictable fashion, as there are assumed to be no hedging possibilities, such as through forward sales of the foreign currency export sales. Moreover, because of costs in adjusting the scale of production, the firm makes its production decision in advance of the realization of the exchange rate and cannot alter its

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output in response to favorable or unfavorable shifts in the profitability of its exports arising from movements in the exchange rate as a consequence. In this situation, the variability in the firm's profits arises solely from the exchange rate and where the managers of the firm are adversely affected by risk, greater volatility in the exchange rate with no change in its average level leads to a reduction in output and hence in exports, in order to reduce the exposure to risk. This basic model was elaborated by Hooper and Kohlhagen (1978), who reached the same conclusion of a clear negative relationship between exchange rate volatility and the level of trade.

The strong conclusion of a negative effect of exchange rate volatility on trade flows by earliest studies was based on a number of simplifying assumptions. First, it is assumed that there are no hedging possibilities either through the forward exchange market or through offsetting transactions.

One reason why trade may be adversely affected by exchange rate volatility stems from the assumption that firms cannot alter factor inputs in order to adjust optimally to take account of movements in exchange rates. When this assumption is relaxed and firms can adjust one or more factors of production in response to movements in exchange rates, increased volatility can in fact create profit opportunities. This situation has been analyzed by Canzoneri et al. (1984) and Gros (1987), for example. The effect of such volatility depends on the interaction of two forces at research. On the one hand, if the firm can adjust inputs to both high and low prices, its expected or average profits will be larger with greater exchange rate volatility, as it will sell more when the price is high and vice versa. On the other hand, to the extent that there is risk aversion, the higher variance of profits has an adverse effect on the firm and constitutes a disincentive to produce and to trade. If risk aversion is relatively low, the positive effect of greater price volatility on expected profits outweighs the negative impact of the higher volatility of profits and the firm will raise the average capital stock and the level of output and trade.

Model Specification

Traditionally, the desired real imports are functionally related to exchange rate volatility, income and relative prices. The standard demand theory indicates that the partial derivative of the demand for imports with respect to the domestic income would be positive. For two reasons, real imports would be expected to increase with real income. First, if an increase in real income leads to an increase in real consumption, with an unchanged distribution of income, more foreign goods will be purchased. And if an increase in income leads to an increase in real investment, then investment goods not domestically produced must be bought from abroad. On the other hand, the effect of the real exchange rate on the demand for imports is negative. This implies that a depreciation of the real exchange rate will raise the cost of imports, all other factors held constant. This could lead to a decline in real imports demanded. Conversely, an appreciation of the real exchange rate will be reflected in a lower cost for imports leading to an increase in the volume demanded. Regarding the effects of exchange rate volatility, it has been argued that higher exchange rate volatility leads to higher import cost for risk-averse traders and to less foreign trade. This is because the exchange rate is agreed on at the time of the trade contract, but payment is not made until the future delivery actually takes place. If changes in exchange rates become unpredictable, this creates uncertainty about the profits to be made and hence, reduces the benefits of trade (Godwin and Benson, 2009).

Therefore, imports can be modeled as:

$$\ln M_t = \alpha_o + \alpha_1 \ln Y_t + \alpha_2 \ln R_t + \alpha_3 \ln V_t + u_t$$

where:

M = Real imports at time t

Y = Real national income at time t

R = Real exchange rate at time t

V = Exchange rate volatility at time t

u = Error term

Using a log-linear specification, it is possible to derive a static long-run import equation (Khan and Ross, 1977). With log-linearity, the coefficients pro-vide an estimate of the relevant elasticities and we expect the following signs:

$$\alpha_2 , \alpha_3 < 0 \ , \ \alpha_1 > 0$$

Definitions of variables are as follows:

Real Exchange Rate

Real exchange rate defined as *P*E/P* where *P** is the US CPI (2004 = 100) which comes from source IMF; *P* is the Iranian CPI (2004 = 100), comes from source of economic time series database of central bank of Iran;

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and *E* is the nominal unofficial market exchange rate (period average rate) defined as Iranian Rls. per US dollar. The data for *E* come from same source.

Exchange Rate Volatility

In line with recent literature, exchange rate volatility is measured using the TARCH model that provides a way of formalizing the fact that large changes in the exchange rates tend to be followed by large changes and then by small changes. This allows for prediction of the range of future movements of exchange rate. This approach is generally regarded as a better measure of exchange rate volatility.

Real Imports and Real National Incomes

The basis for each one of these indexes is (2004=100) and is collected from economic time series database of central bank of Iran.

Estimation Procedure

The first step is to generate the exchange rate volatility series employing the TARCH approach. These generated series are then employed in the estimation of import equation. The analysis is then conducted for Iran's imports.

Sources of Data

Time series data for Imports, national income and foreign exchange rates are collected for 1959-2009 from economic time series database of central bank of Iran. For other indicators that we need, obtained from the International Monetary Fund International Financial Statistics.

TARCH Model

It is often seen that the volatility of financial variables is different along positive and negative trends (Engle and Ng, 1993). The downwards movements of share prices are usually associated with higher volatility of financial data. In this regard, Zakoian (1994) and Glosten, et al. (1993) proposed the threshold ARCH models to analyze asymmetric volatility.

The conditional variance for the simple TARCH (1,1) model is defined by:

$$\delta_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 d_{t-1} + \beta\delta_{t-1}^2$$

Where d_t=1 if ε_t is negative, and 0 otherwise. In this model, volatility tends to rise with the bad news ($\varepsilon_{t-1}<0$) and to fall with the good news ($\varepsilon_{t-1}>0$). Good news has an impact of α while bad news has an impact of $\alpha+\gamma$. This model is concerned with the leverage effect sometimes observed in stock returns. If $\gamma>0$ then there is the leverage effect. If $\gamma\neq0$, the shock is asymmetric, and if $\gamma=0$, the shock is symmetric. The persistence of shocks to volatility is given by $\alpha+\beta+\gamma/2$.

In the above specification ARCH term $\alpha\varepsilon^2_{t-1}$ reflects the impact of 'news' or 'surprises' from previous periods that affects exchange rate volatility: significant and positive α depicts the extent of the shocks' effect on volatility which is not destabilizing. When α is greater than one then shocks materializing in the past are likely to be destabilizing.

GARCH term $\beta\delta^2_{t-1}$ on the other hand, measures the impact of the forecast variance from previous periods on the current conditional variance, or volatility. Significant coefficient β (close to one) thus means a high degree of persistence in exchange rate volatility. The sum of both coefficients also tells us about the speed of convergence of the forecast of the conditional volatility to a steady state: the closer to one its value is, the slower the convergence. TARCH asymmetric term $\gamma\varepsilon^2_{t-1}d_{t-1}$ measures and accounts for the effect of the difference between good and bad news. The value of statistically significant leverage coefficient γ indicates the magnitude of the leverage effect, and the sign its direction. A positive value of coefficient γ indicates an increase-and a negative coefficient a decrease-in subsequent volatility of the exchange rate.

The Exchange Rate Trends in Iran

Generally, we can divide exchange rate progressive trend in Iran (figure 1) to 3 specific periods along with the period 1959-2009:

Fixed Exchange Rate System (1959-1977)

In these years the exchange rate of Iranian Rial to Dollar and the Special Drawing Rights (SDR) in a short period was fixed. In this system the national exchange rate was stable, but it was variable with regards to the other global exchanges. The calculation of equating these exchanges with dollar was based on the established "SDR" system.

In the countries with powerful foreign exchange resources and ability to save a stable connection between national money and foreign exchange, this system has its own application.

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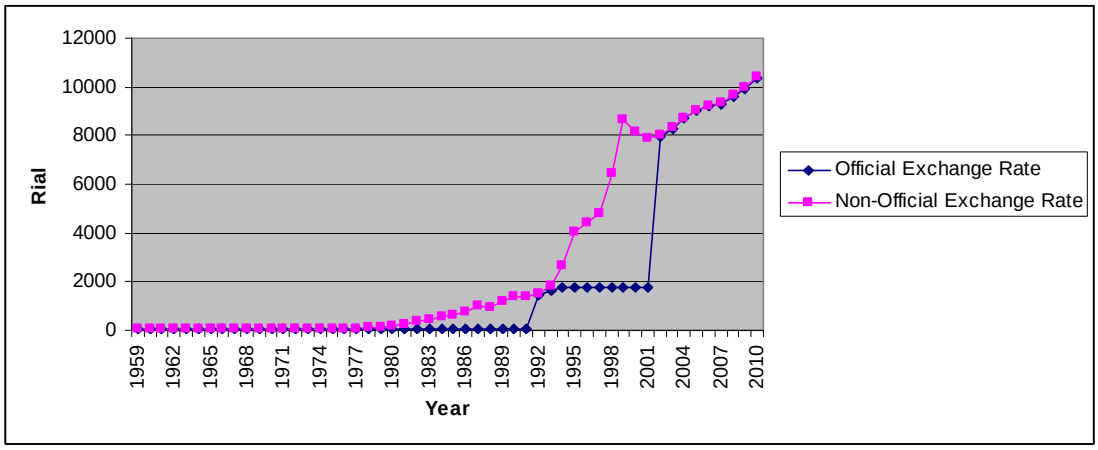

Figure1: IRAN's official and non-official exchange rate

Multi Exchange Rate System (1978-2001)

During these years, as shown in figure 1 as a result of revolution, imposed War and the international sanctions against Iran, there was a severe decrease in foreign exchange revenue with the effects of the dominant exchange restrictions; the multi-exchange rate system was invented. In this system that is called Guideline policy-making, relation with economic plans, several exchange rates has been announced; the following cases among them are as follows:
1-Official Rate 2-Market Rate 3-Preferential Rate 4-Services Rate 5-Competetive Rate 6-Floating Rate 7-Agreement Rate 8-Certificate of Deposit Currency Rate

Managed (Controlled) Floating Exchange Rate System (2002-2009)

In this system the equivalence of exchange rate was floating between Rial and the other current exchanges. But the Central Bank recurring interventions in the market has completely controlled this equivalence rate, and has supported the offer and demand to reach the desired exchange rate targeted. Actually, the Central Bank, as a greatest offer maker and delivery agent of the foreign exchange, has controller and regulator in the years mentioned and really was the only policy maker to determine the exchange rate prices.

We may suggest this period as transitional period among the fixed exchange rate system to multi exchange rate one and then coming to the floating exchange rate system. It is obvious that we are not able to reach the Final point (Floating System) suddenly.

Import Trends in IRAN

During the years 1959-1977 the imports had an ascending trend with a slight slope. Also the oil price had an ascending trend. Since 1974, because of an oil shock and reaching the oil price up to four times the pre-ascended price, consequently there was an increase in the government income. As many obstacles in commercial sector had been removed, Iran's import increased abruptly. The average foreign income increased about 40% in the period 1973-1977 every year. During the imposed war, Iran faced petroleum export problems, so the foreign exchange revenue of the government decreased. In the first few years of the 1980s, the import had been increased slightly because of recovering the oil price to some degrees.

In 1988, after the war, the import has got the lowest value, about 8177 million dollars due to the low oil price and increasing deficiencies of foreign exchange. Shortly afterwards, the investing, consuming and mediating imports of the country increased, with regard to reconstructing the economy and the liberating policies of trade affairs.

But in the years 1993 and 1994, by the restrictive policies on import, the amount of it decreased by 41%. Between the years 1995-1996, government set limits on imports with less intensity; furthermore, it increased oil price and foreign exchange incomes, consequently the amount of imports raised again. In 1997 along with decreasing the global oil price, the value of imports decreased by 6.1% and mounted to 13633 million dollars. This trend continued up to the year 1999, but since 2000 the global oil price along with redemption and decrease of the restriction of import policies to

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encourage and facilitate trade and also to equate the exchange rate in 2002, imports have grown up to the present.

In brief, there is a high dependency of foreign exchange incomes on oil price, i.e. in the decreasing period of that, the foreign exchange incomes and import have decreased (figure 2) and with the emergence of the oil income surplus, the restrictions have diminished and the volume of import has increased, on the other hand.

RESULTS AND DISSCUSSION

This section tries to estimate the import demand model using annual data over 1959-2009 periods. The methodology is based on a co-integration tech-nique which tries to establish whether there is a long-run relationship among sets of variables. The first step in apply-ing the co-integration procedure is to determine the degree of integration of each variable in each of the models. A variable is said to be integrated of order one if it achieves stationarity after being differenced once. Such variable is said to be an I (l) variable. Two or more I (l) variables are said to be co-integrated if a linear combination among them is I (0).

A common practice to determine the degree of integra-tion of a time series is to apply the ADF test. In the case of Iran due to a structural break in the data at the time of revolution, we use dummy variables. Table 1 presents the results of a simple ADF test for the stationarity of level of each variable as well as for their first differences.

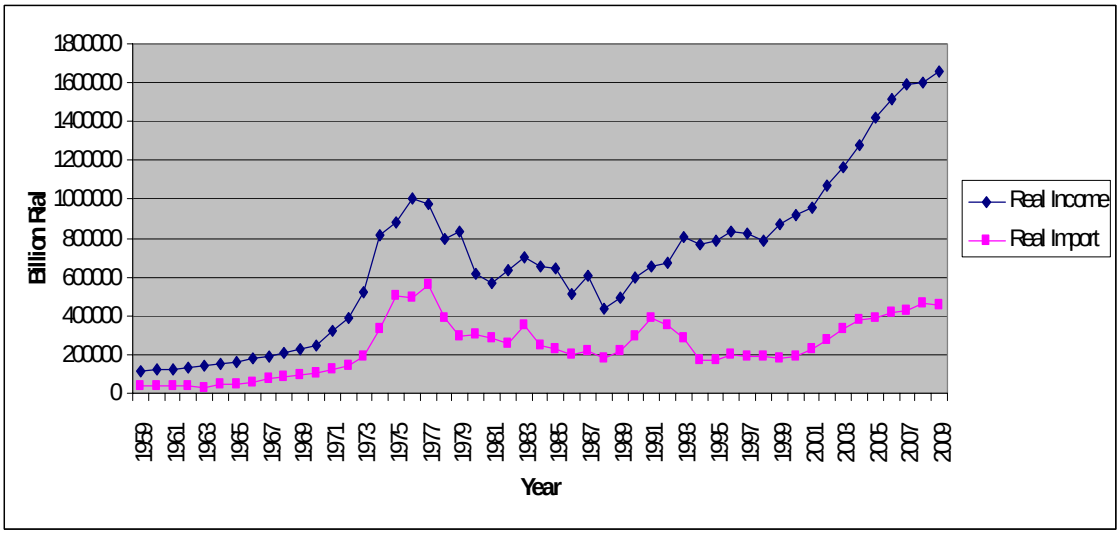

Figure 2: IRAN's real incomes and real imports

Table1: ADF tests

Variable	ADF test [a]	Prob
LogR	-1.49[1] [b]	0.5264
LogM	-1.98[1]	0.2952
LogY	-1.57[1]	0.4905
△ LogR	-4.16[1]	0.0019
△ LogM	-4.78[1]	0.0003
△ LogY	-5.53[10]	0.0000

Notes: (a) The Mackinnon (1991) critical value of the simple ADF test for 31 observations (when a trend term is included in the test) is -3.21 at the 10% level of significance.
(b) Number inside the bracket is the number of lags.

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As shown in table 1 based on the simple ADF test all variables have achieved stationarity after being differenced once.

Since exchange rate volatility is not directly observable, to quantify the variable we use the TARCH model. The real exchange rate uncertainty estimated as follow:

$$h_t = \underset{[1.13]}{0.0003} - \underset{[-2.03]}{0.24}\varepsilon_{t-1}^2 + \underset{[2.02]}{0.48}d\,\varepsilon_{t-1}^2 + \underset{[10.25]}{0.97}h_{t-1}$$

We can see significant effect of TARCH model on Iran's real exchange rate.

Coefficient γ of the asymmetric term illustrates the reaction of volatility to different categories of news. The majority of coefficients is significant and positive ($\gamma \simeq 0.48$): this means that negative shocks (bad news) had a greater impact on volatility during the period.

The sum of the ARCH and GARCH terms' coefficients indicates the degree of convergence to a steady state.

After generating real exchange rate uncertainty series (V), ADF Test on it is done as follows (table 2). In the next stage, we estimated real import equation with OLS method. Results are shown in table 3.

As shown in Table 3, the results of the all estimated coefficients are statistically significant at the 1% levels. Long-run static-state equilibrium is obtained as follows:

LogM = 4.05- 0.33LogR + 0.77LogY -0.21LogV + 0.16D

Table2: ADF tests on logarithm of real exchange rate uncertainty

Variable	ADF test	Prob
LogV	-2.30[1]	0.1760
△ LogV	-8.25[1]	0.0000

Table3: Long run Model of Imports demand function

Regressor	Coefficient	T-statictic	Prob
Constant	4.0507	3.0645	0.0038
LogR	-0.3300	-3.7496	0.0005
LogY	0.7714	9.7924	0.0000
LogV	-0.2093	-6.8036	0.0000
D(Dummy)	0.1593	3.1104	0.0034
AR(1)	0.8352	19.9906	0.0000
MA(4)	-0.9715	-35.656	0.0000
R^2= 0.9793	DW = 1.8	F-statistic = 331.244	

Engle-Granger Test

To test for co-integration between two or more non-stationary time series according to Engle-Granger methodology, it simply requires running an OLS regression, saving the residuals and then running the ADF test on the residual to determine if it is stationary. The time series are said to be co-integrated if the residual is itself stationary. In effect the non-stationary I (1) series have cancelled each other out to produce a stationary I (0) residual.

OLS regression is estimated with non-stationary variables on level. (they become stationary when their first difference is taken). This completes the Engle-Granger methodology on co-integration analysis.

The result of Engle-Granger co-integration test is shown in table 4.

The residual acquired from the estimation process had not unit root and are stationary. So the regression achieved will not be spurious and will be reliable.

Johansen Co-integration Test

To test for co-integration, we apply the Johansen-Juselius (1990) methodology. The Johansen-Juselius, (JJ), procedure utilizes test statistics to determine the number of co-integrating vectors. First we need to estimate the VAR model and test with SC and HQ for the optimal number of lags. According to the SC and HQ criteria (table 5) optimum lag length is selected to be 2.

The result of Johansen co-integration test is shown in table 6 and indicates the existence of a single co-integrating vector at 5 percent significance level. This leads us to rejecting the null hypothesis of no co-integrating vector and accepting the alternative hypothesis of a single co-integrating vector.

Table4: ADF of residual at level

Variable	T statistic	Prob	F statistic	D-W
Residual	-6.19	0.0000	38.27	2

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Table 5: VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-99.65659	NA	0.001268	4.680721	4.998746	4.799855
1	89.48767	328.9465	6.86e-07	-2.847290	-1.893216	-2.489888
2	150.8261	96.00796	9.77e-08	-4.818526	-3.228403*	-4.222856*
3	171.5055	28.77135*	8.39e-08	-5.021978	-2.795806	-4.188041
4	190.5728	23.21231	8.09e-08*	-5.155337*	-2.293116	-4.083132

Table 6: Unrestricted Co-integration rank test (Trace)

Hypothesis		Eigen value	Trace statistic	Critical value 0.05	Prob*
Null	Alternative				
$r = 0$	$r \geq 1$	0.711138	89.32581	55.24578	0.0000
$r \leq 1$	$r \geq 2$	0.408359	29.71909	35.01090	0.1648
$r \leq 2$	$r \geq 3$	0.088141	4.526060	18.39771	0.9582
$r \leq 3$	$r \geq 4$	0.002021	0.097092	3.841466	0.7553

Trace test indicates 1 co-integrating eqn(s) at the 0.05 level
*MacKinnon-Haug-Michelis (1999) p-values

This is so because under the alternative hypothesis of r = 1 the value of the test statistic is 89.32581 which is greater than the critical value at 5 percent (table 6).

Thus there is exactly one co-integrating vector in the model. This means that a single vector uniquely defines the co-integration space; this suggests the existence of a long-run relationship between the series (Harris and Sollis, 2003). The estimated result in Table 3 indicates that change in Iran's imports is mainly affected by real national income. The study finds that real national income affects significantly aggregate real imports, and suggests that 1 percent increase in real national income, boost demand for aggregate real imports by 0.77 percent. This implies that increase in real national income increases economic activity in the country, therefore import demand increases. The long run coefficient of real exchange rate and volatility of real exchange rate are negative and statistically significant, which implies that real exchange rate and volatility of real exchange rate significantly decrease the demand for real aggregate imports, also 1 percent increase in real exchange rate, decrease demand for real imports by 0.33 percent. And 1 percent increase in volatility of real exchange rate, decrease demand for real imports by 0.21 percent.

CONCLUSION

In this paper, we have investigated the possible effects of exchange rates uncertainty on Iran's real imports by using Iranian annual data over 1959-2009 period. We discussed a TARCH class model for measuring Iran's real exchange rate uncertainty. We used this model and generated real exchange rate uncertainty series. Then in the next stage with conventional OLS technique, we estimated real import equation.

As a result, analyzing volatility and asymmetry of the exchange rate shows significant TARCH effect on Iran's exchange rates. Results show negative shocks (bad news) had greater impact on volatility during the period.

Also the empirical results applied in this approach indicate that real exchange rate uncertainty has a negative and significant impact on Iran's real imports and import demand is positively affected by real national income. Also significant and negative impact of real exchange rate on Iran's real imports is found.

Therefore the study indicates that real import demand is sensitive or elastic to real exchange rate uncertainty, real exchange rate and real national income.

In developing countries such as Iran, there is a much degree of uncertainty in the aggregate economic

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variables. The rate of economic growth, inflation, exchange and the other aggregate variables have more volatility in these countries than the industrial countries. Real exchange rate volatility in the developing countries and in the process of development, makes uncertain situation for the traders to make their own decisions, because since distorts profit projection trend. In reality, stability of the exchange rate will result in more trust in investors, and vice-versa.

In this study we only focused on imports. For a systematic analysis, however, it would be desirable to look at the imports and exports simultaneously, thus checking whether the effect of uncertainty in exchange rates on both sides is symmetric or not. This issue could be another direction for future research.

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