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**Article**

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# Impact of Reserve Option Mechanism on Exchange Rate Volatility During the FED's Tapering Period

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**Abstract**: This study investigates the effectiveness of ROM. We conducted the GARCH (1,1) Model to determine whether ROM contributed to decreasing the volatility of USD/TL exchange rate for the period 2013- 2014. We construct four Models where four different variables are separately used that represent the ROM tool, i.e. the amount of FX reserves of CBRT via ROM, and the share of the FX reserves via ROM in Gross FX Reserves of CBRT. Our findings are convincing to say FX facility and the ratio of utilization for the FX facility to ensure the results are statistically meaningful during this period.

**Keywords**: Reserve Options Mechanism, Exchange Rate Volatility, Turkish Lira, Tapering, GARCH.

**JEL Classification:** E58, F31. E40, E43.

## 1. Introduction

After the 2007 financial crisis, there were abundant capital flows into the emerging markets due to central banks' expansionary monetary policy operations. This expansionary approach was intensively performed in a number of countries due to being a vital part of the global financial crisis either by hosting mortgage market in their economies or having a market for several securities derived from this market, e.g. Mortgage-Backed Securities (MBS), or Collateralized Debt Obligations (CDO). An unexpected economic ravage experienced by the U.S. economy

in terms of unemployment, inflation and unthinkable bankruptcy of financial institutions caused FED authority to perform an unprecedented quantitative easing after the collapse of Lehman Brother (Demirbas, 2013).

The recent global financial crisis was an important milestone for central banks to commence extraordinary expansionary monetary policy operations to respond to contagious economic destruction. This expansionary approach was intensively performed in a number of countries due to being a vital part of the global financial crisis either by hosting mortgage market in their economies or having a market for a number of securities derived from this market, e.g. Mortgage-Backed Securities (MBS), or Collateralized Debt Obligations (CDO).

The economy of the United States was calamitously affected by the crisis as it accounts for the largest volume for securitized debt in the world. Unexpected economic ravage in the U.S. triggered a higher unemployment rate, lower production, and unthinkable bankruptcies of financial institutions (Demirbas, 2013). After the Lehman shock in 2008, many central banks in industrialized countries introduced the quantitative easing (Q.E.) program that allows central banks to expand their balance sheets and excess reserves drastically (Tanaka, 2020). Soon after the unexpected predicament in the shadow banking system, the Fed also introduced the Q.E. program which involves large assets scale purchases and induced substantial influence on the amount of the Fed's balance sheet. The first Q.E. program aimed to purchase some selected securities. Current economic conditions made the Fed commence the second Q.E. following the developments in October 2010. In addition to this, the Fed also started another program called Operation Twist that aimed to buy long term governments bonds and to sell some of its short term bonds in September 2011 (Gertler and Karadi, 2012). The Fed announced QE3 program in September 2012. But it was slightly different from previous programs as the targeted end date and targeted total purchase were not given for this unconventional monetary policy (Rosengren, 2015). Mentioned Q.E. programs that aimed to spur economic activities by decreasing interest rates in a long run as the interest rate of a short run stuck to zero lower bound (Bhattarai, Chatterjee and Park, 2018).

Therefore unleashed capital movements by Q.E. programs and zeroed lower bound triggered inner loan surge and paved way to a substantial increase in Turkish Lira's value. This undesired condition exacerbated foreign trade balance and current account balance (Kara, 2012). Apart from Q.E. programs, Federal Reserve's tapering program announced at the end of 2013, also caused a sharp swing in emerging market capital flows (Goldberg and Krogstrup, 2018). Turkish Lira also experienced sharp depreciations (Díez, 2014; Benlialper and Cömert, 2015).

This study investigates the effect of ROM on the fluctuation of the Turkish Lira by using the GARCH framework. The major issues that we argue in this analysis are "Is the implementation of ROM effective during the tapering period?", and "Does the efficacy of ROM differ between Q.E. programs and tapering period?" One of the novel features of this study is that the effect of ROM is specifically studied during the tapering period. Even though there are numerous works that analyse the power of ROM on economic stability, to our knowledge, this is the first empirical research investigating the efficacy of the ROM on the volatility of Turkish Lira (TL) during the tapering period. Related literature is inherently confined to capital inflow periods, but their timeframes are not specifically structured by considering FED's Q.E. programs, and mostly overlap between QE1, 2 and 3 programmes including Oduncu Akcelik and Ermişoğlu (2013b) and Değerli and Fendoğlu (2013).[1]

Furthermore, a number of studies postulate that ROM is superior to sterilized intervention and FX reserve requirements. It also has the potential to act as an automatic stabilizer against capital flow volatility. This policy tool not only curtails the demand for a large interest rate path in terms of alleviating exchange rate fluctuation but also works as a complementary tool with interest rate corridor (Küçüksaraç and Özel, 2012; Alper, Kara and Yörükoğlu, 2013a; Alper et al. 2013b; Oduncu, Ermişoğlu and Polat,2013c; Aslaner, Çıplak, Kara and Küçüksaraç, 2015; Kara and Ekinci, 2018).

Aysan, Fendoğlu and Kılınç, (2014) contribute Alper et al. (2013a), Alper et al. (2013b), Küçüksaraç and Özel (2012), Oduncu et al. (2013c), Aslaner et al. (2015) and Kara and Ekinci (2018) by empirically and comparatively testing the efficiency of interest rate path and reserve option mechanism with a group of countries. Değerliand Fendoğlu (2015) distinctively decouple from previous studies by incorporating the sensitivity of USD/TL exchange rate expectations and volatility of USD/TL expectations. Results of the study show that ROM is a novel unconventional policy tool that lower both expectations and shows up to be a self-stabilizer of assumptions about huge changes of the USD/TL exchange rate. Altuntaş (2018) differs from previous studies by emphasizing the impact duration of ROM on selected indicators. It reveals that even though this duration is short, ROM can still be facilitated as a means of transition in achieving cost and financial balance.

Similar to the above studies' findings on the effectiveness of the ROM, Aytug (2016) stated that the ROM was effective before May 2013. Using a new micro

[1] For example the start date of the CBRT's policy of zero remuneration on needed reserves is selected as a beginning of data set in some studies including Oduncu et al. (2013b) and Değerli and Fendoğlu (2015).

econometric technique entitled Synthetic Control Method, Aytug indicated that ROM was ineffective after tapering program and the fluctuation of the exchange rate was not balanced during this time.

This study, on the other hand, distinguishes the effectiveness of ROM from a comparative perspective. It provides insight into whether the mechanism's efficacy differs between Q.E. and tapering periods by comparing the findings with previous studies. Furthermore, the study contributes the existing literature such as Küçüksaraç and Özel (2012), Alper et al. (2013a), Alper et al. (2013b), Oduncu et al. (2013c), Aslaner et al. (2015), and Kara and Ekinci, (2018) empirically by providing empirical evidence on effectiveness. Furthermore, it contributes to the Aytug (2016) findings by giving similar results with the GARCH Model.

The rest of the paper is organized as follows: Chapter 2 gives information on Turkey's capital flows after the 2008 crisis. Chapter 3 discusses the new monetary policy frame and Reserve Option Mechanism-ROM. Chapter 4 explains the methodology of the study, while chapter 5 is about the description of data. Chapter 6 unveils the empirical results of the study, and in the final part, the conclusion is posed along with suggestions for future works.

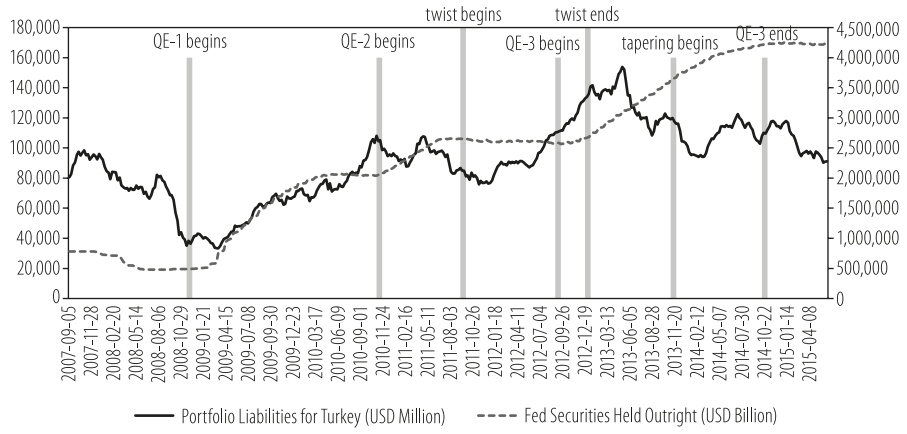
## 2. Capital Flows to Turkey after the 2008 Crisis

The 2008 financial crisis in the US is one of the examples of the change of global economic condition impacting on the global economy (Mukhlis, Hidayah and Retnasih, 2020). For example, the Fed's intention to lower the Federal Funds Rate, and keep it under 0.2% between 2009 and 2015 as a response to the crisis, caused investors to look for higher EME returns (Lin et al. 2018). In addition to this shift, consequences of Lehman's bankruptcy in the financial system, and the Fed's new Q.E. programs have shifted the pattern of U.S. procurement of financial assets. According to the U.S. International Transactions Data (U.S. Bureau of Economic Analysis), the proportion of Asia and Pacific in the net U.S. gains of financial assets excluding financial derivatives was 41% in 2009 and this ratio increased to 51.7% and 66.7% in 2012 and 2015 respectively. Aggravating economic conditions caused a large increase in the Fed's assets via Q.E. programs. Large assets scale purchases can be traced under the Securities Held Outright in the Fed's Balance Sheet. The Fed's assets under Securities Held Outright were tripled between September 2008 and September 2009 by reaching 1.6 trillion U.S. dollar. At the end of the Q.E. 1 period, the balance sheet was four times its value in September 2008. These multipliers were 5.2 and 7.1 for QE2 and QE3 periods respectively (Fed, Factors Affecting Reserve Balances (H.4.1)).

International capital flows have consequences on the real and financial volatilities across countries, and macroeconomic indicators. But, it creates challenges for the monetary authorities where the capital flows in to ensure financial stability in their domestic economies (Rumondor and Bary, 2020). The tremendous growth in the Fed's balance also led to an abundance of global liquidity by spilling mostly over to emerging market economies. It strongly increased emerging markets' capital inflows, and equity prices also caused the appreciation of emerging market currencies, and reduced bond spreads (Tillmann, 2016). This abundant capital flows into the emerging market economies induced a decline in long-term bond profits, and stock market boost within these countries. These findings are similar for a group of nations known as the Fragile Five, including Brazil, India, Indonesia, Turkey, and South Africa (Bhattarai et al. 2018).

The Turkish Government or private sectors' securities are very appealing for foreign investors due to the tremendous gap at interest rate differential between Turkey and their home countries. Being too dependent on swinging foreign investment makes the Turkish economy more vulnerable to the undesired amount of short term international capital movements. The relationship is plotted between portfolio liabilities for Turkey and Fed Securities Held Outright in Figure 1. A positive correlation between portfolio liabilities for Turkey and Fed Securities Held Outright is found during the Q.E. programmes.[2]

**Fig. 1: Fed Securities Held Outright and Portfolio Liabilities for Turkey (Million USD)**

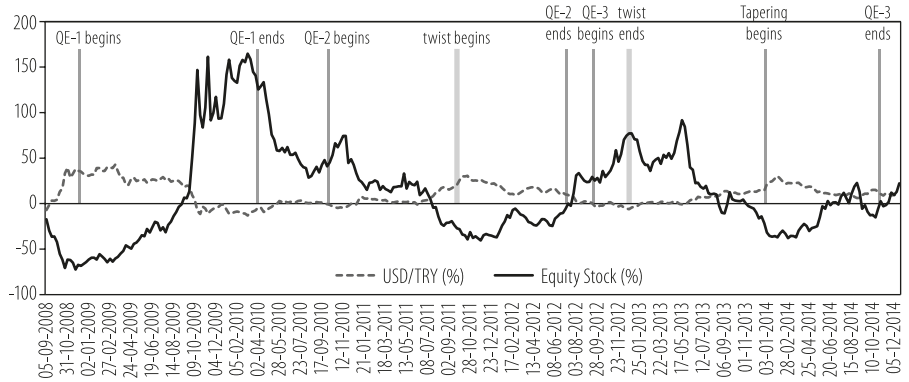



Source: Authors' construction using the data delivery system (EVDS Database) of CBRT, Data Download Program of FED, 2020

[2] The figure showing thecorrelation between portfolio liabilities for Turkey and Fed Securities Held Outright is presented in the appendix (Fig. A.1.)

As illustrated in Fig. 2., the Turkish economy experienced sharp swings in capital movements after the announcements of Q.E. programs and tapering by the Fed and substantial changes in the Turkish Lira's value. It also reveals the yearly change for the Government Domestic Debt Securities (GDDS) Stock issued by the Republic of Turkey`s Ministry of Treasury and Finance and Equity Stock held by non-residents with the U.S. Dollar buying rate. An increase in USD/TL represents depreciation of the Turkish Lira against the U.S. Dollar. Data for the year to year percentage change for all series unveils a negative correlation between equity stock held by non-residents and the U.S. Dollar buying rate in Turkey[3].

**Fig. 2: Equity Stock Held by Foreigners and U.S. Dollar/TRY (Yearly %)**




Source: Authors' construction using the data delivery system (EVDS Database) of CBRT, Data Download Program of FED, 2020

## 3. New Monetary Policy Frame and Reserve Option Mechanism-ROM

Expansionary financial actions appealed by central banks in developed countries after the 2008 mortgage crisis, substantially increased the capital flows to Turkey as much as other emerging economies (Keskin, 2018). The dozens of central banks had authority for financial balance further their cost stability mandate (Klomp and De Haan, 2009). As a result of this, Central Banks initiated alternative monetary policy approaches not just to maintain price stability but also financial stability in their countries (Keskin, 2018).

[3] The figure showing the correlatio nbetween equity stock held by non-residents and the US Dollar buying rate in Turkey is presented in the appendix (Fig. A.2.)

The Central Bank of the Republic of Turkey (CBRT) has initiated and implemented various money tools to compensate for the augmentation impacts of short-term capital flows after the 2008 crisis. For example, CBT has planned and carried out a new structure that considers macrofinancial risks from the end of 2010 (Başcı, 2013). The new structure deals with financial stability as an auxiliary goal without prejudice to cost balance (CBRT, 2013). Therein, the total capacity of inflation aiming was improved, and financial stability was applied as an auxiliary objective. The new policy mix followed the collective adoption of the interest rate path between interim borrowing and lending rates, liquidity policies and demanded funds besides short-term policy rates (Kara, 2012).The surge in loan and reel exchange rate are closely audited under this new approach as the main indexes for financial stability on top of coat balance (Oduncu et al., 2013c).

The analyses conducted throughout the previous papers suggest that the new policy framework effectively contributed to financial stability. For example, Ermişoğlu, Akçelik, Oduncu and Taşkın (2013) argued that the extra monetary constricting by the CBRT had an important role in the decline of fluctuation in the exchange rate and appreciating the Turkish Lira against the rising market currencies. Oduncu et al. (2013c) found out that the new structure of monetary policy that incorporates interest rate path, the strategy of liquidity funding, and demanded funds after 2010 contributed to Turkey's financial stability by lessening the credit growth volatility.

Additional policy means were enhanced to obtain numerous objectives. For example, Reserve Option Mechanism-ROM was added to this policy mix in September 2011. Employing the tools, the CBRT eventually points at influencing price stability and financial stability (Kara, 2012). ROM seeks to the FX reserve executive of the banking system to increase FX reserves of CBRT and limit the negative outcome of abundant capital flow fluctuation on Turkey's macroeconomic and financial stability of Turkey (Oduncu et al., 2013a). This new policy tool is designed to reduce the negative outcome of the extra fluctuation in capital movements on the macroeconomic and financial stability (CBRT, 2013) by favouring banks to easily have a particular cut of their necessary reserve conditions for the Turkish lira liabilities in a foreign currency, either U.S. dollars, euros, or gold in increasing tranches since the end of 2011 (Uysal, 2017; Oduncu et al., 2013b). ROM is mainly planned as an "automatic stabilizer "that enables banks to modify the application rates of reserve option against foreign shocks such as capital flows by granting the flexibileness to Turkish banks adjusting their FX reserves endogenously with their liquidity demands. As ROM facilitates banks to optimize, it is considered superior to other FX liquidity management (Oduncu et al., 2013b; CBT, 2013).

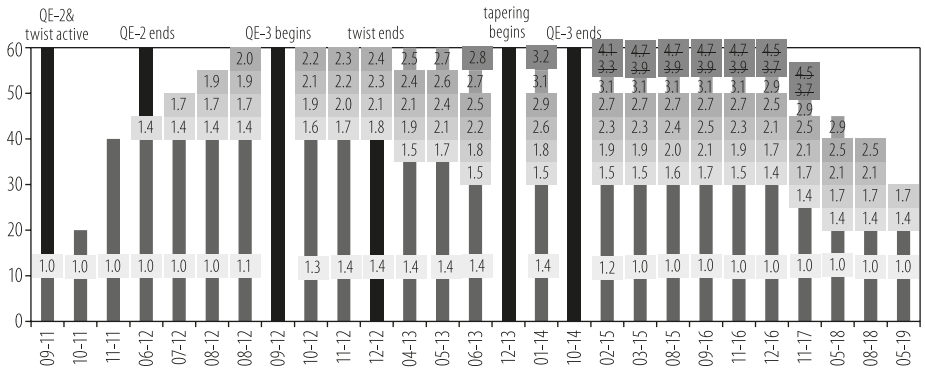
The maximum fraction of T.L. required reserves held in FX or standard gold is set by the Reserve Option Ratio (ROR) (CBRT, 2012). The amount of FX or traditional gold that can be held per unit of T.L. is called the Reserve Option Coefficient (ROC). For example, if the ROC is 2, banks must hold 2 T.L. worth of foreign currency or gold per 1 T.L. reserve demand if they like to apply the ROM facility (Aslaner et al., 2015).

The system is built up such that the ROC enlarges in line with the application of the reserve option. Thus, to facilitate application, the ROR and related ROCs were broken down into 5 percent-individual tranches above a certain level. (CBRT, 2012).The threshold ROC is increased during periods of abundant capital inflows that encourages banks to employ the ROM facility more effectively. Therefore, higher capital inflows result in higher withdrawal of the increased FX liquidity via the ROM (CBRT, 2012).

Initially, the upper limit for one-to-one FX reserves that might be kept to sustain Turkish lira reserve requirements were set at 10% in September 2011 (Oduncu et al., 2013a). For empowering the ROM's automatic stabilizing feature, support the FX liquidity needed by the financial sector, the CBRT changes the upper limit of FX facilities and reserve option (CBRT, 2017). During the abundant capital flows the CBRT increased the reserve option ratio and reserve option coefficients constantly to protect the banking system from additional economic shocks by putting increasing ROCs for each new tranches of the reserve option ratio (Aslaner et al., 2015). For example, the upper limit of FX facilities was incrementally increased to 60% in August 2012 from 40% in November 2011 during the twist programme. Moreover, the CBRT added new tranches of the reserve option ratio and increased the corresponding ROC's during the QE-3 programme. They were making adjustments of ROR and ROC's have increased the FX reserves of the CBRT to 40 billion USD that equals to 61% of the securities held by non-residents as of July 2014.

However. during the periods of low capital inflows, the CBRT aimed to support foreign liquidity to the financial structure by making a necessary adjustment in ROR and ROC.As illustrated in Fig. 3, the new tranches and the corresponding reserve option coefficients (ROCs) have been revised at the time (CBRT, 2015). For example, the ROR and related ROCs were divided into 1 percent-individual tranches above 55% threshold in February 2015 as a response to low capital flows that had fallen since the end of QE-3 programme, while the upper limit left unchanged until late 2017. Since then, the number of tranches has been decreased, and the upper limit for the FX maintenance facility has been constantly dropping from 55 percent to 30 percent (CBRT, 2019).

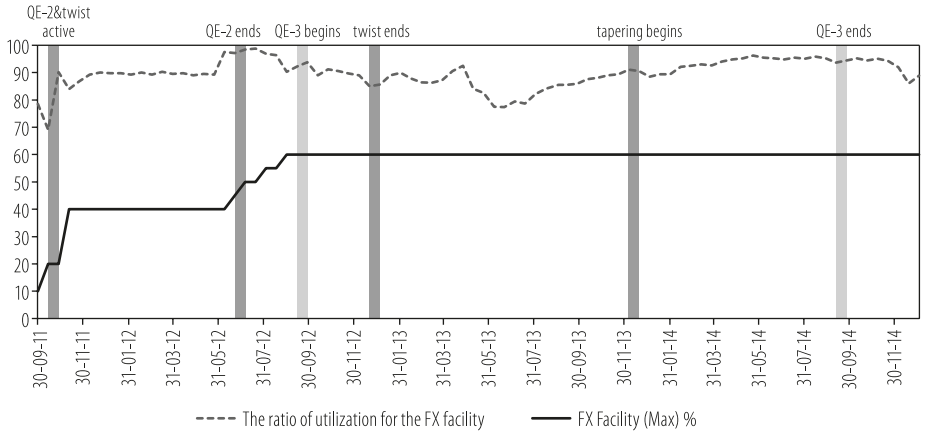
**Fig. 3: Reserve Option Coefficients for Reserve Requirements Held as FX**




Source: Authors' construction using CBRT's Press Releases, 2020

Banks and financing companies continue to employ the CBRT's ROM facility. The ratio of utilization for the FX facility was the highest during the QE-2 and twist operation programmes with 97 percent. After falling to 77 percent during the QE-3 programme, the ratio moderately increased during the tapering period. Moreover, the average ratio of utilization for the FX facility was the highest during the tapering period with 93 percent. In contrast, this ratio was 89 percent for QE-2, twist operation, and QE-3 periods (Fig. 4).

**Fig. 4: The ratio of utilization of ROM's FX Facility (%) during the Q.E. programmes**




Source: Authors' construction using the data delivery system (EVDS Database) of CBRT, 2020.

Like other emerging economies, Turkey received abundant capital inflows during the post-crisis period (Ramírez and González, 2017). Launching ROM created an unprecedented opportunity for CBRT to deploy its FX reserves during the Q.E. programmes that induced the banks to apply the ROM facility more thoroughly by decreasing external borrowing costs. CBRT's impact on deploying FX reserves can also be observed by analysing the nexus between securities portfolio of non-residents4 in Turkey and FX reserves accumulated via ROM. As expected, a very strong positive correlation is spotted between these two variables (See Fig. A.3.). FX ROM continuously increased along with the escalating amount of securities portfolio of non-residents during the Q.E. programmes. FX's value for Turkish lira liabilities within the ROM was about $15 billion by the end of QE-2, climbing to about $28 billion, and reaching its peak before the end of QE-3 programme that equals to 36% of securities portfolio of non-residents. After the end of the QE-3 programme, the amount of FX reserves kept in place of Turkish lira reserve demands continuously fell to 2.7 billion in December 2019 from 37 billion in October 2014 (See Fig. A.4).

## 4. Methodology

The GARCH model was developed by Bollerslev (1986) from the Autoregressive Conditional Heteroskedastic (ARCH) model announced by Engle (1982). ARCH Model process conditional variance is designated as a linear function of past sample variances only, whereas the Bollerslev`s GARCH process permits delayed conditional variances to enter as well. In other words, Generalized ARCH (GARCH) Model allows $\sigma_t^2$ to have an additional autoregressive structure within ARCH Model.

GARCH (1,1) Model specification is easier to estimate and performs well as it requires to estimate three unknown parameters as follows $\alpha_0$, $\alpha_1$ and $\alpha_2$. GARCH (1,1) Model can be extended to a GARCH($p$,$q$) model offered by Bollerslev is illustrated as follows:

$$y_t = \beta X_t + \varepsilon_t \tag{1.a}$$

$$\varepsilon_t | \phi_{t-1} \sim \mathrm{N}(0, h_t) \tag{1.b}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_i h_{t-j} \tag{1.c}$$

[4] Securities portfolio of non-residents equals to sum of Equity Stock and Government Domestic Debt Securities (GDDS).

where $\phi_{t-1}$ denotes the information set at time t-1 on which the distribution of the errors is assumed to be conditioned. $\varepsilon_t$ is the error term of the mean Equation, assumed to has an ordinary allocation with zero mean and a time-varying conditional variance.

$p \geq 0$ , $q > 0$

$\alpha_0 > 0$, $\alpha_i \geq 0$ $i=1,\ldots,q$,

$\beta_j \geq 0$, $j=1,\ldots,p$.

Equation (1.c) is known as the variance equation where $h_t$ is known as the conditional variance or variance of residual derived from Equation (1.a). It explains whether conditional variance ($h_t$) at time t depends both on the past values of shocks captured by the lagged squared error term ($\varepsilon_{t-i}^2$) and the past values of itself ($h_{t-j}$). $e_{t-1}^2$ and $h_{t-1}$ are known as the ARCH term and GARCH term, respectively. $e_{t-1}^2$ itis the information about volatility from the previous period and measured as the lag of the squared residual from the Equation (2.a). $h_{t-1}$ is used to be considered as the last period's (forecast) variance, also derived from the Equation (2.a).

In a GARCH($p,q$) model where $p$ refers to how many GARCH terms appear in the Equation, while $q$ represents the numbers of the ARCH terms used in the Equation. For $p = 0$, the case cuts to the ARCH ($q$) process, and for $p=q= 0$, $\varepsilon_t$ itis just white noise. Bollerslev (1986) shows that the GARCH ($p,q$) model is actually motionless ARCH ($q$) process. The persistence of shocks' impacts on the volatility of the dependent variable is measured by the sum of the coefficients of ARCH and GARCH terms. The GARCH (1,1) equations with $\alpha_0 > 0$, $\alpha_i, \beta_j \geq 0$, have a stationary solution if and only if $\alpha + \beta < 1$.

## 5. Analyses of Data

### 5.1. Description of the Data

The data employed to conduct this work consist of the day-to-day returns in the USD/TL currency equity stock held by non-residents in Turkey[5], the daily amount of the FX sold by the CBRT via auctions, amount of the FX reserves of

[5] We used the equity stock held by non-residents as an independent variables due to its strong negative correlation with USD/TL.

the CBRT via ROM[6]. Moreover, we used three others independent variables i.e. share of the FX reserves via ROM in Gross FX Reserves of the CBRT, the utilization for the FX facility and the ratio of utilization for the FX facility to substitute for the amount of FX reserves of the CBRT via ROM in Model 2, 3 and 4 respectively (See Table 1).

We observe the effect of ROM on exchange rate volatility applying the GARCH estimation framework and daily data for the period June 192013 to October 302014, a total of 337 trading days, excluding weekends and holidays. The starting period was chosen based on the discussion about the probability of expected starting time for actual tapering[7]. All the data are retrieved from the data delivery system (EVDS Database) of the CBRT.

**Table 1: Variables definitions and measurements**

| Variables | Definition & Measurement | Note |
|---|---|---|
| R | Daily returns in the currency of USD/TL, = ln(St /St-1)*100 | used in all Models |
| logsec | Logarithm of equity stock held by non-residents in Turkey | used in all Models |
| Logfxs | Logarithm of the daily amount of FX sold by CBRT through auctions | used in all Models |
| logfxr | Logarithm of amount of FX reserves of CBRT via ROM | used in Model 1 |
| Fxsh | Share of the FX reserves via ROM in Gross FX Reserves of CBRT | used in Model 2 |
| Ufx | The utilization for the FX facility | used in Model 3 |
| ufr | The ratio of utilization for the FX facility,=100*[Use of FX Facility/FX Facility(Max)] | used in Model 4 |

All independent variables used in the mean equations in all Models also added into variance equation as variance regressors to demystify their impact on volatility of the USD/ TL parity as follows:

[6] The daily amount of the FX sold by CBRT through auctions and the amount of FX Reserves of CBRT are used in a number of studies including Oduncu et al. (2013a) and Değerli and Fendoğlu (2015) to examine their impact on volatility of exchange rate.

[7] Tapering program was first put on the FOMC agenda during the early 2013 and some participants supported the idea of starting reduction of purchasing assets (FOMC, 2013). In May 2013 Bernanke emphasized that the FOMC may decide to decrease pace of asset purchases in the near future by considering unemployment rate and inflation target (The Economic Outlook, 2013). Less than a month later Bernanke not just reiterated the FOMC's plan but also unveiled the date of expected starting time for actual tapering in a press conference held on June 19, 2013 as follows "...we would expect probably to slow or moderate purchases some time later this year..."(Bernanke, 2013).

**Model 1:**

$$R_t = \beta_0 + \beta_1 R_{t-1} + \beta_2 logsec + \beta_2 logfxs + \beta_3 logfxr + \varepsilon_t \quad (2.a)$$

$$\varepsilon_t \sim \mathrm{N}(0, h_t) \quad (2.b)$$

$$h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 \mathrm{logsec} + \alpha_4 \mathrm{logfxs} + \alpha_5 \mathrm{logfxr} \quad (2.c)$$

Equation (2.a) represents the mean Equation, where $R_t$ is the natural log difference of the USD/TL exchange rate ($S_t$), computed as $R_t = \ln(S_t/S_{t-1})$. $e_{t-1}^2$ and $h_{t-1}$ are known as the ARCH term and GARCH term, correspondingly. $e_{t-1}^2$ is the information about volatility from the earlier course and $h_{t-1}$ is previous days' volatility of exchange rate.

Equation (2.c) is known as variance Equation, designed to analyse the impact of equity stock held by non-residents in Turkey and amount of FX reserves of CBRT via ROM on the volatility of exchange rate along with ARCH and GARCH terms.

Moreover, three additional variables are separately used in the following Models as a substitution for the amount of FX reserves of the CBRT via ROM to ensure the results are statistically meaningful.[8]

**Model 2:**

$$R_t = \beta_0 + \beta_1 R_{t-1} + \beta_2 logsec + \beta_2 logfxs + \beta_3 fxsh + \varepsilon_t \quad (3.a)$$

$$\varepsilon_t \sim \mathrm{N}(0, h_t) \quad (3.b)$$

$$h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 \mathrm{logsec} + \alpha_4 \mathrm{logfxs} + \alpha_5 \mathrm{fxsh} \quad (3.c)$$

**Model 3:**

$$R_t = \beta_0 + \beta_1 R_{t-1} + \beta_2 logsec + \beta_2 logfxs + \beta_3 ufx + \varepsilon_t \quad (4.a)$$

$$\varepsilon_t \sim \mathrm{N}(0, h_t) \quad (4.b)$$

$$h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 \mathrm{logsec} + \alpha_4 \mathrm{logfxs} + \alpha_5 \mathrm{ufx} \quad (4.c)$$

[8] Mentioned variables are separately added into the Models to avoid multicollinearity due to presence of high correlation among them.

**Model 4:**

$$R_t = \beta_0 + \beta_1 R_{t-1} + \beta_2 logsec + \beta_2 logfxs + \beta_3 ufr + \varepsilon_t \quad (5.a)$$

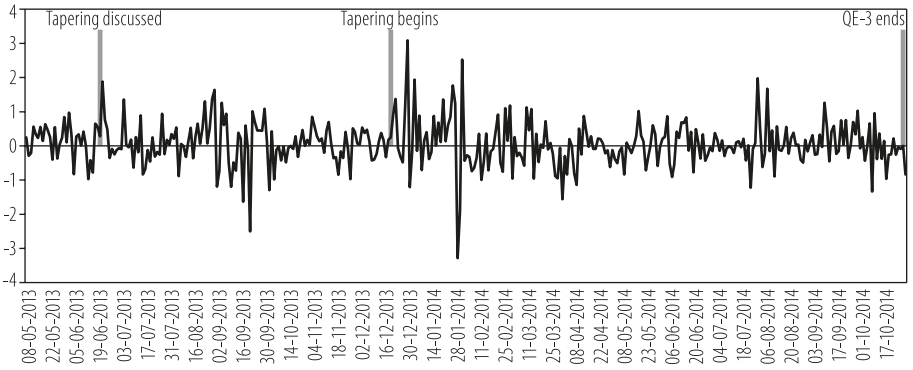
$$\varepsilon_t \sim \mathrm{N}(0, h_t) \quad (5.b)$$

$$h_t = \alpha_0 + \alpha_1 e_{t\ 1}^2 + \alpha_2 h_{t\ 1} + \alpha_3 \mathrm{logsec} + \alpha_4 \mathrm{logfxs} + \alpha_5 \mathrm{ufr} \quad (5.c)$$

For this purpose, we have chosen GARCH (1,1) model as an optimal model according to three information criteria, namely Akaike (AIC), Schwarz (S.C.) and Hannan–Quinn(H.Q.), all of which consider both how good the fitting of the models are and the number of parameters in the Model. The selected models are the one with the minimum criteria values mentioned above.

GARCH processes are widely used in the literature as they are available structure to inspect time-varying volatility in financial markets. To proceed with GARCH (1,1) model, two critical statuses must be to be fulfilled, i.e. the existence of volatility clustering and the ARCH effect. The first condition implies that cases of sharp fluctuation are followed by periods of high volatility. This indicates continuing conditionally heteroscedastic and it can be represented by ARCH and GARCH Models. Fig. 6 illustrates fluctuation gathering in regularly returns of the USD/TL along with the Fed's tapering programme.

**Figure 5: Daily Returns of T.L. during the Tapering period and implementation of ROM**




After proving the first condition of running GARCH (*p,g*) model above, ARCH-LM test is applied to find out whether any conditional heteroscedasticity (ARCH effect) exists within the Model. Table A.1 indicates that the null hypothesis of no ARCH effect is rejected and concluded that there is an ARCH effect in return series.

## 5.2. Unit Root Test

In general, time-series data is dominated by stochastic trends and carries a unit root. If the series bears a unit root, it is inappropriate to take the first difference of the data to achieve stationarity and continue this process until the series becomes stationary. Here, the study used the Augmented Dickey-Fuller (ADF) test elaborated by Dickey and Fuller (1979) to test the hypothesis. According to the ADF Test outcomes, all the series have a unit root problem except the return series, the utilization for the FX facility (ufx) and the ratio of utilization for the FX facility (ufr). Table 2 indicates that the series with a unit root become stationary after initial change.

**Table 2: Unit root test results**

| Variables | ADF t-statistic | p-value |
|---|---|---|
| R | -18.0390 | 0.0000*** |
| logsec[a] | -2.1905((-18.3095) | 0.2102(0.0000)*** |
| logfxs[a] | -2.7900(-14.8454) | 0.0607(0.0000)*** |
| logfxr[a] | -2.1307(-18.4714) | 0.2328(0.0000)*** |
| fxsh[a] | -2.2388(-18.9331) | 0.1930(0.0000)*** |
| Ufx | -3.0982 | 0.0276** |
| Ufr | -3.0982 | 0.0276** |

Note: *** and ** illustrates the relevance at the level of 1% and 5%, respectively. a represents the series that become stationary after taking the first difference is shown in the brackets.

## 5.3. Estimation Results

The estimation results of the variance models are represented by GARCH Method in Table 3. These conclusions apparently build the existence of time-varying conditional volatility of returns in the USD/TL currency. According to the results, estimated coefficients of the ARCH and GARCH criterions are positive and statistically important at the 5% and 1% level respectively in all Models.

The study also finds that an increase in the amount of equity stock held by non-residents in Turkey culminated in the dropof exchange rate volatility with a force that is statistically significant at the 5% level in Model 2, and 10% level in other Models. However, the regular amount of FX sold by the CBRT via auctions is found to be insignificant in all Models. This result is aligned with the investigations of Oduncu et al. (2013a) and Değerli and Fendoğlu (2015). Moreover, the variables that are used to represent the ROM tool i.e. *logfxr, fxsh, ufx* and *ufr*

found to be insignificant in all Models. Findings of insignificancy of the ROM tool for the period of tapering is consistent with Aytug (2016) that highlighted the ineffectiveness of the ROM at the same period.

**Table 3: Estimation Results of Variance Equations**

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | Std. Error | Coefficient | Std. Error | Coefficient | Std. Error | Coefficient | Std. Error |
| $e^2_{t-1}$ | 0.1891 | 0.0831** | 0.1718 | 0.0771** | 0.1887 | 0.0040** | 0.1887 | 0.0834** |
| $h_{t-1}$ | 0.7297 | 0.0898*** | 0.7029 | 0.1026*** | 0.7275 | 0.0924*** | 0.7275 | 0.0924*** |
| *logsec* | -0.8308 | 0.4585* | -0.8343 | 0.3688** | -0.8069 | 0.4546* | -0.8069 | 0.4546* |
| *logfxs* | 0.0044 | 0.0161 | 0.0090 | 0.0150 | 0.0047 | 0.0158 | 0.0047 | 0.0158 |
| *logfxr* | -0.1942 | 1.0648 | -- | -- | -- | -- | -- | -- |
| *fxsh* | -- | -- | 0.0160 | 0.0121 | -- | -- | -- | -- |
| *Ufx* | -- | -- | -- | -- | -0.0047 | 0.0210 | -- | -- |
| *Ufr* | -- | -- | -- | -- | -- | -- | -0.0028 | 0.0126 |
| Diagnostics | | | | | | | | |
| ARCH LM (Chi2) | 0.3044 | | 0.5729 | | 0.3070 | | 0.3070 | |
| $\alpha + \beta = 1$ | 0.92 | | 0.87 | | 0.91 | | 0.91 | |

Note: Asterisks denote the significance of coefficients, with ***, ** and * indicating significance at the 1%, 5% and 10% level, respectively.

Diagnostics test result related to all Models are also summarized in Table 3. As for the stationarity of the variance process, all coefficients of the conditional variance specification face the stability condition of of $0 < \alpha < 1$, $0 < \beta < 1$ and $\alpha + \beta < 1$. However, the sums are rather close to the ones which indicated a long persistence of shocks in volatility in all Models.

In the residual diagnostic check, heteroskedasticity and serial correlation tests are employed on the residual from estimated GARCH (1,1) models. L.M. test gives the results for heteroscedasticity in Table 3. We acknowledge the null hypothesis of the presence of homoskedasticity as the p-values are greater than 5% in all Models. Furthermore, Correlogram Q-statistics show that that residuals are not suffering from serial correlation in all Models. (See Table A.2)

## 6. Conclusion

The ROM is a relevant macroprudential tool, which aims to support the FX reserve management of the banking structure and has been used as an automatic stabilizer against capital flow volatility by the CBRT. As highlighted in previous studies, ROM significantly contributed to lessening the fluctuation of the Turkish Lira in selected periods. The research examines the impact of ROM on the fluctuation of the Turkish Lira due to the lack of studies that have investigated the effectiveness of the ROM during the Fed's tapering period.

We construct four Models where four different variables are separately used that represent the ROM tool, i.e. the of the amount of FX reserves of the CBRT via ROM, the share of the FX reserves via ROM in Gross FX Reserves of the CBRT, the utilization for the FX facility and the ratio of utilization for the FX facility to demystify whether ROM was an effective tool during this period.

Results of the four Models are consistent with each other and show that ROM did not do its job thoroughly and it decreased the volatility of the USD/TL exchange rate after the official announcement about the probability of expected starting time for actual tapering. Findings of the Models for this specific period are in line with Aytug (2016) that reached the same conclusion by using the synthetic control method. As far as we know, this is the first study that examines the effectiveness of ROM during the tapering program by using the GARCH Model.

Furthermore, studies to follow may comparatively inspect the impact of ROM on the volatility of the USD/TL exchange rate during the Fed's Q.E. programmes.

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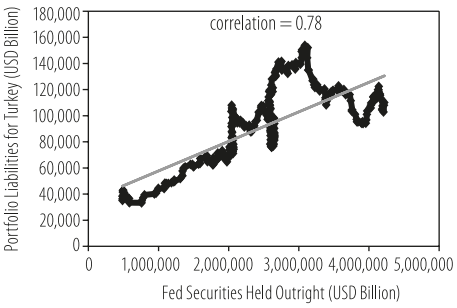
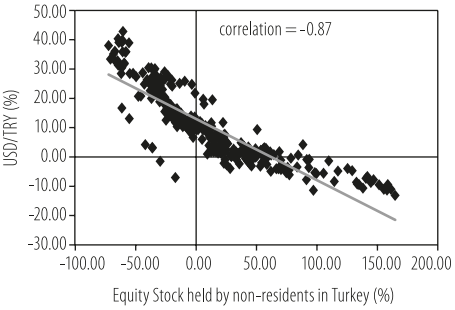
# Appendix

**Fig. A.1: Correlation between Fed Securities Held Outright and Portfolio liabilities for Turkey**



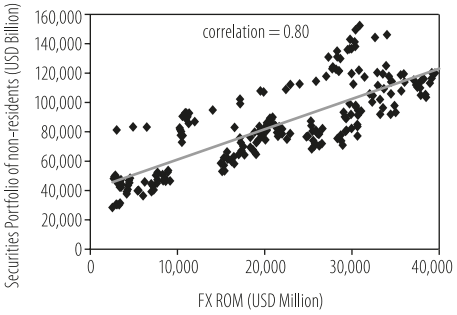

Source: Authors' construction using the data delivery system (EVDS Database) of CBRT and Fed, Factors Affecting Reserve Balances (H.4.1), 2020

**Fig. A.2: Correlation between the equity stock held by non-residents and the US Dollar buying rate in Turkey**



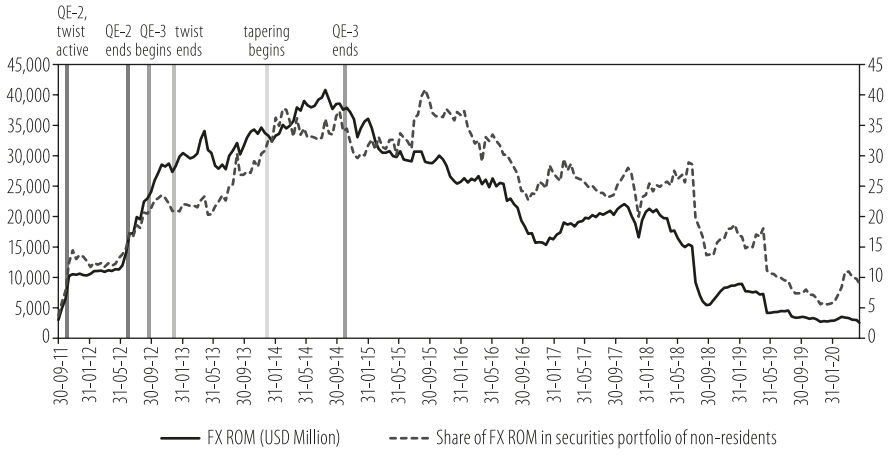

Source: Authors' construction using the data delivery system (EVDS Database) of CBRT, 2020

**Fig. A.3: Correlation between FX Reserves collected via ROM and Securities portfolio of non-residents in Turkey**




Source: Authors' construction using the data delivery system (EVDS Database) of CBRT, 2020

**Fig. A.4: FX ROM and its share in securities portfolio non-residents during the QE programmes**




Source: Authors' construction using the data delivery system (EVDS Database) of CBRT, 2020.

**Table A.1: Heteroskedasticity Test: ARCH**

| F-statistic | Chi2 |
|---|---|
| 17.33829 | 16.58564 |
| (0.0000) | (0.0000) |

Note: *p*-values are shown in parenthesis.

**Table A.2: Correlogram Q-statistics**

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | Standardized Residuals | | Standardized Residuals | | Standardized Residuals | | Standardized Residuals | |
| Lags | Q-Stat | p-value | Q-Stat | p-value | Q-Stat | p-value | Q-Stat | p-value |
| 1 | 0.0468 | -- | 0.0208 | -- | 0.0510 | -- | 0.0510 | -- |
| 2 | 0.5532 | 0.457 | 0.5979 | 0.439 | 0.5134 | 0.474 | 0.5134 | 0.474 |
| 3 | 1.6350 | 0.442 | 1.4423 | 0.486 | 1.5810 | 0.454 | 1.5810 | 0.454 |
| 4 | 1.6834 | 0.641 | 1.6535 | 0.647 | 1.6298 | 0.653 | 1.6298 | 0.653 |
| 5 | 6.4208 | 0.170 | 7.3442 | 0.119 | 6.3494 | 0.175 | 6.3494 | 0.175 |
| 6 | 7.4862 | 0.187 | 8.1461 | 0.148 | 7.4172 | 0.191 | 7.4172 | 0.191 |
| 7 | 8.1620 | 0.226 | 8.8612 | 0.182 | 8.0603 | 0.234 | 8.0603 | 0.234 |
| 8 | 8.9385 | 0.257 | 10.001 | 0.189 | 8.8242 | 0.266 | 8.8242 | 0.266 |
| 9 | 12.851 | 0.117 | 14.197 | 0.077 | 12.913 | 0.115 | 12.913 | 0.115 |
| 10 | 13.202 | 0.154 | 14.519 | 0.105 | 13.198 | 0.154 | 13.198 | 0.154 |
| 11 | 13.263 | 0.209 | 14.607 | 0.147 | 13.247 | 0.210 | 13.247 | 0.210 |
| 12 | 13.534 | 0.260 | 14.905 | 0.187 | 13.521 | 0.261 | 13.521 | 0.261 |
| 13 | 14.448 | 0.273 | 15.798 | 0.201 | 14.480 | 0.271 | 14.480 | 0.271 |
| 14 | 14.716 | 0.325 | 16.009 | 0.249 | 14.760 | 0.323 | 14.760 | 0.323 |
| 15 | 14.733 | 0.397 | 16.136 | 0.305 | 14.772 | 0.394 | 14.772 | 0.394 |
| 16 | 14.814 | 0.465 | 16.418 | 0.355 | 14.867 | 0.461 | 14.867 | 0.461 |
| 17 | 15.014 | 0.524 | 16.714 | 0.404 | 15.089 | 0.518 | 15.089 | 0.518 |
| 18 | 15.086 | 0.589 | 16.730 | 0.473 | 15.154 | 0.584 | 15.154 | 0.584 |
| 19 | 15.434 | 0.632 | 17.179 | 0.511 | 15.511 | 0.627 | 15.511 | 0.627 |
| 20 | 15.680 | 0.678 | 17.270 | 0.572 | 15.753 | 0.674 | 15.753 | 0.674 |
| 21 | 16.111 | 0.710 | 17.627 | 0.612 | 16.219 | 0.703 | 16.219 | 0.703 |
| 22 | 17.464 | 0.683 | 19.296 | 0.566 | 17.657 | 0.671 | 17.657 | 0.671 |
| 23 | 18.506 | 0.676 | 20.016 | 0.582 | 18.654 | 0.667 | 18.654 | 0.667 |
| 24 | 18.845 | 0.710 | 20.409 | 0.617 | 19.016 | 0.700 | 19.016 | 0.700 |
| 25 | 20.096 | 0.691 | 22.233 | 0.565 | 20.280 | 0.681 | 20.280 | 0.681 |
| 26 | 20.133 | 0.740 | 22.241 | 0.622 | 20.317 | 0.730 | 20.317 | 0.730 |
| 27 | 20.492 | 0.768 | 22.372 | 0.668 | 20.672 | 0.759 | 20.672 | 0.759 |
| 28 | 20.679 | 0.801 | 22.766 | 0.698 | 20.874 | 0.792 | 20.874 | 0.792 |
| 29 | 22.347 | 0.765 | 25.017 | 0.627 | 22.695 | 0.748 | 22.695 | 0.748 |
| 30 | 22.438 | 0.802 | 25.073 | 0.674 | 22.780 | 0.787 | 22.780 | 0.787 |
| 31 | 22.656 | 0.829 | 25.369 | 0.707 | 22.991 | 0.816 | 22.991 | 0.816 |
| 32 | 23.118 | 0.845 | 26.092 | 0.717 | 23.479 | 0.831 | 23.479 | 0.831 |
| 33 | 23.614 | 0.858 | 26.519 | 0.740 | 23.928 | 0.847 | 23.928 | 0.847 |
| 34 | 23.801 | 0.880 | 26.651 | 0.775 | 24.134 | 0.869 | 24.134 | 0.869 |
| 35 | 23.807 | 0.904 | 26.690 | 0.810 | 24.135 | 0.895 | 24.135 | 0.895 |
| 36 | 24.388 | 0.910 | 27.226 | 0.823 | 24.752 | 0.901 | 24.752 | 0.901 |