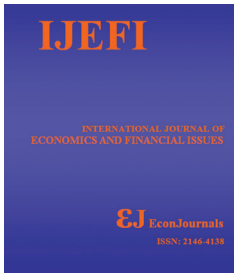

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Exchange Rate Volatility and Central Bank Actions in Egypt: Generalized Autoregressive Conditional Heteroscedasticity Analysis

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ABSTRACT

Egypt has passed through different development stages, followed different exchange rate regime at each, ranging from fixed to floating. This study tries to examine empirically how Central Bank of Egypt actions influence exchange rate volatility using generalized autoregressive conditional heteroscedasticity (1,1) model under Gaussian normal distribution, considering monthly observations of Egyptian Pound against US Dollar, spanning the period from 2003 after the adoption of floating exchange rate regime till 2014. The model includes three exogenous variables as they can contribute to the exchange rate volatility; interest rate differentials, trade balance and official reserves. Results show the presence of volatility clustering but this volatility shocks are not so quite persistent. Central Bank actions impacted exchange rate volatility positively through interest rate, and negatively through reserves amount. Finding solutions to trade deficits to encourage exports and tackle down imports can hinder exchange rate volatility in Egypt.

Keywords: Exchange Rate Volatility, Generalized Autoregressive Conditional Heteroscedasticity, Monetary Policy
JEL Classifications: C23, E58

1. INTRODUCTION

The collapse of the Bretton Woods system in 1970s brought major changes and broad variety of choices for exchange rate regimes[1], each country had been free to choose any form of exchange arrangement, varying from pure free floating to intermediate regimes, hard pegs, crawling pegs, currency unions and flexible exchange rate[2]. The choice of the convenient regime depends on each country specific characteristics, political situation and economic condition. Generalizations across countries and over time are misleading (Bordo and Schwartz, 1996).

The determination of an exchange rate regime is key factor for countries' macroeconomic stability. Both fixed and flexible regimes have their pros and cons, whereas, fixed regime reduces transaction cost, makes investment and trade of a lesser risk and lowers speculation, while flexible regime has the ability to adjust to external shocks, restores equilibrium to the balance of payments and government does not need to hold large reserves of foreign currency, instruments of financial markets have to be accessible to hedge the risks associated with exchange rate fluctuation (Stone et al., 2008).

Since the late 1970s, there has been a continuous reduction in the number of developing countries that keep some type of formal pegged exchange rate, and a rise in the number of countries with more flexible regimes (International Monetary Fund [IMF], 1997). This trend drove a large exchange rate volatility, acceleration of inflation following oil shocks of the 1970s and 1980s, rise in capital mobility and a series of external shocks including a rise in international interest rates and a slowdown of growth in the industrial countries. In developing countries, fixed exchange rate regimes often creates a high uncertainty about real exchange rate than flexible regimes, as their real exchange rates tend to appreciate due to high rates of inflation (Coudert and Couharde, 2005).

1 In August 1971, Richard Nixon (U.S. President at that time) adopted his new economic policy; known as the "Nixon shock," he announced the breakdown of the dollar's conversion into gold, and since then all reserve currencies have been fiat currencies.
2 For more details see: Yagci (2001).

In the 1990s a number of countries[3] maintained to shift their exchange rate regime from soft pegs towards floating rates and hard pegs. In 1991, 59% of developing countries had some kind of soft peg regime. By 1999, this proportion had fallen to 34% while the share of floating regimes increased from 25% to 42%, and the share of hard pegs rose from 16% to 24% (Fisher, 2001).

In 2013, according to a study conducted by the IMF on 191 countries and regions, 82 countries and regions, or 43% of all countries are adopting a managed floating exchange rate system, especially as a number of emerging countries try to protect their currencies from increased volatility in foreign exchange markets caused by monetary easing measures from developed countries. This was up from 35% in 2009, indicating that more countries are now adopting this regime than the floating exchange mechanisms (Nikkei Asian Review, 2014).

A debate has continued over many years on the appropriate degree of foreign exchange rate flexibility. One view criticized that the exchange rate should be freely determined by market forces, independently of any intervention or targeting by Central Bank's monetary policy, other view confirming the Central Bank intervention and control (Michael et al., 2000). Therefore, the choice of an exchange rate regime is a critical aspect to ensure competitiveness and economic growth[4]. Floating exchange rate has been regarded as an automatic stabilizer, which is able in some cases to rebalance the unbalanced economy. However, many countries are unwilling to let their currencies fluctuate because of the possibility for severe exchange rate fluctuations (Calvo and Reinhart, 2000).

2. AN OVERVIEW ABOUT EXCHANGE RATE IN EGYPT

The Egyptian economy has developed through five basic stages stated as follows; the nationalization and heavy government intervention of the 1960s; the Infitah (open door) policy adopted during the 1970s; the economic reform as a response to external shocks during the 1980s; the comprehensive Economic Reform and Structural Adjustment Program (ERSAP) in the early 1990s, and 25th January revolution at 2011. Egypt has followed different exchange rate regimes at each of these stages.

From the sixties till 1990, Egypt had applied fixed exchange rate[5]. The Egyptian authority had kept the exchange rate of the Egyptian Pound fixed to the US Dollars (USD). The Central Bank of Egypt (CBE) had adjusted the exchange rate of the Egyptian Pound from LE1.1/$1 to LE2/$1 in July 1990 (El-Ramly and Abdel-Haleim, 2008).

In 1987, the government of Egypt had signed the macroeconomic reform program in coordination with the IMF and the World Bank, aiming to decrease both internal and external imbalances. Hence, some improvements occurred in the exchange rate regime[6], consequently the Egyptian Pound was devalued by 25% in nominal terms and a free exchange market was settled, reduction of quantitative restrictions on imports and liberalization of exports (Dailami and Dinh, 1991).

Egypt's ERSAP was introduced in February 1991[7], as a part of the economic reform program; the Egyptian authority modified its exchange rate policy from the adoption of a fixed but adjustable peg exchange rate regime to a managed floating exchange rate regime. As a consequence of the new regime, exchange rate of the Egyptian Pounds devalued from LE2/$1 to $3.4, on average between February 1991 and December 2000. On the contrary, the Central Bank's foreign exchange reserves rose from $10.5 billion in 1992, to more than $20 billion in 1997 (Mongardini, 1998). However, starting from 1998, the Egyptian economy faced three shocks that had a great adverse stated as follows; the worldwide decline in oil prices, emerging markets financial crisis, and the Luxor terrorist attack that negatively affected the tourism sector. Consequently, foreign exchange reserves declined to reach $13.8 billion in 2001 (Mohieldin and Ahmed, 2002).

In January 2001, the CBE reported the adoption of a de jure crawling peg exchange rate regime. From January 2001 to December 2002, the exchange rate of the Egyptian pound was devalued as a result of the followings; the CBE adopted the new exchange rate regime which caused the exchange rate for the Egyptian pound to set at LE3.85/$1, on September 2001, as a result of terrorist act against USA and its effect on the Egyptian economy and specially on tourism sector, hence, the Egyptian pound was devaluated to LE4.14/$1. In January 2002, the CBE forced to devalue the Egyptian Pound one more time and it set the exchange rate at LE4.5/$1. The CBE kept this rate till its announcement of adopting floating exchange rate regime in January 2003. During this period of adopting a de jure crawling peg exchange rate regime reserves fluctuated between $14.1 billion in July 2001 and $12.5 billion in February 2002 (Massoud and Willett, 2014).

In 2003, the CBE announced the adoption of the free floating exchange rate regime[8], the Egyptian Pounds lost around 20% of its value against the USD during the month of the adoption of the

3 Five of these (Indonesia, Thailand, Russia, Brazil, and Mexico) moved to floating regimes, and two (Argentina and Bulgaria) instituted currency board arrangements. Among other developing countries, a larger shift has been towards flexibility; only six small countries moved to hard peg regimes.

4 The IMF has produced analytical studies on countries' selection of exchange rate regime that build on the existing empirical literature both within and outside the IMF. These studies helped the member countries of how their choice of exchange rate regime can affect their macroeconomic performance in respect of economic growth, inflation control and of international monetary system stabilization. (Ghosh et al., 1997; Ghosh et al., 2002; Levy-Yeyati and Sturzenegger, 2003; Rogoff, et al., 2004; and Reinhart and Rogoff, 2004).

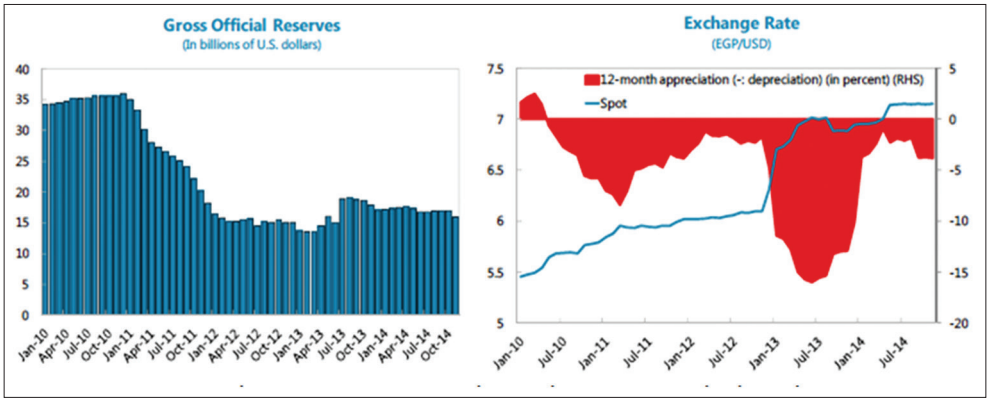
5 Adjustable peg in practice.

6 Exchange rates were reduced from at least five different rates to three.

7 ERSAP is a comprehensive program aiming to create a decentralized open economy; it included financial sector reform, exchange rate unification, interest rate liberalization, subsidies reduction, price decontrols, foreign trade liberalization, public sector reforms and private sector participation -privatization was considered an integral part of the economic reform program- to rectify the balance of payment deficit, the budget deficit, inflation, output and employment, poverty and income distribution.

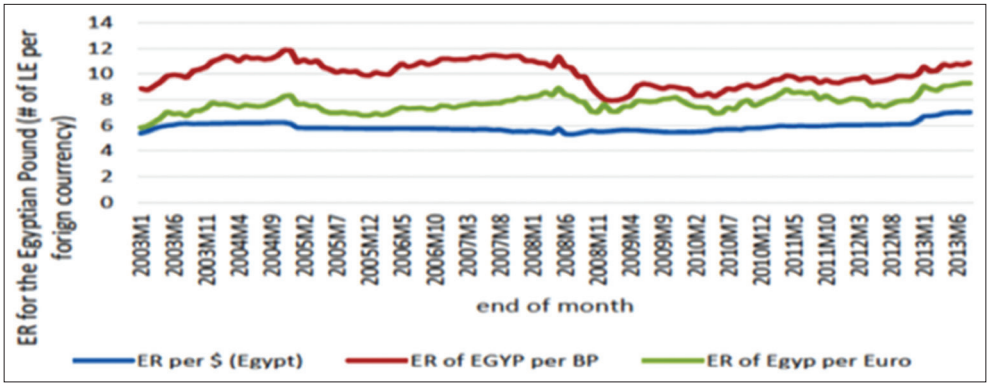
8 Following the move to a floating exchange rate regime in February 2003, inflation rates have increased considerably, reaching 17%.

Figure 1: Gross official reserves and exchange rate in Egypt from January 2010 to July 2014



Source: Egyptian authorities, International Financial Statistics and Bloomberg

Figure 2: The exchange rate of the Egyptian Pound against British Pound, US Dollar and EURO from January 2003 to August 2013



Source: IMF Country Report, 2015

new regime. The exchange rate of the Egyptian Pound elevated from LE4.5/$1 to be LE5.4/$1 (Selim, 2012). This depreciation continued until December 2004, when the exchange rate for the Egyptian Pound reached LE6.3/$1. During this period, reserves were volatile with an increasing trend. They increased from $12.9 billion in December 2002 to LE14. 3 billion in December 2004. During this interval the CBE was interfering to keep the exchange rate of the Egyptian Pound against the USD as quite stable (Elbadawi and Kamar, 2006).

The CBE announced in 2005 its intention to adopt inflation targeting as a nominal anchor for the monetary policy over the medium term (Awad, 2008). This step affected the exchange rate of the Egyptian Pound rapidly. The Egyptian Pound appreciated against the USD, moving from LE6.1/$1 to be LE5.8/$1. The exchange rate of the Egyptian Pound appreciated moderately then fluctuated within a narrow range against the USD[9] (Al-Mashat, 2008). However, reserves steadily increased from $15.4 billion in January 2005 to $21.3 billion in June 2006. This trend in reserves continued until 2010 when the reserves stock reached a record of $33.6 billion (Ghalwash, 2010).

In January 2011, the 25th of January revolution occurred. Consequently, Egypt has been in political, economic and social instability. Unexpectedly, the exchange rate of the Egyptian Pound against the USD was fairly stable following this turmoil, only depreciating from LE5.8/$1 in January 2011 to be LE6.1/$1 in November 2012. This is explained by a sharp decline in reserves - to $11.6 billion from $32.6 billion in January 2011 - as shown in Figure 1 - Signifying that monetary authorities reconcile to support the currency[10].

In 2012, IMF reclassified Egypt as having a stabilized exchange rate arrangement (International Monetary Fund, 2012). With the intention to discontinue the massive losses of reserves, the CBE announced in December 2012 the adoption of a new system of putting the USD on auction to float the exchange rate in practice. The result of the new regime was the depreciation of the Egyptian Pound against the USD, the British Pound and the Euro (Figure 2).

Since June 2013 the official exchange rate has remained stable, creating increasing demand for foreign exchange. The Egyptian Pound depreciated by 13% few months following the adoption of the CBE's tightly managed foreign exchange auctions in December 2012. In addition to this, the large support from gulf countries permitted the CBE to stabilize the official exchange rate, which

9 This was not the case for the ER of the Egyptian Pound against the Euro and the British Pound.

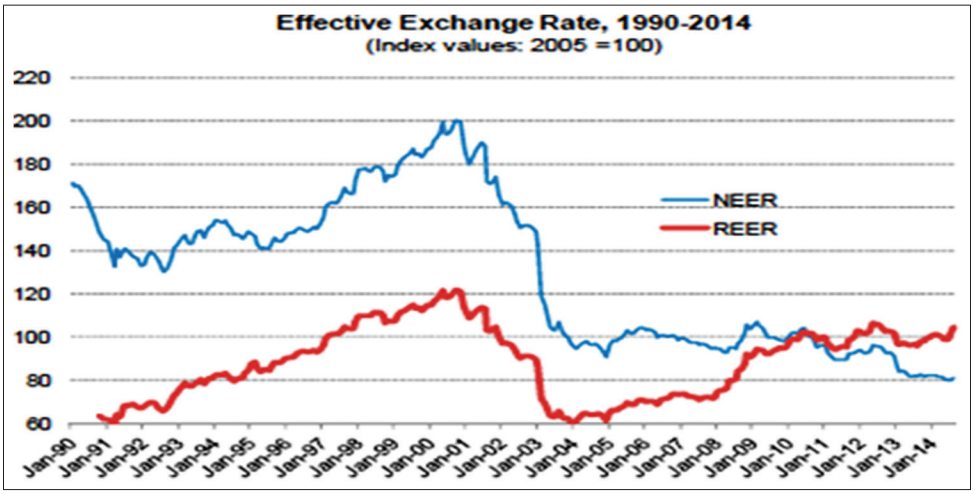
10 During this period, the ER of the Egyptian Pound was stable against the Dollar, it was fluctuating substantially against both the British Pound and the Euro. Thus, there is strong evidence that the CBE had been intervening extensively to keep the ER of the Egyptian Pound stable against the USD.

Table 1: Egypt assessment of effective exchange rate 1990-2014

Assessment	I. November 2014 REER difference against:		II. Macroeconomic balance	III. External sustainability[1] 2018/2019[2]	ERER[4]	Average
	10-year average	15-year average				
Country team	(Misalignment as percentage deviation from estimated equilibrium, overvaluation [+], undervaluation [−])					
	28.8	27.8	3.3[3]	17.7	28.1	16.4

[1]Estimates the adjustment needed to stabilize Egypt's net foreign assets to GDP radio, [2]Based on data for Egypt's financial year (July 1-June 30), including for the real effective exchange rate, [3]Based on CGER methodology, [4]Based on equilibrium real exchange rate approach. CGER: Consultative group on exchange rate, GDP: Gross domestic product

Figure 3: Effective exchange rate 1990-2014



Source: Central Bank of Egypt, Economic Review, 2014

depreciated by <2% against the USD. This has caused the real effective exchange rate to appreciate by 18% at end of November 2014, due to high inflation differentials with trading countries and the appreciation of the dollar against other major currencies. In December 2014, the CBE raised the weekly auctioned amounts by 25% (International Monetary Fund, 2015). Due to continuous inflation differentials with the majority of the Egyptian trading partners, the effective exchange rate has depreciated by 11% during end of 2010 till October 2014. Over long time scope, the effective exchange rate is about 28% above its average of the past 15 years and 29% above its average of the past 10 years (Table 1 and Figure 3).

3. ECONOMETRIC FRAMEWORK

3.1. Scope and Data Source

To explore the volatility of the exchange rate in Egypt, this study employs monthly data. The data set concludes the exchange rate of the Egyptian Pound against USD spanning from January 2003 to December 2014 that is a total of 144 observations. Thus, observations are enough to carry out time series analysis, monthly data period starts by 2003 with the adoption of free floating exchange rate regime. Exchange rate data is obtained from (http://www.exchangerates.org.uk/USD-EGP-exchange-rate-history-full.html).

3.2. Methodology

Exchange rate volatility same as other financial assets, usually exhibits periods of large volatility followed by periods of relatively lower volatility which called heteroscedasticity phenomenon (Brooks, 2002). To measure exchange rate volatility within this phenomenon, standard deviation of exchange rates fluctuations should be measured. Most recent empirical studies are modeling volatility by adopting the use of generalized autoregressive conditional heteroscedasticity (GARCH)[11] models pioneered by Engle (1982).

Since then volatility can be estimated using time series econometric techniques. GARCH family is used by many researchers worldwide, demonstrating that there exists temporal clustering in the variances of the exchange rate changes. Amongst, Syarifuddin et al. (2014) results revealed that, USD/IDR volatility in Indonesia is obviously persistent using ARCH family. A study by Musyoki et al. (2012) in Kenya, concluded that real exchange rate volatility has a negative impact on economic growth in Kenya economy. Volatility was found quite persistent for seven currencies by Abdalla (2012). Bakhromov (2011) found evidence that exchange rate volatility has a negative effect on real export in the short run in Uzbekistan. Vee et al. (2011), evaluated volatility forecasts for the USD/mauritian rupee exchange rate via GARCH (1,1) model. Mahmood et al. (2012) in Pakistan found that there is a positive impact of exchange rate volatility on GDP, growth rate and trade openness. The effects of US, German and Japanese monetary and intervention policies on dollar-mark and dollar-yen exchange

11 As heteroscedasticity has been commonly existing in financial time series return, Engle (1982) proposes a model in which a variance to be modeled and therefore instead of considering heteroscedasticity as a problem to be corrected.

rate volatility over the 1977-1994 period has been examined by Dominguez (1998), the results indicated that intervention operations generally increase exchange rate volatility. Empirical results from the exponential GARCH model by Mwansa (2009) suggest that both sales and purchases of USD cause the exchange rate to appreciate. The results on the impact of intervention on volatility are mixed though generally intervention appears to be increasing volatility.

Following these previous studies, this work applies GARCH analysis to model the exchange rate volatility and how effective the Central Bank actions throughout study period 2003-2014.

3.2.1. Unit root test

To investigate whether the variables are stationary and to determine the order of integration of the variables, the augmented Dickey–Fuller (ADF) test is employed. Variables are tested in both level and 1st difference forms, with intercept and with intercept and time trend. The ADF test results in Table 2 strongly reject the null hypothesis of a unit root (variables are stationary) for 1st difference, as the absolute value of t-statistics is higher than critical values at 5% level and P < 5%. While results at level form, both with intercept and with intercept and time trend were insignificant at 5% level so that data is integrated to order (1).

3.2.2. GARCH analysis

GARCH (1,1) model is used to investigate volatility characteristics using monthly data (January 2003 to December 2014). The model is estimated under ARCH (Marquardt) - Gaussian normal distribution.

GARCH (1,1) model for the monthly data is to as follows;

$$ERm = c_1 + c_2 ERm_{t-1} + \varepsilon_t \quad (1)$$

Where, *ERm* is - dependant variable - the log monthly exchange rate measured by USD/EGP Pound average monthly BID rates, c_1 is the constant term (indicating currency appreciation/depreciation), c_2 is coefficient of the lagged dependent term ERm_{t-1} and ε_t is the error term.

$$\sigma_t^2 = \alpha + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 + \gamma_1 IRD + \gamma_2 TRBAL + \gamma_3 RES \quad (2)$$

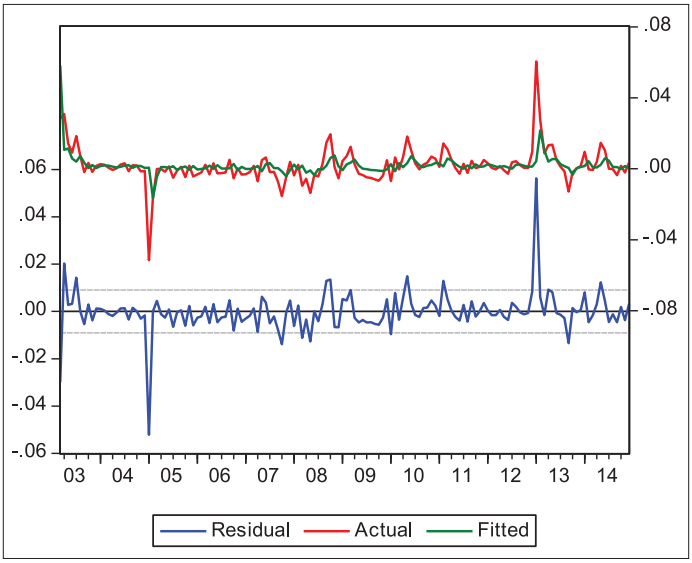
Residual derived from mean Equation (1) is used in forming variance Equation (2), for the variance equation, σ_t^2 is the conditional variance of the residual (error term ε_t), it measures the volatility of exchange rate in Egypt (Figures 4 and 5) - α, is the constant term of the variance equation, ε_{t-1}^2 is the lagged squared residual derived from Equation (1) (it is the ARCH term), σ_{t-1}^2 is the lagged conditional variance (it is the GARCH term). The model includes three exogenous variables as they can contribute to the exchange rate volatility in Egypt; interest rate differentials (IRDs) is IRDs defined by the difference between Egyptian and US interest rates of government securities, 6-month treasury bills, TRBAL is trade balance defined by the difference between goods value of exports and goods value of imports in Egypt (calculated in billion USD) and RES is the official Egyptian reserves (calculated in billion USD). While, β_1 and β_2 are coefficients of ε_{t-1}^2 and of σ_{t-1}^2 respectively, and Υ_1, Υ_2 and Υ_3 are coefficients of *IRD*, *TRBAL* and *RES* respectively. Descriptive statistics of variables used in monthly analysis are shown in Table 3. The source of monthly

Table 2: ADF test statistics

Variable	Level		1st difference	
	Intercept	Intercept+time trend	Intercept	Intercept+time trend
ERM	−0.6391	−0.5042	−14.4024*	−14.5338*
IRD	−1.6246	−3.0794	−10.5586*	−10.5193*
TRBAL	−2.0321	−6.6169*	−16.7391*	−16.6778*
RES	−1.19567	−1.2455	−4.3280*	−4.6215*

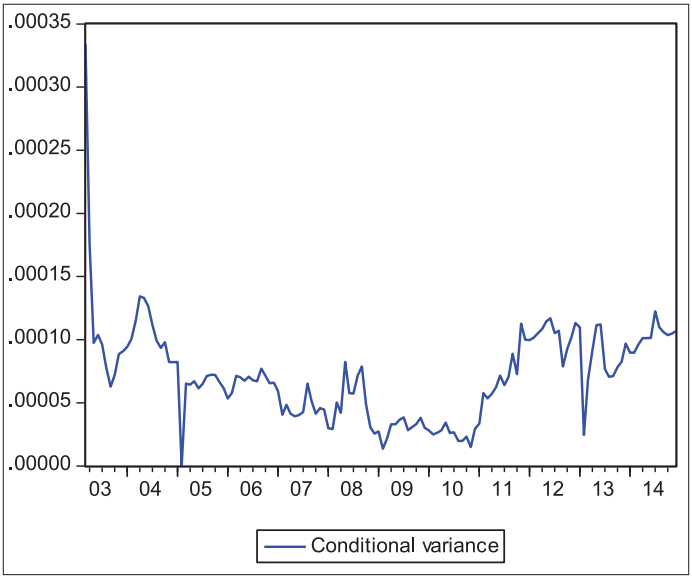
Source: Author's estimation (statistical work is performed using E-views software version 6). *Result is significant at 5% level. IRD: Interest rate differentials, ADF: Augmented Dickey–Fuller

Figure 4: Residual derived from mean equation January 2003-December 2014



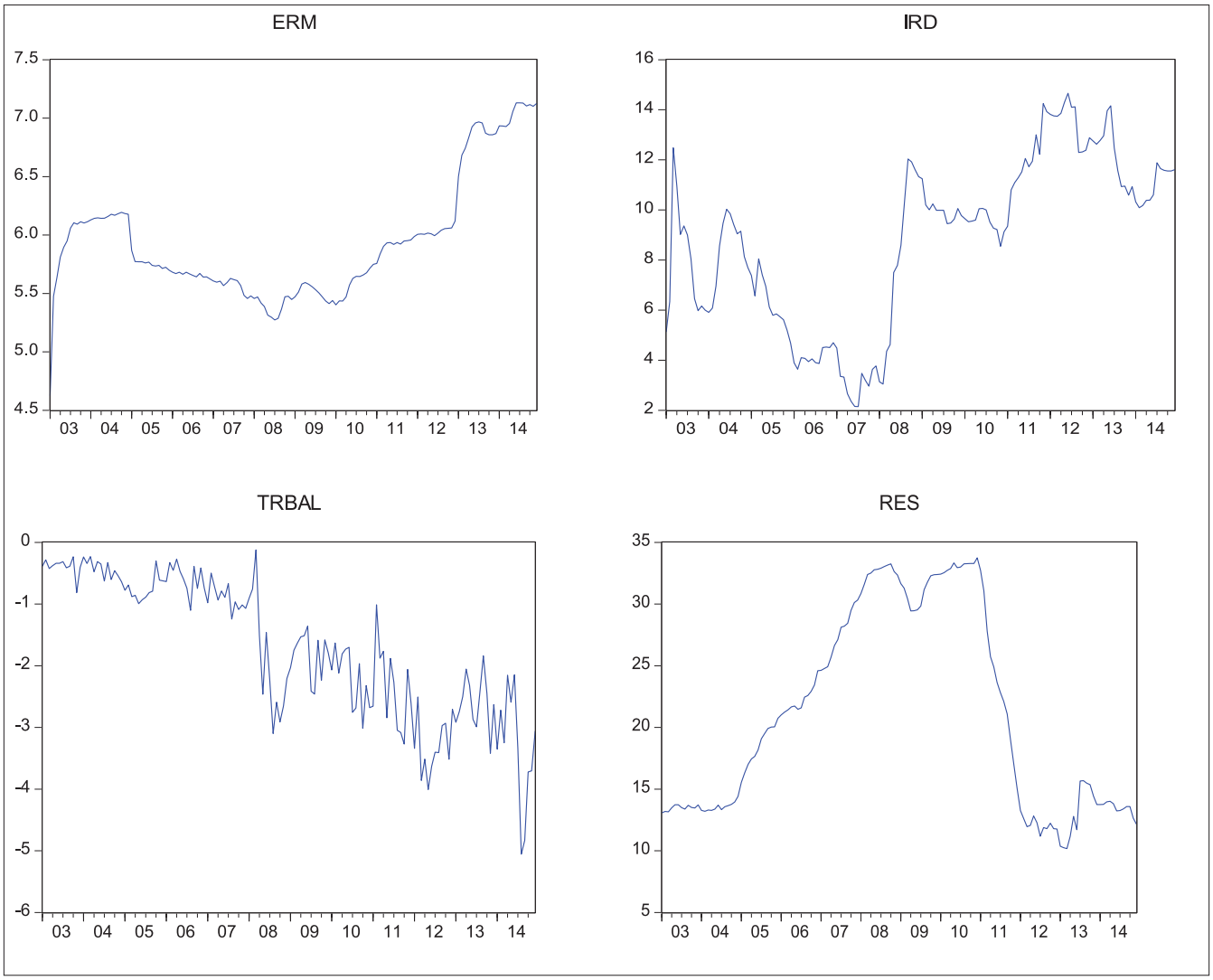
Source: Author's estimation (statistical work is performed using E-views software version 6)

Figure 5: Conditional variance January 2003-December 2014



Source: Author's estimation (statistical work is performed using E-views software version 6)

Figure 6: Time series plots of monthly data; (ERM) exchange rate of Egyptian pound against US Dollars, interest rate differential interest rate differentials, (TRBAL) trade balance and (RES) Official Egyptian Reserves



Source: Author preparation using International Financial Statistics database

Table 3: Descriptive statistics of variables used in monthly analysis

Statistics	USD/EGP average (monthly BID rates)	IRDs	Trade balance (billion USD)	Official reserves (billion USD)
Mean	5.941176	8.834347	−1.71758	21.14794
Standard error	0.043247	0.281666	0.095897	0.675919
Median	5.7697	9.543	−1.63255	19.974
Mode	5.4706	8.05	−0.8154	#N/A
Standard deviation	0.518962	3.379989	1.150762	8.111023
Sample variance	0.269321	11.42432	1.324253	65.7887
Kurtosis	0.258624	−0.99424	−0.72989	−1.52647
Skewness	0.950078	−0.3202	−0.45305	0.306696
Range	2.506	12.517	4.935624	23.57246
Minimum	4.6249	2.146	−5.05612	10.17031
Maximum	7.1309	14.663	−0.1205	33.74277
Sum	855.5293	1272.146	−247.332	3045.303
Count	144	144	144	144

data is International Financial Statistics database; time series plots of monthly data are shown in Figure 6.

Since one of the main CBE's policies is to reduce the exchange rate volatility, including some monetary policy variables in the model allows addressing the issue of how effective they are. That is, whether they have calming effect on exchange rate volatility or they further accelerate the volatility.

The interest differentials, offering chances for arbitragers and therefore induce markets to create liquidity, raise volatility in the short period but is insignificant in the longer prospect. Egyptian regulations to limit arbitrage are more effective in the long run. Greater IRD are more likely to increase exchange rate volatility (Kocenda and Valachy, 2006). Larger differentials may signal inefficiency of business cycle management, thus, monetary policy and exchange rate required to be adjusted. Central Bank intervenes against volatile fluctuation of its currency by reserves. Reserves act as shock absorber against factors affecting currency

stability; therefore, the Central Bank uses reserves to maintain exchange rate stability. Trade balance investigating if export and import performances have significant influence on exchange rate volatility, the degree of commercial liberalization and trade barriers affecting the degree of country's trade openness, capital flow and hence, exchange rate. Some variables were excluded from this study such as inflation differentials and public debt as trials investigated the existence of multicollinearity problem.

4. EMPIRICAL RESULTS

The estimation results of GARCH (1,1) model in Table 4 show that the first three coefficients constant (α), ARCH term (β_1) and GARCH term (β_2) are statistically significant at the 5% level. The statistical significance of the coefficient α shows the presence of volatility clustering in GARCH (1,1) model. Also the significance of both (α) and (β) indicates that, lagged conditional variance and lagged squared disturbance have an impact on the conditional variance, in other words this means that information about volatility from the previous periods has an effective power on current volatility. Moreover, Table 4 also shows that; the sum of the two estimated ARCH and GARCH coefficients $\beta_1 + \beta_2$ (persistence coefficient) is approximately 0.5 which is not close to unity indicating that volatility shocks are not that quite persistent, and volatility will not remain for so long time. The negative sign of the mean equation is an indication to the depreciation of the Egyptian Pound against USD during study period.

The IRDs coefficient is positively signed and it is statistically significant, meaning that differences between interest rates across countries increase the variance of the exchange rate. The negative sign and the statistical significance of RES indicating that amount of reserves had moved the exchange rate in the desired direction. This shows that the CBE achieved its objective of calming down exchange rate fluctuations - as mentioned earlier. However, it is important to notice that the positive impact of trade deficit on exchange rate volatility, one may however, assume that purposed depreciation of Egyptian Pound against USD aiming to enhance export performance rather than to stabilize the exchange rate.

Table 4: GARCH estimation of the exchange rate

Dependent variable: LOG (ERM) Method: ML-ARCH (Marquardt)-Normal distribution Sample (adjusted): 2003M02 2014M12				
Variable	**Coefficient**	**Standard error**	**z-statistic**	**P**
C	−0.029569	0.031291	−0.944956	0.3447
LOG (ERM(-1))	1.017715	0.017767	57.28214	0.0000
Variance equation				
C	7.92E-05	2.71E-05	2.923621	0.0035
RESID(-1)^2	0.071131	0.028400	2.504645	0.0123
GARCH(-1)	0.474657	0.134574	3.527105	0.0004
IRD	6.30E-06	2.53E-06	2.487005	0.0129
TRBAL	2.09E-05	1.01E-05	2.072290	0.0382
RES	−1.97E-06	6.55E-07	−3.008650	0.0026

Source: Author's estimation (statistical work is performed using E-views software version 6), IRD: Interest rate differentials, GARCH: Generalized autoregressive conditional heteroscedasticity

In general, it is regarded that the effectiveness of intervention in influencing exchange rate is more difficult to assess, since the exchange rate is more susceptible to multi-dimensional indicators and market reactions to them.

5. CONCLUSION

This study analyzes empirically the impact of Central Bank actions through IRDs and reserves level as well as trade balance on exchange rate volatility in Egypt using GARCH framework. The main results are as follows; volatility clustering exists during study period, IRDs and trade deficits accelerates exchange rate volatility, while keeping high reserves calms it down.

As CBE tends to decrease exchange rate volatility, it is highly recommended that reserves level should be maintained quite elevated, mitigate IRDs and it is important to find solutions for trade deficit that Egypt encounter for long time through import substitution or export promotion trade policies.

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