Does currency substitution affect exchange rate uncertainty? the case of Turkey

Korap Levent

Istanbul University Institute of Social Sciences, Besim Ömer Paşa Cd. Kaptan-ı Derya Sk. 34452 Beyazıt /ISTANBUL

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DOES CURRENCY SUBSTITUTION AFFECT EXCHANGE RATE UNCERTAINTY? THE CASE OF TURKEY

Cem SAATÇİOĞLU

Istanbul University, Faculty of Economics, Department of Economics, İstanbul / TURKEY

Cihan BULUT

Qafqaz University, Faculty of Economics, Department of International Economics, Baku / AZERBAIJAN

H. Levent KORAP

Economist, Marmara University, İstanbul / TURKEY

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Abstract

In this paper, we investigate whether the currency substitution can affect the exchange rate uncertainty for the Turkish economy. Considering the whole time period 1987M01-2006M12 as well as thesub-periods 1987M01-1999M12 and 2001M03-2006M12 for sensitivity analysis, our estimation results employing contemporaneous exponential GARCH (EGARCH) methodology of Nelson (1991) indicate that currency substitution leads to the exchange rate uncertainty. Besides, conditional variance reacts more to past positive shocks than to negative innovations of equal size.

Keywords: Exchange rate, dollarization, currency substitution, inflation, exponential GARCH models, conditional variance, leverage effect, Turkish economy

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I. INTRODUCTION

One of the salient characteristics of high inflation countries is that economic agents tend to increase to a great extent switch from holding of domestic currency to the foreign currencies as a means of exchange or as a store of value in line with the precautionary motive to demand

for money. As Choudhry (1995) expresses, demand for exchange rate alternative to holding real money balances in domestic currency may provide evidence of currency substitution in high inflation countries, which reduces domestic monetary control as well as base for inflation tax. Thus, due to the lack of foreseeing future courses of domestic economy, increasing demand for exchange rate as a hard currency ensures that economic agents can hedge somewhat the real value of their wealth against high depreciation of real money stocks under a chronic or high inflationary framework, which in turn increases dollarization of the economy such as Turkey, subject to inflationary pressures over a two-decades period.

When considered with a highly instable real income growth process dominated in the Turkish economy by the late-1980s and whole 1990s, the Turkish economy witnessed that a substantial currency substitution phenomenon dominated the course of domestic financial system. Beginning by the liberalization of foreign currency holdings in 1983 and of foreign currency controls in 1989, Turkish currency depreciated in considerable amount that led the domestic residents to increase foreign currency holdings in their financial wealths rather than to demand for domestic currency or assets. This phenomenon accelerates especially for the post-1992/93 period in the sense that the ratio of foreign exchange deposits in the whole financial system represented by the sum of currency in circulation plus domestic currency-based demand and time deposits and also foreign exchange deposits is above 40% till the end of 2004, and in some sub-periods such as April-1994 and post-February 2001 economic crises, exceeds 50% with an increased volatility in financial crisis periods. And such a structural change in the economy may easily raise some questions about the stability of the whole financial system (Koğar, 1995).[1]

Many papers emphasize the importance of currency substitution on the Turkish economy.[2] Selçuk (1994) finds that domestic residents have a preference for substituting foreign currencies for domestic currency because of real exchange rate depreciations, and that a policy aiming to increase the expected real return on domestic assets is required for reversing this process. Likewise, Selçuk (1997) reveals that the share of foreign balances in the production of money services in Turkey is quite high and that foreign exchange deposits are

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[1] See Ertuğrul and Selçuk (2002) for an overview of the Turkish economy for the post-1980 period.
[2] Giovannini and Turtelboom (1992), Yılmaz (2005) and Civcir (2005) touch on the difference between the terms dollarization and currency substitution in the sense that in high inflation countries foreign currency is first used as a store of value or unit of account representing dollarization and only at the later used as a medium of exchange. That is, currency substitution is the last stage of the dollarization process.

strong substitute for the Turkish Lira. Alçay et al. (1997) examine the extent of currency substitution and its effects on exchange rate instability and find evidence in favor of that exchange rate instability increases with the degree of currency substitution. Also Şıklar (1998), Selçuk (2002) and Soydan (2003) try to estimate the effect of currency substitution on seigniorage revenue for the Turkish economy. Bahmani-Oskooee and Domaç (2002) investigate the role of dollarization in the dynamics of inflation such as monetary base and administered prices. Civcir (2005) finds interest rate differential and the expected exchange rates as the dominant factors in determining dollarization.[3] Thus many different aspects of currency substitution have been tried to be explored empirically on the Turkish economy.

In this paper, our aim is to shed some light upon the possible effect of currency substitution on exchange rate uncertainty such as Akçay et al. (1997), but by extending the time period till the end of 2006 as well as employing a sensitivity analysis considering two different time periods subject to structural changes in the Turkish economy. The next section highlights the methodological issues in estimation process. Section III tries to construct an empirical model upon the Turkish economy, while section IV is devoted to sensitivity analysis of the empirical findings to some sub-periods in line with structural changes in the Turkish economy. And the final section concludes.

II. METHODOLOGY

The traditional generalized ARCH (GARCH) methodology of Bollerslev (1986) and its more recent variants such as treshold GARCH (TARCH) proposed by Zakoïan (1994) and Glosten et al. (1993), exponential GARCH proposed by Nelson (1991), power ARCH (PARCH) generalized in Ding et al. (1993) and also component GARCH (CGARCH) models have been widely used in economics literature to measure the volatility pattern of financial time series or to proxy the uncertainty in economic modeling. In our paper, we apply to a similar methodology to Domaç and Mendoza (2004) employing EGARCH methodology on Turkish financial time series and aim at revealing the information content of volatility on exchange rate uncertainty conditional on a proxy for currency substitution in variance equation.

Following QMS (2004), the specification for conditional variance in EGARCH model is,

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[3] An extensive theoretical and empirical literature on currency substitution can be found in Calvo and Végh (1992) and Giovannini and Turtelboom (1992).

$$\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{i=1}^{p} \alpha_i \left| (\varepsilon_{t-i}) / (\sigma_{t-i}) \right| + \sum_{k=1}^{r} \gamma_k [(\varepsilon_{t-k}) / (\sigma_{t-k})] \tag{1}$$

for which σ_t^2 gives the forecast variance based on past information, and is called the conditional variance. This implies that the leverage effect allowing the variance to respond differently following equal magnitude negative or positive shocks is exponential, rather than quadratic, and that forecasts of the conditional variance are guaranteed to be nonnegative. The impact would be asymmetric if $\gamma_i \neq 0$. There are a couple of differences between the EViews specification of the EGARCH model used in this paper and the original Nelson model. First, Nelson assumes that error term from mean equation, ε_t, follows a Generalized Error Distribution (GED), while EViews gives a choice of normal, Student's t-distribution, or GED. Second, Nelson's specification for the log conditional variance is a restricted version of:

$$\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{i=1}^{p} \alpha_i \left\| (\varepsilon_{t-i}) / (\sigma_{t-i}) - E[(\varepsilon_{t-i}) / (\sigma_{t-i})] \right\| + \sum_{k=1}^{r} \gamma_k [(\varepsilon_{t-k}) / (\sigma_{t-k})] \tag{2}$$

which differs slightly from the specification above. Estimating this model will yield identical estimates to those reported by EViews except for the intercept term ω, which will differ in a manner that depends upon the distributional assumption and the order p. Also to deal with potential model misspecification, we have calculated robust t-ratios using the quasi maximum likelihood method suggested by Bollerslev and Wooldridge (1992) so that parameter estimates will be unchanged but the the estimated covariance matrix will be altered.

III. ESTIMATION RESULTS

Following these model specification issues, we use the exchange rate depreciation of the log difference form (E), i.e., TL/US$ in first differences, in mean equation of the EGARCH specification for empirical purposes, and the whole time period consists of monthly observations beginning from 1987M01 till 2006M12 considering 239 observations, while 1987M01-1999M12 and 2001M03-2006M12 sub-periods will also be taken into account below for sensitivity analysis. Since the GARCH methodology requires stationary variables to employ regression analysis, we performed some preliminary unit root tests, and the results indicated that the TL/US$ exchange rate is I(1), whereas the first differenced form leads us to

that exchange rate return ensures the stationarity required for regression analysis.[4] Descriptive statistics not reported here reveal that exchange rate series considered have a symmetric distribution around its mean through skewness statistics. Besides, there exists a normal kurtosis verifying the flatness of the distribution of the series under normal distribution.[5]

To find the possible effect of the currency substitution on exchange rate uncertainty, we include a proxy for currency substitution in the variance equation of the EGARCH model specification. For this purpose, we use the ratio of foreign exchange based accounts to the sum of currency in circulation plus domestic demand and time deposits (DOL), i.e., M2 monetary aggregate, in the Turkish financial system. We choose the autoregressive order of the exchange rate series considered by applying to lag information criterions of the unrestricted vector autoregression models conditional on the series itself as endogenous variable. All five information criterions, i.e. Sequential Modified Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion and Hannan-Quinn Information Criterion, suggest 1 lag order for the whole period 1987M01-2006M12 and for the sub-period 1987M01-1999M12 periods, while LR and SC statistics suggest 1, FPE and AIC statistics suggest 3 and HQ statistics suggest 2 lag orders for the sub-period 2001M03-2006M12.

Following these model specification issues, we try to estimate the EGARCH-M model of the exchange rate letting also conditional variance affect the mean equation. For this purpose, we give the EViews 5.1 output of the estimated mean and variance equations in Table 1 below.

EGARCH estimation results reveal that no significant effect of conditional variance on the mean equation can be detected. Autoregressive coefficient indicates a positive effect on the mean level of exchange rate return. We estimate in Table 1 that EGARCH parameter, which measures the degree of how persistent is the volatility shocks, is statistically significant and seems to be persistent so that the forecasts of the conditional variance converge to the steady state somewhat slowly. The leverage effect term, γ, denoted as C(6)*RESID(-1)/@SQRT(GARCH(-1)) in the output, is positive and statistically different from zero indicating that the news impact is asymmetric, thus, the existence of the leverage effect during

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[4] The ADF *t*-statistic is -2.21 (-9.28) assuming only constant and 0.78 (-9.69) assuming both constant and trend terms in the test equation, of which the differenced values are in parentheses. The relevant 5% test critical values are -2.87 and -3.43, respectively, under the null of a unit root.
[5] These estimation results not reported here to save space are available from the authors upon request.

TABLE 1: EGARCH ESTIMATION RESULTS (1987M01-2006M12)

Dependent Variable: E

Method: ML-ARCH (Marquardt) - Normal Distribution

Sample (adjusted): 1987M03 2006M12

Included observations: 238 after adjustments

Bollerslev-Wooldridge robust standard errors & covariance

Variance backcast: ON

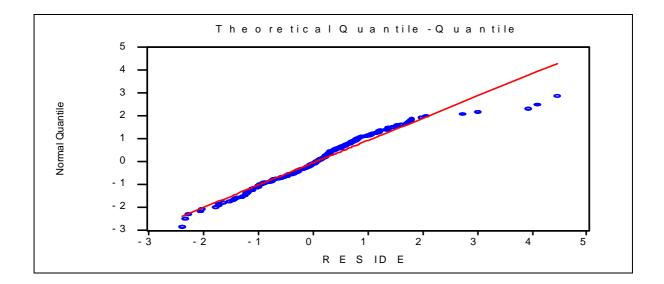$\text{LOG(GARCH)} = C(4) + C(5)*\text{ABS(RESID(-1)/@SQRT(GARCH(-1)))} +$
$\quad C(6)*\text{RESID(-1)/@SQRT(GARCH(-1))} + C(7)*\text{LOG(GARCH(-1))} + C(8)*\text{DOL}$

	Coefficient	Std.Error	z-Statistic	Prob.
GARCH	-1.875526	1.508739	-1.243109	0.2138
C	0.012551	0.002370	5.296331	0.0000
E(-1)	0.629374	0.060026	10.48503	0.0000
Variance Equation				
C(4)	-3.974391	0.912934	-4.353426	0.0000
C(5)	0.766682	0.139570	5.493159	0.0000
C(6)	0.306509	0.123854	2.474754	0.0133
C(7)	0.613066	0.100270	6.114138	0.0000
C(8)	0.858249	0.367445	2.335717	0.0195
AIC	-4.386020			
SC	-4.269305			

$Q(1) = 1.29\ (0.26),\ Q(12) = 13.46\ (0.34),\ Q^2(1) = 0.09\ (0.76),\ Q^2(12) = 0.97\ (0.99)$

ARCH LM(12)

F-statistic	0.065764	Prob. F(12,213)	0.999
Obs*R-squared	0.834241	Prob. Chi-Square(12)	0.999

the sample period. The positive and significant coefficient of the proxy used for currency substitution supports the findings of Akçay et al. (1997) in the sense that the higher the currency substitution the higher is the uncertainty attributed to the exchange rate return. Dealing with diagnostics where probs. are given in parentheses, correlogram-Q statistics for the presence of autocorrelation in the standardized residuals and in the squares of standardized residuals cannot reject the null at conventional levels in the sense that no remaining serial correlation in the mean equation is detected.

One way of further examining the distribution of the standardized residuals is to plot the quantiles. If the residuals are normally distributed, the points in the Quantile-Quantile (QQ) plots should lie alongside a straight line. We see below in Figure 1 that it is primarily large positive shocks that are driving the departure from normality:

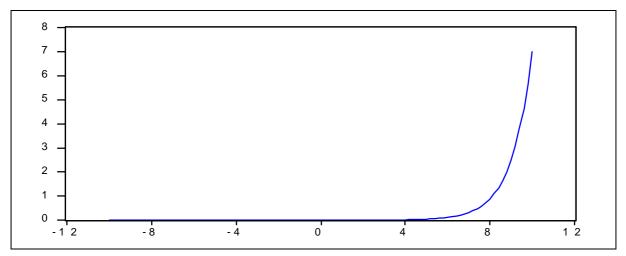FIGURE 1: QUANTILE-QUANTILE GRAPH

Having established the EGARCH model for the whole period considered, we now plot the News Impact Curve (NIC) using EViews 5.1. Our goal is here to plot the volatility σ^2, against the impact $z = \varepsilon / \sigma$, where:

$$\log \sigma_t^2 = \omega + \hat{\beta} \log \sigma_{t-1}^2 + \hat{\alpha} \left| z_{t-1} \right| + \hat{\gamma} z_{t-1} \tag{3}$$

We will fix last period's volatility σ_{t-1}^2 to the median of the estimated conditional variance series and estimate the one-period impact, conditional on last period's volatility. Below is shown the NIC of inflation in Figure 2.

An asymmetric leverage effect can easily be noticed in Figure 2 supporting the estimation results in Table 1 above. We can here conclude that the conditional variance reacts more to past positive shocks than to negative innovations of equal size.

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FIGURE 2: NEWS IMPACT CURVE

IV. SENSITIVITY ANALYSIS

We now conduct some robustness tests to the empirical analysis above and try to find whether estimation results in Table 1 can be supported using the data in sub-periods. For this purpose, the first sub-period consists of the data from 1987M01-1999M12, and the second sub-period from 2001M03-2006M12. We have excluded the period of 2000 anti-inflationary stabilization program and the subsequent two crises periods from the analysis for they constitute a structural break point in the Turkish economy, which cannot be fully reconciled with any of the two periods expressed above. Regression results can be seen in Table 2 and Table 3 below.

Our findings from both sub-periods verify the estimates of the whole period. For 1987M01-1999M12, one-period lagged autoregressive coefficient in the mean equation is positive and statistically significant, while it loses it significance for the latter sub-period. EGARCH and leverage parameters follow the characteristics from the main period revealing again that past positive shocks affect the conditional variance predominantly. Supporting the above findings, currency substitution leads to more uncertainty for the exchange rate return. Both sub-periods have good diagnostics, as well.

TABLE 2: EGARCH ESTIMATION RESULTS (1987M01-1999M12)

Dependent Variable: E

Method: ML-ARCH (Marquardt) - Normal Distribution

Sample (adjusted): 1987M03 1999M12

Included observations: 154 after adjustments

Bollerslev-Wooldridge robust standard errors & covariance

$LOG(GARCH)= C(4) + C(5)*ABS(RESID(-1)/@SQRT(GARCH(-1))) +$

$C(6)*RESID(-1)/@SQRT(GARCH(-1)) + C(7)*LOG(GARCH(-1)) + C(8)*DOL$

	Coefficient	Std.Error	z-Statistic	Prob.
GARCH	-1.566835	5.347698	-0.292992	0.7695
C	0.011622	0.002341	4.965474	0.0000
E(-1)	0.721554	0.080542	8.958682	0.0000
Variance Equation				
C(4)	-3.522193	1.247329	-2.823788	0.0047
C(5)	0.364788	0.162283	2.247860	0.0246
C(6)	0.559030	0.113914	4.907478	0.0000
C(7)	0.624206	0.140311	4.448720	0.0000
C(8)	0.518190	0.272113	1.904318	0.0569
AIC	-4.842810			
SC	-4.685046			

$Q(1) = 0.03 (0.87), Q(12) = 6.39 (0.90), Q^2(1) = 0.44 (0.51), Q^2(12) = 2.31 (0.99)$

ARCH LM(12)

F-statistic	0.164059	Prob. F(12,129)	0.999
Obs*R-squared	2.134532	Prob. Chi-Square(12)	0.999

TABLE 3: EGARCH ESTIMATION RESULTS (2001M03-2006M12)

Dependent Variable: E

Method: ML-ARCH (Marquardt) - Normal Distribution

Sample (adjusted): 2001M03 2006M12

Included observations: 70 after adjustments

Bollerslev-Wooldridge robust standard errors & covariance

LOG(GARCH)= C(4) + C(5)*ABS(RESID(-1)/@SQRT(GARCH(-1))) +

   C(6)*RESID(-1)/@SQRT(GARCH(-1)) + C(7)*LOG(GARCH(-1)) + C(8)*DOL

	Coefficient	Std.Error	z-Statistic	Prob.
GARCH	17.70521	4.607933	3.842333	0.0001
C	-0.021604	0.005741	-3.763330	0.0002
E(-1)	0.024821	0.171049	0.145108	0.8846
Variance Equation				
C(4)	-3.611782	0.774249	-4.664887	0.0000
C(5)	0.304720	0.131849	2.311120	0.0208
C(6)	0.544371	0.100579	5.412350	0.0000
C(7)	0.592919	0.100241	5.914906	0.0000
C(8)	0.742125	0.362967	2.044608	0.0409
AIC	-3.532852			
SC	-3.275881			

$Q(1) = 1.21 \ (0.27), \ Q(12) = 14.66 \ (0.26), \ Q^2(1) = 0.15 \ (0.70), \ Q^2(12) = 13.81 \ (0.31)$

ARCH LM(12)

F-statistic	0.958950	Prob. F(12,45)	0.500
Obs*R-squared	11.81136	Prob. Chi-Square(12)	0.461

IV. CONCLUSION

In this paper, we try to investigate whether the currency substitution can affect the exchange rate uncertainty for the Turkish economy. Considering the whole time period 1987M1-2006M12 as well as the sub-periods 1987M01-1999M12 and 2001M03-2006M12 with quarterly observations, we apply to the contemporaneous exponential GARCH (EGARCH) methodology to bring out the volatility component of the TL/US$ exchange rate, allowing the variance to respond differently following equal magnitude negative or positive shocks. Our findings indicate that for all the periods considered, the higher the currency substitution the

higher is the uncertainty attributed to the exchange rate return. Besides, conditional variance reacts more to past positive shocks than to negative innovations of equal size.

Complementary papers as future researches employing more recent developments in contemporaneous estimation techniques will also help reserchers confirm whether the estimation results in this paper are in fact of the stylized facts for the Turkish economy.

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