# The Effect of Exchange Rate Volatility on Import Demand: Evidence from Turkey

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## Abstract

Since 2001 financial crisis, Turkey has adopted fluctuating exchange rate regime in order to make the economy stronger against external shocks. This has lead to a high volatility of Turkish lira against to foreign currencies. Therefore, it became essential for policy makers to evaluate the potential effects of exchange rate volatility on international trade. The purpose of this study is to provide new evidence on the effects of exchange rate volatility on the import demand of Turkey along with income and price elasticities. Our data cover the period 2010:01 to 2010:05. We, initially, employed a GARCH model to evaluate exchange rate volatility one of the independent variables that estimate real import. The study also includes conventional determinants such as relative price level of imports and real GDP. Afterwards, our paper investigates long-run and short-run relationship between real imports and its determinants by using ARDL error correction model. The empirical results indicate that real exchange rate volatility of local currency has significant and reverse effect on import demand.

***Keywords:*** Exchange rate volatility, Import demand, GARCH model, ARDL error correction model, Turkey.

## 1. INTRODUCTION

The high degree of volatility and uncertainty of exchange rate movements since the beginning of the generalized floating in 1973 have led policy makers and researchers to investigate the nature and extent of the impact of such movements on the volume of trade. Most studies investigate empirically the effects of exchange rate volatility on the export flow. However, there are only a few studies which investigate the impact of exchange rate volatility on import demand.

Gotur (1985) found mixed evidence regarding the effect of exchange rate volatility on import demand using aggregate data for the US, Germany, France, Japan and UK. The main conclusion of this analyze is that the Akhtar-Hilton methodology fails "to establish a systematically significant link between measured exchange rate variability and the volume of international trade". Anderton and Skudelny (2001) estimated euro area import demand function for the period 1989:01 to 1999:02. They found a significant negative effect of extra-euro area bilateral exchange rate volatility on euro area imports. Aydın et al. (2004) examines the export supply and import demand for the Turkish economy using both single equation and vector auto regression frameworks. The analysis shows the real exchange rate as a significant determinant of imports and the trade deficit, but not of exports. Baum et al. (2004) estimates the impact of exchange rate volatility on real international trade flows utilizing a 13 country dataset of monthly bilateral real exports for 1980-1998. They find that the effect of exchange rate volatility on trade flows is nonlinear, depending on its interaction with the importing country's volatility of economic activity, and that it varies considerably over the set of country pairs considered.

Arize (1998) tried to apply the co-integration technique to the import demand model using quarterly data over 1973:02 through 1993:04 and estimated the short- and long-run influence of exchange-rate volatility on the import flows of the United States. The major finding is that there is a significant long- as well as short-run negative effect of exchange-rate volatility on the volume of imports. Arize and Shwiff (1998) provided new evidence on the long-run relationship between import flows and exchange-rate volatility in G-7 countries, during the quarterly period 1973:02 to 1995:01. They found that exchange rate volatility has a significant negative effect on the volume of imports of G-7, countries whereas for Canada, it is positive and significant.

Hwang and Lee (2005) examine the impact of exchange rate volatility on trade flows in the UK, over the period 1990-2000. Volatility is modelled by GARCH-M method. This study identifies the existence of a positive relationship between exchange rate volatility and imports in the U.K. in the 1998. Gül and Ekinci (2006) investigate the interactions between the real exchange rates and export and import applying bivariate Granger causality test in Turkey. The results indicate that there is a cointegrating relationship between the real exchange rates and export and import. Erden and Sağlam (2009) investigate the impact of exchange rate volatility on import demand in Turkey. The results indicate that while volatility and import demand on investment goods are co-integrated and are negatively related, there is no co-integrating relationship between exchange rate volatility and import demand on consumptions goods. Sarı (2010) provides the exchange rate volatility by using MSARCH which is a new econometric method; the results indicate that the import and exchange rate volatility are inversely related. Alam and Ahmed (2010) estimated the import demand function for Pakistan covering quarterly period 1982:01 to 2008:02 by employing ARDL approach. The result from ARDL analysis, support the hypothesis that in Pakistan there exist a long run relationship among, import demand, real economic growth, relative price of imports, real effective exchange rate and volatility of real effective exchange rate.

## 2. Data and Methodology

For the following analysis, we gathered data on real import demand (RIMP) which is constructed as nominal import level deflated by the unit value index of import level, relative price (RELPR) which is the ratio of import price index of Turkey to consumer price index for Turkey (CPI), real GDP (GDP) seasonally adjusted using by CENSUS X12 method and exchange rate volatility (VOL). A continuous monthly sample from 2000:01 to 2010:05 is used in this study. RIMP, RELPR, GDP and CPI variables collect from Turkish Statistical Institute. Exchange rate volatility means that risk level faced by importers due to unpredictable fluctuations and thus it is an unobservable variable. We, therefore, used the conditional variance measure derived from GARCH model by Bollerslev (1986):

$$ER_t = c + \vartheta_i \sum_{i=1}^{p} ER_{t-i} + \mu_t;\ \mu \sim N(0,\sigma^2) \qquad (1)$$

where c is constant term, $\vartheta_i$ are the coefficients and $\mu_t$ is the error term normally distributed with mean zero and variance $\sigma^2$. ARCH model developed by Engle (1982) presume that the variance can be obtained from the following AR process:

$$\sigma_t^2 = c + \partial_i \sum_{i=1}^{p} \mu_{t-i}^2$$

where $\sigma_t^2$ is the conditional variance of exchange rate, $\partial_i$ are the coefficients and $\mu_{t-i}^2$ indicates the squared residuals from the mean equation. However, the GARCH (p,q) process is a widening version of ARCH in which $\sigma_t^2$ is a function of the lagged values of itself as well as of $\mu_{t-i}^2$. The conditional variance of exchange rate is estimated by:

$$\sigma_t^2 = c + \partial_i \sum_{i=1}^{p} \mu_{t-i}^2 + \alpha_i \sum_{i=1}^{q} \sigma_{t-i}^2 \qquad (3)$$

The most familiar drawback of testing for nonstationary in the process of time series is the very low power of unit root tests. Thus, a method which has received considerable attention over the past years is the autoregressive distributed lag (ARDL) bounds testing approach to cointegration developed by Pesaran and Shin (1999) and Pesaran et al. (2001) is usually used. The advantages of this method are to compare with other cointegration procedure. Firstly, a major advantage of this approach is that order of integration for each variable is not required for testing on the existence of a long-run relationship between them. More precisely, it is not relevant whether the variables are I(0) or I(1). Moreover, the long and short run coefficients can be estimated simultaneously and a dynamic error correction model (ECM) can be derived from ARDL through simple linear transformation.

Applying the method, the error correction version of the ARDL model is given by:

$$\Delta RIMP_t = c + \varphi_1 RIMP_{t-1} + \varphi_2 RELPR_{t-1} + \varphi_3 GDP_{t-1} + \varphi_4 VOL_{t-1} + \delta_1 \sum_{i=1}^{k} \Delta RIMP_{t-i} + \delta_2 \sum_{i=0}^{k} \Delta RELPR_{t-i} + \delta_3 \sum_{i=0}^{k} \Delta GDP_{t-i} + \delta_4 \sum_{i=0}^{k} \Delta VOL_{t-i} + \varepsilon_t \qquad (4)$$

where the c is the constant tem, $\varphi$ are the long run multipliers, $\delta$ are the short run coefficients and $\varepsilon_t$ is the white noise error term. To test the long run relationship, an F-test on the null hypothesis of no cointegration in the long run relationship is defined by $H_0: \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = 0$, against the alternative hypothesis of $H_0: \varphi_1 \neq \varphi_2 \neq \varphi_3 \neq \varphi_4 \neq 0$ is conducted. The calculated F statistic is compared with the critical values provided by Pesaran et.al (1999). If the calculated F statistic lies above the upper bound, the null hypothesis of no cointegration is rejected. In other case, the null hypothesis can be accepted if F statistic below the lower bound. If the existence of a cointegration relationship is identified, then following cointegration model is projected:

$$RIMP_t = c + \gamma_1 \sum_{i=1}^{k} RIMP_{t-i} + \gamma_2 \sum_{i=0}^{l} RELPR_{t-i} + \gamma_3 \sum_{i=0}^{m} GDP_{t-i} + \gamma_4 \sum_{i=0}^{n} VOL_{t-i} + \omega_t \qquad (5)$$

The selection of the orders of lags in ARDL model is very important which is guided by Akaike Information Criterion (AIC). Furthermore, the properties of the residuals are checked to ensure the absence of serial correlation. Finally, the dynamic short-run coefficients for the error correction representation are estimated according to;

$$\Delta RIMP_t = c + \pi_{ecm} ECM_{t-1} + \pi_1 \sum_{i=1}^{k} \Delta RIMP_{t-i} + \pi_2 \sum_{i=0}^{l} \Delta RELPR_{t-i} + \pi_3 \sum_{i=0}^{m} \Delta GDP_{t-i} + \pi_4 \sum_{i=0}^{n} \Delta VOL_{t-i} + v_t \qquad (6)$$

where ECMt-1 is the error correction term resulting from estimated long run equilibrium relationship;

$$ECM_t = RIMP_t - c - \gamma_1 \sum_{i=1}^{k} RIMP_{t-i} - \gamma_2 \sum_{i=0}^{l} RELPR_{t-i} - \gamma_3 \sum_{i=0}^{m} GDP_{t-i} - \gamma_4 \sum_{i=0}^{n} VOL_{t-i} \qquad (7)$$

and $\pi_{ecm}$ is the coefficient represent the speed of adjustment to long run equilibrium i.e. the percental monthly correction of a deviation from the long run equilibrium the month before.

## 3. Empirical Results

The Augmented Dickey Fuller (ADF) and Philips-Perron (PP) tests results are shown in Table 1. This tests shows that RIMP, RELPR, GDP are to be integrated of order one, I(1), except for measures exchange rate volatility (VOL). VOL is to be integrated of order zero, I(0). Evidently, composition of I(0) and I(1) variables provides a good reason for using the bounds test approach (ARDL model).

**Table 1. ADF and PP tests of the series**

| Variable | ADF test with intercept | | Philips-Perron test with intercept | |
|---|---|---|---|---|
| | Level | First Difference | Level | First Difference |
| RIMP | -0.861 | -2.906** | -1.912 | -18.695* |
| RELPR | -1.665 | -5.889* | -1.383 | -9.185* |
| GDP | -1.366 | -8.245* | -1.462 | -7.136* |
| VOL | -7.441* | -15.659* | -7.484* | -67.973* |

Critical values are: -3.483 (for 1% level), -2.887 (for 5% level), -2.581 (for 10% level). *,** and *** indicates significant at 1%, 5% and %10 level respectively.

In the first stage of the ARDL procedure, the order of lags on the first differenced variables for eq. (4) is usually obtained by means of Akaike Information Criterion (AIC). Given that we are using monthly observations, we experimented up to 8 lags on the first-difference of each variable and decided to choose 2 lags length.

**Table 2. Lag Lengths for Bounds Test**

| Lag Length | AIC | Breusch-Godfrey LM Test (Prob.) |
|---|---|---|
| 8 | 6,9658 | 0.142 |
| 7 | 6,9673 | 0.571 |
| 6 | 6,9036 | 0.734 |
| 5 | 6,9024 | 0.108 |
| 4 | 6.8588 | 0.104 |
| 3 | 6.7958 | 0.413 |
| 2 | 6.7951 | 0.507 |
| 1 | 6.7976 | 0.401 |

In Table 3, the results of the bounds co-integration test demonstrate that the null hypothesis of against its alternative is easily rejected at the 5% significance level. The computed F-statistic of 4.738 is greater than the lower critical bound value of 3.49; thus indicating the existence of a steady-state long-run relationship among RIMP, RELPR, GDP and VOL.

**Table 3. Bounds Test for Cointegration Analysis**

<table>
<tr><td>K</td><td>Bounds F test</td><td colspan="3">Critical Values</td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">4.738</td><td></td><td>Lower Bound</td><td>Upper Bound</td></tr>
<tr><td>%90 level</td><td>2.97</td><td>4.00</td></tr>
<tr><td>%95 level</td><td>3.49</td><td>4.58</td></tr>
<tr><td>%99 level</td><td>4.56</td><td>5.83</td></tr>
<tr><td colspan="5">Diagnostics</td></tr>
<tr><td colspan="2">R2=0.440</td><td colspan="2">F-Statistics=5.398 (0.000)</td><td>D-W Stat=1.938</td></tr>
<tr><td colspan="2">Breush-Godfrey LM=1.59 (0.451)</td><td colspan="2">Jarque-Bera=10.307 (0.005)</td><td>White Test= 7.872 (0.928)</td></tr>
<tr><td colspan="2">Ramsey RESET=0.312 (0.577)</td><td colspan="2"></td><td></td></tr>
</table>

Given the existence of a long-run relationship, in the next step we used the ARDL cointegration method to estimate the parameters of ARDL (1,0,1,1) model. GDP and VOL variables display the expected signs for the regressors and they are highly statistically significant. The results of long run test suggest that the demand for imports in Turkey has not been affected by an increase in the relative price level of import. Because, Turkey mostly imports goods that are essential for continuing economic activity like petroleum products and raw materials.

**Table 4. ARDL (1,0,1,1) Model and Long Run Coefficients**

| Variable | Coefficient | t-stat |
|---|---|---|
| Constant | -33.426 | -3.758* |
| RIMPt-1 | 0.331 | 3.763* |
| RELPR | 0.139 | 0.825 |
| GDP | 2.48E-06 | 0.507 |
| GDPt-1 | 8.73E-06 | 1.843* |
| VOL | -0.069 | -1.996** |
| VOLt-1 | 0.034 | 1.002 |
| Coefficients for Long Run | | |
| Constant | -50.002 | -3.815* |
| RELPR | 0.208 | -0.989 |
| GDP | 1.676E-05 | 3.763* |
| VOL | -0.051 | -3.994* |
| Diagnostics | | |
| R2=0.892 | F-Statistics=157.948 (0.000) | D-W Stat=2.043 |
| Breush-Godfrey LM=0.97 (0.636) | Jarque-Bera=13.375 (0.001) | White Test=3.279 (0.785) |
| Ramsey RESET=1.184 (0.278) | | |

*, **and *** denote significance at the1%, 5%  and 10% level, respectively.

Error Correction Model (ECM) is employed to check the short run relationship among RIMP, RELPR, GDP and VOL. The t-statistics of ECM is statistically significant which shows that there is short run relationship among variables and results are incorporated in Table 5. The coefficients of error correction term represent the speed of adjustment of this variable back to its long- run value following a shock. 81% of any deviation from the long-run equilibrium is corrected every month.

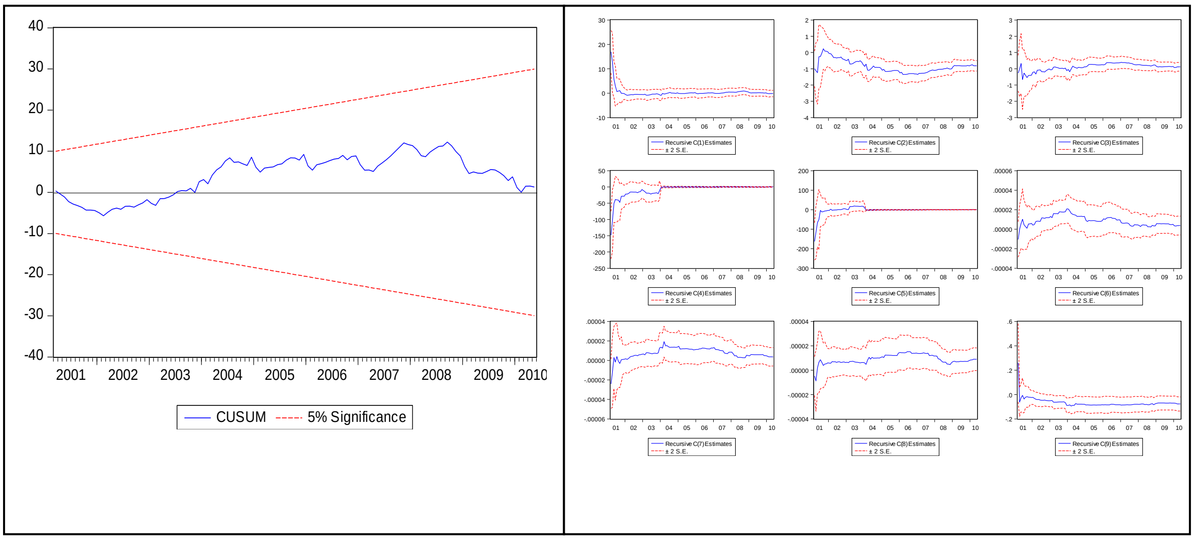
**Table 5. Error Correction Representation of ARDL Model**

| Variable | Coefficient | t-stat |
|---|---|---|
| Constant | -0.171 | -0.254 |
| ECMt-1 | -0.816 | -5.039* |
| RIMPt-1 | 0.119 | 0.913 |
| RELPR | 0.321 | 0.688 |
| RELPRt-1 | 0.376 | 0.806 |
| GDP | 3.73E-06 | 0.775 |
| GDPt-1 | 3.61E-06 | 0.769 |
| GDPt-2 | 8.93E-06 | 1.918*** |
| VOL | -0.077 | -2.687* |
| Diagnostics | | |
| R2=0.365 | F-Statistics=7.984 (0.000) | D-W Stat=2.061 |
| Breush-Godfrey LM=1.79 (0.182) | Jarque-Bera=7.388 (0.024) | White Test=1.182 (0.316) |
| Ramsey RESET=1.168 (0.190) | | |

*, **and *** denote significance at the1%, 5% and 10% level, respectively.

In order to check for parameter constancy, we employ the CUSUM stability test to the estimated ARDL model.

**Graph 1. Stability tests for Short Run ARDL (ECM) Model**



The CUSUM plot for the model is shown in Graph 1 (a). As can be seen, the plot is within the 5% critical bounds. Furthermore, we conduct the Recursive Coefficient Test to confirm the stability of parameters [see Graph 1 (b)]. As the coefficients do not display significant variation as more data is added to the estimating equation, it is a strong indication of stability. For the model, the stability tests show an overall constancy of the cointegration space.

## 4. CONCLUSION

In this paper, we have analyzed real import demand for Turkey using available monthly time series data from 2000:01 to 2010:05. It could be concluded from this study that there is a long run relation among import demand, relative prices, real GDP and real exchange rate volatility. CUSUM and Recursive Coefficient Tests also indicate that there exists a stable import demand function. By employing an error correction framework, we also obtain estimates for the speeds of adjustment to long run equilibrium and short run elasticities for the import demand of Turkey. Therefore, it found that import demand of Turkey is positively affected by real GDP indicating that it is growth driven. Further, the results show that relative price level has no significant effect on import demand, which is quite obvious for growth driven economy.

Results of the study also disclose that real exchange rate volatility of local currency has significant and reverse effect on import demand. The import demand of Turkey is sensitive and elastic (long run elasticity is -0.051 meanwhile short run elasticity is -0.077) to real depreciation and its volatility. The short-run dynamics assessed by estimation of the error correction models indicate an average adjustment coefficient of -0.82. For sustainable foreign trade policy (mediately sustainable economic growth), Central Bank of the Republic of Turkey should conduct more stable exchange rate policy.

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