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MONETARY POLICY RESPONSE ON EXCHANGE RATE VOLATILITY IN INDONESIA

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Abstract

High fluctuation of exchange rate in short horizon is obviously making economic activity more risky as uncertainty rises. As it is not good for the economy, then there should be a systematic and measured policy to mitigate the foreign exchange fluctuations and to minimize the fluctuations, as well as to drive it to its fundamental value. In this part this research measures how persistent the exchange rate fluctuation in Indonesia is, and how are thus the central banks able to perform appropriate monetary policy, especially in determining their policy interest rate, or to make foreign exchange intervention to stabilize the exchange rate. In this study, USD/IDR volatility is investigated using TGARCH approach. The result reveals that, USD/IDR volatility in Indonesia is obviously persistent. This study also presents the outcomes of effectiveness of policy response by the Central Bank. Foreign-exchange sale interventions by the Central Bank lead to a slight USD/IDR decrease. Whatever Bank of Indonesia's efforts to exert a stabilizing effect of foreign exchange interventions, the results are inconclusive.

Keywords*: exchange rates, foreign-exchange intervention, GARCH*

JEL Classification: *F31, E52, C58*

Introduction

Following global economic integration, rapid growth of international trade and capital flows development push exchange rate transactions to grow even more as financial markets also have been playing an increasing role in funding the international trade and foreign exchange speculation. As a consequence, it is noted that daily foreign-exchange turnover

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is exponentially increasing followed by higher volatility. This is supported by Kocenda and Valachy (2006) that confirm volatility increases under a less tight floating regime than pegged regime. Using TARCH approach, they claim asymmetric decreasing effects of news on exchange rate volatility, as well as contemporaneous impact of the interest differential. This is also supported by Kóbor and Székely (2004). Using Markov regime-switching model (low volatile regime and high volatile regime), they confirm that volatility is lower in lowly volatile periods. Meanwhile, Bulí (2005) arrives at an opposite conclusion that financial liberalization significantly contributes to the stability of the exchange rates in all four countries examined. Meanwhile a study by Kocenda (1998) finds that the Czech exchange rate is less volatile with a wider fluctuation band in EU countries.

Over the last few decades, many countries have been adopting floating exchange rate regime. As a consequence, these respected countries have been facing wide fluctuations of their exchange rates as capital flows freely coming in or out the countries. Nevertheless, free floating exchange rate will be needed by independent monetary authority to conduct independent monetary policy. Floating exchange-rate has also been regarded as an automatic stabilizer which is able in some cases to rebalance the unbalanced economy. However, many countries usually are reluctant to allow their currencies to fluctuate because of the potential for sharp exchange rate movements to exacerbate inflationary pressures and financial sector vulnerabilities (Calvo and Reinhart, 2000). Foreign exchange rates can move to undesired long-run fundamental levels (overshoot phenomenon) in the short horizon which is not good for domestic economy if it persists.

Besides a free foreign exchange market mechanism, foreign-exchange regime adopted plays a significant role in the dynamics of the foreign-exchange rates. The failure of Bretton Woods exchange rate system followed by free floating exchange rate, has led to significant fluctuation in both real and nominal exchange rates. Exchange-rate fluctuation has widened since then. The liberalization of capital flows and the associated intensification of cross-border financial transactions also appear to have amplified the volatility of exchange rates and the misalignment movement of exchange rate from its fundamental value. The increase in exchange rate volatility and misalignment is widely believed to have detrimental effects on international trade and capital flows, thus having a negative impact on domestic economy.

The exchange-rate fluctuation has a close relationship with the supply and demand of foreign exchange which is ignited by economic fundamentals such as inflation rates, productivity, real interest rates, consumer preference, government trade policy, and market sentiments such as news about future market fundamentals and traders' opinion about future exchange rates. In the short run horizon, foreign-exchange transactions are dominated by transfers of assets (bank accounts, government securities) that respond to differences in real interest rates and to shifting expectations of future exchange rates. Over the medium run, exchange rates are governed by cyclical factors such as cyclical fluctuations in economic activity. Over the long-run, foreign-exchange transactions are dominated by flows of goods, services, and investment capital, which respond to forces such as inflations rates, investment profitability, consumer taste, productivity, and government trade policy (Carbaugh, 2013).

Indonesia is among the countries that adopted a free floating exchange rate regime. By freely floating exchange rate and its position as a small open economy, Indonesia' exchange rate movements are strongly influenced by capital flows and net export's proceeds. Although Indonesia adopted ITF, it does not mean that rapid exchange-rate fluctuation is desirable.

Hence, existence of central bank optimal monetary response (i.e. foreign exchange intervention) is needed to mitigate the exchange-rate fluctuations and drive the exchange rate for the long-term equilibrium exchange rate. For example, Bank Indonesia applied various monetary policies including exchange-rate intervention policy to stabilize USD/IDR and drive it to its fundamental value. Hence, even though the IDR performed worse between 2011 and 2013, Rupiah experienced the lowest volatility when compared to the other currencies of regional economies.

Since Indonesia has adopted a floating exchange rate regime in the wake of the 1997 economic crisis, the value of the rupiah continues to be volatile and determined by fundamental and speculative forces. If exchange rate fluctuations are not anticipated, increasing exchange rate volatility may lead risk-averse agents to reduce their international trading activities (Chit, Rizov, and Willenbockel, 2010). As a small open economy, sometimes the Rupiah movements overshoot in a short horizon ignited by market sentiments. This condition is deteriorated when macroeconomic indicators announcements show unfavorable development. Countering this, Bank Indonesia as the monetary authority, has had exchange-rate interventions in order to prevent sharp currency movements. These efforts should be made in order to avoid domestic price fluctuations, as well as to promote export competitiveness through the maintenance of a low, stable exchange rate. In this regard, Bank Indonesia's foreign-exchange intervention has been to enter the foreign-exchange market so as to stabilize market expectations, calm disorderly market, and limit unwarranted short term exchange rate movements because of temporary shocks (Warjiyo, 2005).

Exchange rate is determined by supply and demand of foreign exchange in a free foreign exchange market that causes the exchange rate movements, i.e. to appreciate or depreciate. The exchange rate might be very volatile in a short period. Indeed, exchange rates can fluctuate by several percentage points even during a single day. Exchange rate volatility is commonly accepted to have a negative effect on domestic economy passed through international trade and capital flows. The fluctuations are ignited directly through uncertainty and adjustment costs, and indirectly through its effect on the allocation of resources and government policies. Investors rely on favorable economic environment to invest and avoid an uncertain climate. Exchange-rate volatility worsens the economic climate as it is interpreted as uncertainty; it becomes a key input to many investment decisions and portfolio design. The first Basle Accord in 1996 suggests financial risk management as a tool to forecast volatility as compulsory exercise for many financial institutions around the world. Indeed, monetary and financial authorities often rely on market estimates of volatility as an indicator of the vulnerability of financial markets and the economy.

Discussing exchange-rate volatility which is characterized by mild and volatile periods is as interesting and important when measuring it. Two proposed processes to measure volatility are presented in autoregressive conditional heteroscedasticity (ARCH) model developed by Engle (1982) and general autoregressive conditional heteroscedasticity (GARCH) model developed by Bollerslev (1986). These models have been proven to provide a good fit for many exchange rate series in literature, allowing volatility shocks to persist over time by imposing autoregressive structure on the conditional variance. This persistence is consistent with periods of relative volatility and tranquility in returns and it is employed to explain the non-normalities in exchange rate series. As it is crucial to observe and investigate the underlying reasons for volatility as well as measuring it, this dissertation tries to measure and explain the volatility in the USD/IDR exchange rate utilizing TGARCH model.

The study is organized as follows: Section 1 provides the background of the research. Section 2 briefly discusses the theory and empirical evidences of volatility of exchange rate, including an econometric framework for measuring exchange rate volatility. Section 3 provides the applications of exchange-rate volatility models to Indonesian case. Section 4 offers conclusions.

The volatility of financial time series data: the theory and empirical evidences

It is commonly admitted that rapid volatility in financial time series data, is caused by the presence of statistically significant correlations between observations. Financial data generally characterized by heteroscedasticity in the data showing time-varying volatility. Further explanation can be found in Ozturk (2006), Harris and Sollis (2003). Meanwhile, as outlined by Brooks (2002), conventional time series model such as:

$$y = \beta_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + u$$

is also unable to explain a number of important features common to much financial data, including:

- *Leptokurtosis* – that is, the tendency for financial asset returns to have distributions that exhibit fat tails and excess peakedness at the mean.
- *Volatility clustering or volatility pooling* – the tendency for volatility in financial markets to appear in bunches. Thus large returns (of either sign) are expected to follow large returns, and small returns (of either sign) to follow small returns.
- *Leverage effects* – the tendency for volatility to rise more following a large price fall than following a price rise of the same magnitude.

As heteroscedasticity has been commonly existing in financial time series return data, Engle (1982) proposes a model in which a variance to be modeled and therefore instead of considering heteroscedasticity as a problem to be corrected. the conditional variance of a time series is a function of past shocks. Generally, financial price changes deviate consistently from log normality when the normality is considered as unconditional distribution of the series will be non-normal. There are more very large changes and (consequently) more very small ones than a lognormal distribution call. Brooks (2002) argued that the phenomenon called “fat tails or leptokurtic” as excess kurtosis. This fact explains that the lognormal diffusion model fails because of price overshoot occasionally from one level to another without trading at the prices in between. He also explains the characteristic known as volatility clustering, as shown by the fact that large changes of the data tend to follow large changes, of either sign, and small changes tend to follow small changes. Studies by Mussa (1979), Friedman and Vandersteel (1982), and Hsieh (1988) find that means and variances of daily USD exchange rate series change over time. Meanwhile, study by Hsieh (1989) finds that GARCH (1,1) and EGARCH (1,1) are able to overcome conditional heteroscedasticity problem from daily exchange-rate movements in 5 countries examined. Moreover, he claims that EGARCH is fitted to the data slightly better than standard GARCH using a variety of diagnostic checks. Furthermore, studies by Bollerslev (1987), Hsieh (1989) and Baillie and Bollerslev (1989b) conclude GARCH (l,1) provide good description for most exchange rate series under free floating exchange rate regime.

Ozturk (2006); Baillie and Bollerslev (1989a); Pagan and Schwert (1990) find that time series appear to have unit roots and warn against non stationarity problem. Positive (negative) correlation between consecutive price changes lowers (raises) measured volatility relative to the true value. They also find that there is trade-off between increasing accuracy by using daily data with a larger number of observations and losing accuracy because of the relatively greater effect of transitory phenomena on daily prices. There is an assumption that, volatility persistence, which is highly significant in daily data, weakens as the frequency of data decreases. On the other, Drost and Nijman (1993) find opposite conclusion on their study. They insist that the structure of the volatility does not depend on frequency of the data used. Therefore, he argues that different frequent data such as hourly, daily, or monthly intervals in the data would result in the same volatility. However, important findings by Diebold (1988), Baillie and Bollerslev (1989b) show that conditional heteroscedasticity disappears if the sampling time interval increases to infinity.

Measuring volatility: ARCH/GARCH model

As outlined by Brooks (2002), most financial time series data exhibit periods of unusually large volatility followed by periods of relative tranquility which called heteroscedasticity phenomenon. To measure exchange-rate volatility within this phenomenon, the most popular time-varying volatility model or non-linear model is widely used such as Arch model. This model was pioneered by Engle (1982).

In this part of this dissertation, the exchange rate volatility is investigated within the ARCH family models. Threshold GARCH (TGARCH) is chosen to model the exchange rate volatility clustering where large changes in returns are likely to be followed by further large changes in addition to include leverage effect. GARCH itself estimates conditional volatility by forming a weighted average of a long term average (the constant term), from information about the volatility observed in the previous period (the ARCH term), and the forecasted variance from the last period (the GARCH term). In order to estimate models from the ARCH family, maximum likelihood is employed to find the most likely values of the parameters given the actual data.

Therefore, to explain the fluctuation/volatility of the exchange rate in Indonesia, TGARCH approach is implemented. TGARCH model is relevant to be applied in exchange-rate model as it assumed that downward movements in the market are less volatile than upward movements of the same magnitude (a kind of irreversibility) a TGARCH model can be specified. The 'T' stands for threshold – a TGARCH model is a GARCH model with a dummy variable which is equal to 0 or 1 depending on the sign of u_{t-1}. A TGARCH (1,1) model is specified as:

$$\sigma_{u_t}^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \cdots + \alpha_p u_{t-p}^2$$

Foreign exchange volatility: the empirical literature

As this rising exchange-rate volatility would hamper domestic economy through international trade performance and inflation through its power of pass-through, measuring exchange rate volatility has been an important area of research as supported by empirical study

Bakhromov (2011), Boar (2010), and further study by Fountas and Bredin (1998). They find evidence that exchange-rate volatility has a negative effect on real export in the short run on in the respective countries examined. While in the long run, its influence is insignificant. A study by Musyoki, Pokhariyal, Pundo (2012) in Kenya, concludes that real exchange rate volatility has a negative impact on economic growth in Kenya economy. Similar research is elaborated by Dell'Ariccia (1999) investigating the effect of exchange rate volatility on bilateral trade flows, and further investigation of the impact of exchange rate volatility on the volume of bilateral exports is done by Baum, Caglayan, Ozkan(2004), and Choudhry (2005), applying the GARCH model for measuring volatility. Further study by Musyoki, Pokhariyal, Pundo (2012) also concludes that excessive exchange-rate volatility in Kenya generally exhibited an appreciation and volatility trend that undermines Kenya's International trade competitiveness. With respect on exchange rate volatility, a study by Fountas and Bredin (1997) also found evidence that in the short run the exchange rate volatility and the associated uncertainty has a negative effect on real export, while in the long run it is insignificant. On the other hand, opposite conclusion is found in the study by Mahmood, Ehsanullah, and Ahmed (2011) in Pakistan. They indicate the presence of positive impact of exchange rate volatility on GDP, growth rate and trade openness. Meanwhile, he finds negative impact of exchange rate volatility on foreign direct investment. Further study for G-7 countries by Abdur and Chowdhury (1997) find result indicating the exchange-rate volatility has a significant negative impact on the volume in each respective country. This implies that exchange-rate uncertainty as a response to excessive exchange-rate volatility, reduces their activities, changes prices, and shifts sources of demand and supply.

The magnitude of exchange rate dynamics within countries depends not only on macroeconomic conditions but also on the exchange-rate regime chosen by them. Most countries prefer price stability and therefore avoid rapid change of their exchange rate as literature largely confirms a negative relationship between exchange-rate volatility and economic growth. Actually, there are several reasons why a country chooses a specified exchange-rate regime or even prefers adopting a fixed exchange rate regime. One of them is mainly based on its own interest to protect their domestic interest even though other countries maz feel unhappy with the choice. Some of them think that tighter exchange-rate regime is safer to ensure domestic price stability environment. This is confirmed by Baxter and Stockman (1989). While Ghosh, Gulde, and Wolf (2003) also support that reason as pegged regimes is no worse than that of floating regimes. Supported by overshooting theorem By Dornbush, they test for speed of convergence within Purchasing Power Parity (PPP) theorem and their findings confirmed a positive significant coefficient for exchange rate volatility, meaning that the higher the exchange rate volatility, the stickier the prices are.

With regard to monetary policy, central banks will continue to intervene in foreign-exchange markets by trading directly or indirectly to mitigate the high exchange-rate volatility. Orlowski (2003) examines the impact of monetary policies on exchange rate risk premiums and inflation in the Czech Republic, Hungary, Poland, and Slovakia. Republic Poland and Hungary confirm the success of these countries, in lowering inflation, rather than exchange rate volatility. Meanwhile, Dominguez (1998) suggests that official purchases of the dollar increase the exchange rate volatility. He also examines the effects of US, German and Japanese monetary and intervention policies on dollar-mark and dollar-yen exchange rate volatility over the 1977-1994 periods, which confirm that the presence of a central bank in the foreign exchange market influences volatility. Another study employing FIGARCH model by Beine, Bénassy-Quéré and Lecourt (1999), finds that traditional GARCH estimations

tend to underestimate the effects of central bank interventions

With regard to the effectiveness of interventions, studies in Turkey by Domac and Mendoza (2002), Agcaer (2003), Guimarães and Karacadag (2004) and Akinci, Culha, Ozlale, and Sahinbeyoglu (2005a) and (2005b), employing EGARH model, suggest that overall central bank auctions have reduced the conditional variance. However, when the impact of auctions is studied separately, the reduction of volatility is a result of sales and purchase operations which do not seem to have statistically significant effect on volatility of exchange rate. The interesting finding also confirms that the overnight interest rate has a negative effect on exchange rate volatility. Furthermore, Agcaer (2003) finds that the presence of the central bank matters, and foreign exchange auctions and direct interventions have a favorable impact on both the level and volatility of exchange rates. However opposite result are found by Domac and Mendoza (2002). They find that purchases have a positive effect on the level of exchange rates, while sales have no such significant effect.

On the other hand, Guimarães and Karacadag (2004), reveal that neither foreign exchange sales nor purchases appear to be significant in affecting exchange rate level. When variance equations are examined, only the foreign exchange sales are found to be reducing volatility in the short-term, but increasing it in the long-term. Other study by Akinci, Culha, Ozlale, and Sahinbeyoglu (2005a) and (2005b) using probit analysis and Granger causality tests to analyze the main motivation of CBRT interventions, finds that, there is two-way causality between sale interventions and volatility.

Application of foreign-exchange volatility model to Indonesia

Measure of volatility

As previously explained, unlike real sector data, heteroscedasticity exists in many financial series including foreign exchange which do not have constant mean and variance (where). It also exhibits phases of relative tranquility followed by periods of high volatility. An econometric model that can encounter this problem in time-series models is the autoregressive conditional heteroscedasticity (ARCH) or (GARCH).Utilizing TGARCH models, this study tries to measure and explain the volatility in the USD/IDR exchange rate level.

Regarding the dependent variable, i.e., the volatility of exchange rates, this dissertation employs the Threshold General Autoregressive Conditional Heteroskedasticity (TGARCH) model. This model comprises a leverage term that allows for the asymmetric effects of good and bad news. The general *TGARCH (p,q)* model is specified as:

$$r_t = a_0 + \sum_{i=1}^{p} a_i r_{t-i} + \sum_{i=0}^{Q} b_i \varepsilon_{t-i}\,;\ \varepsilon_t \sim N(0, \sigma_t^2)$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{p} a_i \varepsilon_{t-1}^2 + \sum_{i=1}^{q} \beta_i \sigma_{t-1}^2 + \xi d_{t-1} \varepsilon_{t-1}^2$$

Where:
r_t : the exchange rate change over two consecutive trading days.
σ^2_t : the conditional variance that is a function of not only the previous realizations of ε_t, but also the previous conditional variances and the leverage term.

The leverage term in this model is the dummy variable d_{t-1} which equals 1 in the case of a negative shock ($\varepsilon_{t-1} \leq 0$) and 0 in the case of a positive shock ($t-1 > 0$). Thus, the positive value of the coefficient ξ indicates an increased conditional variance by ε^2_{t-1} in the case of negative shocks or news that occur at time t-1, while the negative value of coefficient indicates a decreased conditional variance. The additional restriction $\sum_{i=1}^{p} a_i + \sum_{i=1}^{q} \beta_i < 1$ is a sufficient and necessary condition for stability of the conditional variance.

The most appropriate ARMA(P,Q) model of the exchange rate return is estimated using the Box-Jenkins methodology (Box and Jenkins, 1976) in order to get a properly specified model and correctly conditioned volatility. Then the Ljung-Box Q-test is applied to test squared residuals of the ARMA(P,Q) model for the presence of conditional heteroskedasticity (Ljung and Box ,1978). The next step is to identify the orders of the TGARCH(p,q) process by experimenting with different orders p and q; estimating the whole ARMA(P,Q)-TARCH (p,q) model is estimated using the maximum likelihood estimation where the log-likelihood function has the form

$$L = -\frac{1}{2T}\sum_{t=1}^{T} \log \sigma_t^2 + \varepsilon_t^2/\sigma_t^2$$

Finally, the standardized residuals are diagnosed by applying the Ljung-Box Q-test and the LM test for the presence of an ARCH process (Engle, 1982). If the estimated model is a correct one, then these residuals should be white noise and no further GARCH process should be present.

Overview of the data

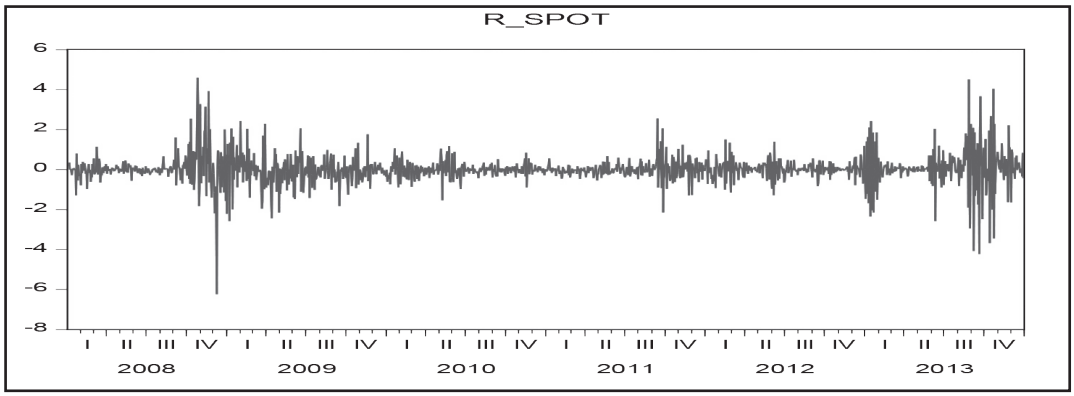
A broad consensus has emerged that nominal exchange rates over the free float period are best described as non stationary, or specifically I (1), type processes: see e.g. Baillie and Bollerslev (1989b). Therefore in this empirical study, exchange rate series is calculated as the daily difference in the logarithm form:

$$Dlfx = \ln fx_t - lnfx_{t-1} \cong \left(\frac{fx_t}{fx_{t-1}}\right) - 1$$

The foreign exchange rate data (*fx*) are the daily market foreign exchange closing rate for 1 USD. Data consist of daily prices from 3 January 2008 and 31 December 2013, for a total of 1,564 observations excluding weekends and holidays. In fact, the sampled period offers a clear picture as it includes both appreciation and depreciation periods, and both selling and purchasing foreign-exchange interventions by BI.

Graphical illustration of the data in Figure 1 displays volatility clustering which means that there are periods of high and low variance.

Figure 1. Volatility in USD/IDR series (daily return)



Source: Author's calculations

Before modeling time series data, it is important to check the stationarity of data. In order to test the stationarity of the series three different unit root tests: (1) the Augmented Dickey-Fuller (ADF) test with optimal lag length determined by both the Schwarz Info Criterion and Akaike Info Criterion, (2) the Phillips-Perron (PP) test, and (3) the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are employed. While the ADF and PP test statistics test the null hypothesis that exchange rate return series contains a unit root, KPSS statistics test the null hypothesis that series is stationary. The tests are repeated with constant term and with constant and trend terms. Table 1 displays the results of the tests and all tests indicate the stationarity of the return of the foreign exchange rate series denoted with R_Spot_t I(0).

Table 1. Unit root tests

Null Hypothesis: R_SPOT has a unit root Exogenous: Constant Lag Length: 0 (Automatic – based on SIC, maxlag = 23			Null Hypothesis: R_SPOT has a unit root Exogenous: Constant Bandwidth: 19 (Newey-West automatic) using Bartlett kernel			Null Hypothesis: R_SPOT has a unit root Exogenous: Constant Bandwidth: 19 (Newey-West automatic) using Bartlett kernel	
	t- statistic	Prob.*		Adj t-stat	Prob.*		LMStat
Augmented Dickey-Fullertest statistic	**-47.25723**	**0.0001**	Philips-Perron test statistic	**-46.63928**	**0.0001**	Kwiatkowski-Philips-Schmidt-Shin test statistic	**0.29534**

Source: Author's calculations

Additionally, Table 3 reports the Ljung-Box–Pierce Q statistics of autocorrelation of the deviations and the squared deviations of exchange rate series from its sample mean. Ljung-Box–Pierce Q statistics carries out the Breusch-Godfrey Lagrange multiplier test for high-order serial correlation. While the Q-statistic of the deviations are employed to detect autocorrelation, Q-statistic of the squared deviations (Q^2), are employed to test the volatility clustering or ARCH effects. For the exchange rate series, the statistics are calculated for lags up to 24 days. According to the results, there is a serial correlation and Q^2 statistic displays strong evidence of ARCH effect. The null hypothesis of the test is that there is no

serial correlation in the residuals up to the specified order. Rejection of the null hypothesis implies volatility clustering in the series.

Impact of Central Bank's Foreign Exchange Interventions

Generally, the literature investigating Indonesia experiences focused on the effectiveness of the Bank Indonesia (BI) interventions in general. Differently, in this study the impact of the Bank Indonesia's sale of foreign-exchange intervention (D_INT_Sell_Spot) and other possible relevant variable such as NDF rate and real interest rate differential (RIRD) and foreign-exchange turn over (GTOV_FX_TOTAL), will be examined. Therefore, the following model is proposed to model mean of the exchange rate returns and conditional volatility as follows:

$$R_{Spot_1} = a_0 + a_1 R_{Spot_{t-1}} + a_2 R_{NDF_t} + a_3 RIRD_t + a_4 GTOV_{FX_{TOTAL_t}} + a_5 D_{INT^*Sell_{Spot_t}} + \varepsilon_t \quad (1)$$
$$\varepsilon_t \,|\, \Omega_{t-1} \sim N\,(0, h_t)$$

For TGARCH (1,1)

$$h_t = b_0 + b_1 R_{Spot_{t-1}} + b_2 R_{NDF_t} + b_3 RIRD_t + b_4 GTOV_{FX_{TOTAL_t}} + b_5 D_{INT^*Sell_{Spot_t}} + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1} + \xi d_{t-1}\varepsilon_{t-1}^2 \quad (2)$$

where $b_{0,}$ α, β > 0 dan α + β < 1

Table 2. Mean equation and pre-estimation test results

Dependent Variable: R_SPOT
Method: Least Squares
Date: 07/15/14 Time: 14:16
Sample (adjusted): 1/04/2008 12/31/2013
Included observations: 1563 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.073351	0.054676	-1.341570	0.1799
R_SPOT(-1)	-0.306758	0.022883	-13.40573	0.0000
R_NDF	0.402657	0.019795	20.34148	0.0000
RIRP	0.009802	0.009116	1.075332	0.2824
INT_SELL_SPOT	4.41E-10	1.12E-10	3.938418	0.0001
GTOV_FX_TOTAL	-0.001270	0.000603	-2.108006	0.0352

R-squared	0.250244	Mean dependent var	0.018866
Adjusted R-squared	0.247836	S.D. dependent var	0.688651
S.E. of regression	0.597249	Akaike info criterion	1.810867
Sum squared resid	555.3921	Schwarz criterion	1.831421
Log likelihood	-1409.192	Hannan-Quinn criter.	1.818508
F-statistic	103.9351	Durbin-Watson stat	2.269315
Prob(F-statistic)	0.000000		

Source: Author's Calculations

Table 3. Q Statistics of deviations and squared deviations

Date: 07/15/14 Time: 14:17
Sample: 1/03/2008 12/31/2013
Included observations: 1563
Q-statistic probabilities adjusted for 1 dynamic regressor

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	-0.13...	-0.13...	28.592	0.000
		2	-0.01...	-0.03...	28.808	0.000
		3	0.045	0.040	31.992	0.000
		4	0.035	0.047	33.871	0.000
		5	0.054	0.069	38.515	0.000
		6	0.004	0.021	38.541	0.000
		7	0.075	0.079	47.314	0.000
		8	-0.04...	-0.03...	50.295	0.000
		9	0.126	0.116	75.332	0.000
		1...	-0.06...	-0.04...	82.073	0.000
		1...	-0.00...	-0.01...	82.076	0.000
		1...	-0.00...	-0.03...	82.196	0.000
		1...	0.036	0.028	84.231	0.000
		1...	0.002	-0.00...	84.235	0.000
		1...	0.002	0.015	84.239	0.000
		1...	0.017	0.002	84.711	0.000
		1...	-0.00...	0.015	84.751	0.000
		1...	0.045	0.029	88.019	0.000
		1...	-0.06...	-0.04...	94.208	0.000
		2...	0.058	0.039	99.543	0.000
		2...	0.058	0.071	104.91	0.000
		2...	-0.00...	0.010	104.91	0.000
		2...	-0.03...	-0.03...	106.61	0.000
		2...	-0.01...	-0.03...	107.04	0.000

*Probabilities may not be valid for this equation specification.

Date: 07/15/14 Time: 14:18
Sample: 1/03/2008 12/31/2013
Included observations: 1563

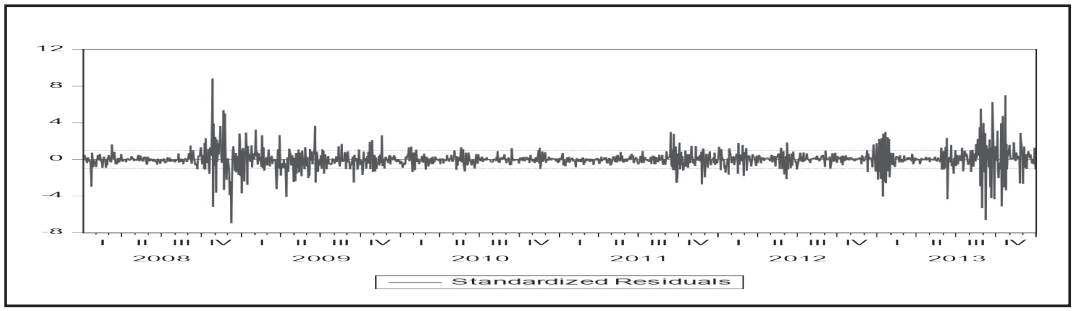
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.326	0.326	166.52	0.000
		2	0.297	0.214	305.09	0.000
		3	0.158	0.014	344.26	0.000
		4	0.191	0.098	401.29	0.000
		5	0.178	0.084	450.98	0.000
		6	0.210	0.100	520.21	0.000
		7	0.161	0.028	560.74	0.000
		8	0.137	0.012	590.42	0.000
		9	0.110	0.010	609.63	0.000
		1...	0.096	0.001	624.07	0.000
		1...	0.211	0.152	694.02	0.000
		1...	0.144	0.010	726.74	0.000
		1...	0.196	0.072	787.14	0.000
		1...	0.148	0.034	821.96	0.000
		1...	0.124	-0.01...	846.07	0.000
		1...	0.098	-0.00...	861.32	0.000
		1...	0.190	0.104	918.34	0.000
		1...	0.205	0.089	984.63	0.000
		1...	0.213	0.054	1056.5	0.000
		2...	0.161	0.011	1097.8	0.000
		2...	0.146	0.021	1131.8	0.000
		2...	0.064	-0.08...	1138.4	0.000
		2...	0.073	-0.02...	1146.8	0.000
		2...	0.089	-0.00...	1159.4	0.000

Source: Author's calculations

Figure 2. Error terms from the OLS estimation of mean equation

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	72.93069	Prob. F(2,1555)	0.0000
Obs*R-squared	134.0388	Prob. Chi-Square(2)	0.0000



Source: Author's calculations

The results of standard OLS estimation of equation (1) are reported in Table 2, with the test statistics applied to estimated error terms. As can be seen from the graphical representation of estimated errors (Figure 2), although addition of explanatory variables to the model relatively loosens the clustering, the ARCH effect in series is obvious. Moreover, Ljung-Box serial correlation tests show sign of autocorrelation and the test p-values of Q^2 shown in the Table 3 are all zero, resoundingly rejecting the "no ARCH" hypothesis. As for the ARCH LM test for absence of conditional heteroscedasticity, it is highly significant at any level.

Table 4. Results of model 2 (with-without FX intervention by the Central Bank)

Dependent Variable: R_SPOT
Method: Least Squares
Date: 07/15/14 Time: 14:35
Sample (adjusted): 1/07/2008 12/31/2013
Included observations: 1562 after adjustments
Convergence achieved after 10 iterations
MA Backcast: 1/04/2008

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007601	0.006471	1.174687	0.2403
R_SPOT(-1)	0.295084	0.025348	11.64130	0.0000
R_NDF	0.598566	0.020733	28.87040	0.0000
RIRP	-0.001031	0.001126	-0.915022	0.3603
GTOV_FX_TOTAL	-0.001314	0.000520	-2.525501	0.0117
AR(1)	-0.141327	0.028888	-4.892204	0.0000
MA(1)	-0.849609	0.020714	-41.01658	0.0000

R-squared	0.385542	Mean dependent var	0.018762
Adjusted R-squared	0.383171	S.D. dependent var	0.688860
S.E. of regression	0.541020	Akaike info criterion	1.613749
Sum squared resid	455.1519	Schwarz criterion	1.637741
Log likelihood	-1253.338	Hannan-Quinn criter.	1.622669
F-statistic	162.6144	Durbin-Watson stat	2.006158
Prob(F-statistic)	0.000000		

Inverted AR Roots	-.14
Inverted MA Roots	.85

Dependent Variable: R_SPOT
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/15/14 Time: 14:28
Sample (adjusted): 1/08/2008 12/31/2013
Included observations: 1561 after adjustments
Convergence achieved after 39 iterations
MA Backcast: 1/07/2008
Presample variance: backcast (parameter = 0.7)
GARCH = C(9) + C(10)*RESID(-1)^2 + C(11)*RESID(-1)^2*(RESID(-1)<0) + C(12)*GARCH(-1)

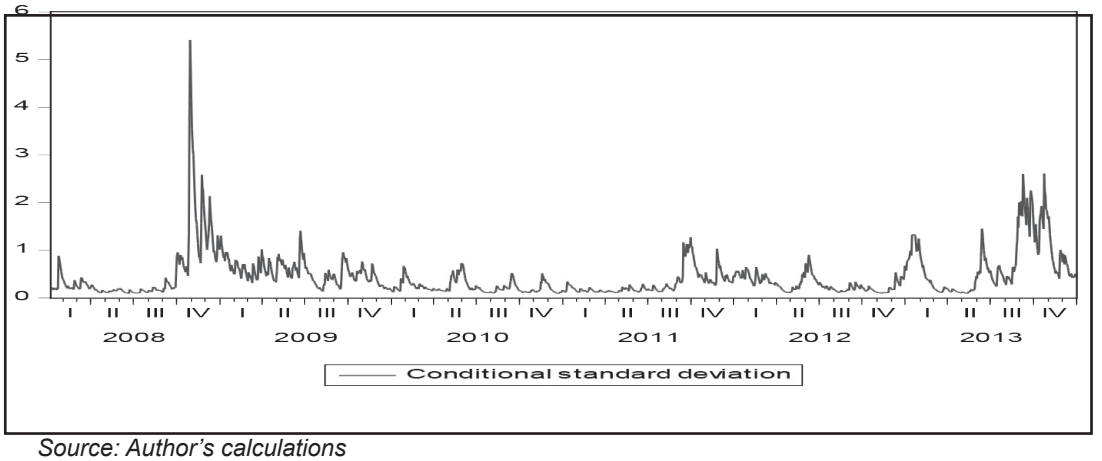
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.006336	0.002615	2.422762	0.0154
R_SPOT(-1)	0.086846	0.015244	5.697197	0.0000
R_NDF	0.829069	0.013576	61.06929	0.0000
RIRP	-0.001452	0.000435	-3.339679	0.0008
INT_SELL_SPOT	2.31E-11	1.20E-11	1.935385	0.0529
GTOV_FX_TOTAL	-0.000694	0.000141	-4.907635	0.0000
AR(2)	0.074764	0.031810	2.350323	0.0188
MA(1)	-0.864373	0.015371	-56.23538	0.0000
Variance Equation				
C	0.001834	0.000278	6.603382	0.0000
RESID(-1)^2	0.374907	0.026984	13.89345	0.0000
RESID(-1)^2*(RESID(-1)<...	-0.077814	0.034502	-2.255343	0.0241
GARCH(-1)	0.736115	0.012730	57.82519	0.0000

R-squared	0.327331	Mean dependent var	0.018550
Adjusted R-squared	0.324299	S.D. dependent var	0.689029
S.E. of regression	0.566389	Akaike info criterion	0.535563
Sum squared resid	498.1972	Schwarz criterion	0.576714
Log likelihood	-406.0069	Hannan-Quinn criter.	0.550863
Durbin-Watson stat	2.121663		

Inverted AR Roots	.27	-.27
Inverted MA Roots	.86	

Source: Author's calculations

Figure 3. Conditional standard deviation of TGARCH



Source: Author's calculations

Results of the Model 2 (volatility), estimated with TGARCH (1,1) are displayed in Table 4. According to the results of the model, the results confirm IRP theory, which suggests that an increase in real interest rate parity (RIRP) causes appreciation of the domestic currency. Furthermore, foreign exchange sale interventions lead return of exchange rate to decrease. On the other hand, foreign-exchange turn-over (GTOV_FX_TOTAL) has a negative impact on exchange-rate return significantly. It means that higher foreign exchange transactions (in value) will make the domestic foreign-exchange market more efficient. Besides, foreign-exchange sale intervention is estimated to be negative and statistically significant, which

can be interpreted as, an increase in foreign-exchange sale intervention causes Indonesian Rupiah Return to decrease. *However, the results of Bank Indonesia's efforts to exert a stabilizing effect of foreign exchange interventions are inconclusive*. Bank Indonesia's policy response in minimizing exchange rate volatility cannot be said to be effective as it cannot reduce the volatility of USD/IDR (in term of reduced conditional variance).

On the other hand, the NDF return has a positive impact on the on-shore exchange rate return. When the impact on return of exchange rate is investigated, as expected, R-NDF is estimated to be positive and statistically significant, which can be interpreted as an increase in return of NDF causes Indonesian Rupiah return to increase for more. Therefore, it is important for the central bank to introduce a new policy called JISDOR (Jakarta Interbank Spot Dollar Rate) to reduce the role of NDF in driving on-shore exchange rate.

The coefficients on all four terms in the conditional variance equation are highly statistically significant. Also, as is typical of TGARCH model estimates for financial asset returns data, the sum of the coefficients on the lagged squared error and lagged conditional variance is very close to unity. This implies that shocks to the conditional will be highly persistent. This can be seen by considering the equations for forecasting future values of the conditional variance using a TGARCH model given in a subsequent section. A large sum of these coefficients will lead future forecast of the variance to be high for a protracted period. The conditional variance coefficients are also as one would expect. The variance intercept term 'C' is very small, while the coefficient on the lagged conditional variance ('GARCH') is smaller at 0.74 when the Central Bank enters the domestic FX market. The core of this leverage term is the dummy variable d_{t-1} that equals 1 in the case of a negative shock ($\varepsilon_{t-1} \leq 0$) and 0 in the case of a positive shock ($t-1 > 0$). Thus, the positive value of the coefficient ξindicates an increased conditional variance by ε^2_{t-1} in the case of negative shocks or news that occur at time t-1, while the negative value of coefficient indicates a decreased conditional variance. In this case, the negative value of the coefficient ξindicates a decreased conditional variance by ε^2_{t-1} in the case of negative shocks or news that occurs at time t-1.

Table 5. Q, Q,2, and ARCH LM test statistics of TGARCH model

Date: 07/14/14 Time: 13:59
Sample: 1/03/2008 12/31/2013
Included observations: 1561
Q-statistic probabilities adjusted for 2 ARMA terms and 1 dynamic regressor

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	0.009	0.009	0.1357	
		2	-0.01...	-0.01...	0.6347	
		3	-0.01...	-0.01...	0.8020	0.370
		4	0.004	0.003	0.8225	0.663
		5	0.005	0.005	0.8613	0.835
		6	-0.01...	-0.01...	1.3408	0.854
		7	0.028	0.028	2.5428	0.770
		8	-0.02...	-0.02...	3.5535	0.737
		9	-0.00...	-0.00...	3.5636	0.828
		1...	-0.03...	-0.03...	5.9606	0.652
		1...	0.000	0.000	5.9606	0.744
		1...	-0.01...	-0.01...	6.3087	0.789
		1...	-0.00...	-0.00...	6.3446	0.849
		1...	-0.00...	-0.01...	6.4852	0.890
		1...	0.046	0.047	9.7734	0.712
		1...	0.008	0.005	9.8724	0.771
		1...	0.009	0.013	10.006	0.819
		1...	0.029	0.028	11.373	0.786
		1...	-0.00...	-0.00...	11.456	0.832
		2...	0.051	0.050	15.614	0.619
		2...	0.006	0.008	15.680	0.679
		2...	0.025	0.022	16.664	0.675
		2...	0.012	0.015	16.895	0.717
		2...	0.037	0.038	19.053	0.642

*Probabilities may not be valid for this equation specification.

Date: 07/14/14 Time: 13:59
Sample: 1/03/2008 12/31/2013
Included observations: 1561

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob...
		1	0.041	0.041	2.6198	0.106
		2	-0.00...	-0.00...	2.6833	0.261
		3	-0.03...	-0.03...	4.4049	0.221
		4	-0.02...	-0.02...	5.3416	0.254
		5	-0.01...	-0.01...	5.6134	0.346
		6	-0.01...	-0.01...	6.1556	0.406
		7	-0.01...	-0.01...	6.4316	0.490
		8	-0.01...	-0.01...	6.8735	0.550
		9	-0.00...	-0.00...	6.8735	0.650
		1...	0.003	0.001	6.8866	0.736
		1...	-0.00...	-0.00...	6.8979	0.807
		1...	-0.02...	-0.02...	7.5820	0.817
		1...	-0.00...	-0.00...	7.6285	0.867
		1...	0.006	0.005	7.6814	0.905
		1...	-0.00...	-0.01...	7.8070	0.931
		1...	-0.00...	-0.00...	7.8784	0.952
		1...	0.007	0.007	7.9578	0.967
		1...	0.006	0.004	8.0198	0.978
		1...	0.026	0.024	9.0821	0.972
		2...	0.036	0.034	11.172	0.942
		2...	-0.02...	-0.02...	11.952	0.941
		2...	-0.03...	-0.02...	13.615	0.915
		2...	-0.00...	0.001	13.642	0.937
		2...	0.077	0.077	22.961	0.522

*Probabilities may not be valid for this equation specification.

Heteroskedasticity Test: ARCH

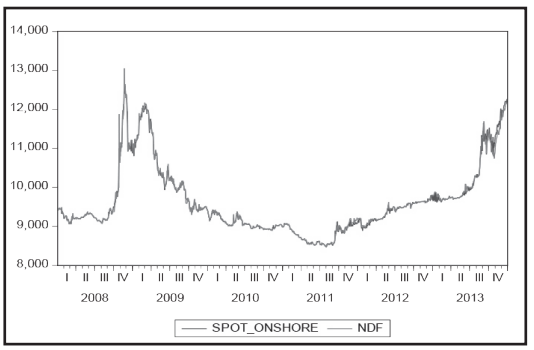
F-statistic	2.614953	Prob. F(1,1558)	0.1061
Obs*R-squared	2.613923	Prob. Chi-Square(1)	0.1059

Source: Author's calculations

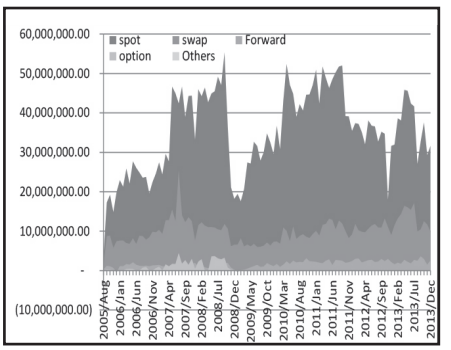
In Indonesia's case, this research is of the view that exchange rate movement does not always reflect the economic fundamental. Thus, foreign exchange intervention is applied in order that the exchange rate is consistent with the overall objective of achieving price stability and supporting financial system stability. Exchange rate overshooting occurs as previously mentioned because of a number of factors, such as excessive capital flows, speculative intention of foreign-exchange market players, and the microstructure conditions of the market, and ignited by sudden external shocks impact on the domestic financial market. Thus, as stated above, the objective of foreign exchange intervention is to mitigate the exchange-rate volatility as well as to drive the exchange rate along its fundamental path. Furthermore, beyond of that the foreign-exchange intervention implementations are consistent with achieving the inflation target and supporting financial stability.

However, it is regarded that the effectiveness of intervention in influencing exchange rate expectations is more difficult to assess, since the exchange rate is more susceptible to news developments and market reactions to them. In general, when market reactions are not excessive, foreign-exchange supply and demand in the market would be in equilibrium. Therefore, exchange-rate intervention by a central bank may be more effective in influencing both the spot and forward exchange markets if it is used to deal with any remaining excess demand or supply in the market. As shown in figure 5, foreign exchange turn-over in Indonesia is relatively shallow and dominated by spot transactions. This shallow turn-over is vulnerable to any external shocks or negative news. When news and market reactions are erratic, excess supply or demand of foreign exchange tends to widen, and the exchange rate movements tend to diverge from the central bank's view on where the fundamental exchange rate path should be. An example is what happened when negative rumors such as widening current account deficits, increasing fuel subsidy burdens related to fiscal unsustainability, and worries about foreign exchange liquidity in the domestic market, the spread between offshore (NDF-Non deliver forward) and onshore forward rates widened at that period (Figure 4). At the same time, the aggregate turnover in regional NDFs of Asian countries has risen, particularly in Renmimbi Yuan China. Asian NDFs tend to correlate positively among them and respond similarly to movements of major currencies. Fortunately, the spreads have diminished in recent years as central banks have performed several actions to mitigate the problem by ensuring foreign-exchange adequacy as well as by performing intensively moral suasion.

Figure 4. Exchange rate: Onshore vs NDFFigure 5 volume of FX transactions



Source: Bloomberg



Source: Bank Indonesia

The thinness of domestic foreign-exchange market makes exchange rate more volatile when external shocks exist. This shallow foreign-exchange market let the banks heavily dependent on the central bank absorb any excess supply in the market (during current account surplus and/or large capital inflow periods) and supply any excess demand in the market (during current account deficit and/or capital outflow periods). Therefore, Bank Indonesia ensures the adequacy of foreign exchange reserves daily as it may increase the credibility and effectiveness of intervention policy. To increase the supply of foreign exchange in the market, BI releases a regulation requiring all exporting/importing companies to repatriate their foreign exchange receipts from exports and offshore borrowing to domestic banks. In addition, a holding period for investment in the central bank's bill is implemented to limits on short-term offshore borrowing. Another policy has also been directed toward deepening the domestic foreign exchange market by including offering of foreign exchange term deposits, and toward relaxing forward transactions. The most recent measure in this area is the establishment of a market reference rate for onshore foreign exchange transactions (JISDOR – Jakarta Interbank Spot Dollar Rate), including forward transactions, thus limiting the impact of the offshore NDF rate on the domestic market. However, it is admitted that the effectiveness of intervention will also depend on the central bank's ability to influence market expectations; its credibility is a necessary condition.

Conclusion and policy implications

Conclusion

In this research, the sources of USD/IDR exchange rate volatility in Indonesia and the related exchange-rate policy are analyzed. Exchange rate volatility is estimated by TGARCH model with emphasis on the monetary response. Exchange rate volatility is determined by several factors such as fundamental economy or sentiment factors. In this research, Bank Indonesia foreign-exchange interventions, NDF return, and real interest rate parity, domestic foreign-exchange transactions, are considered and their impacts are investigated by bringing such factors together in a general framework and by trying to disentangle their significant effects on exchange rate volatility. This study further confirms the assumption that Indonesia as a small open economy tends to have a high and persistent exchange rate volatility when this result holds in most open emerging countries.

The fact is that the vulnerability of Indonesia may be explained by the different strengths of its economic fundamental. According to the results of the model, the results confirm IRP theory, which suggests that an increase in real interest rate parity causes appreciation of the domestic currency. Foreign-exchange-Sale Interventions move return of exchange rate to decrease slightly. However, the results of Bank Indonesia's efforts to exert a stabilizing effect of foreign exchange interventions, are inconclusive. This is supported by the findings by Dominguez (1998) which suggests that official purchases of dollar increase the exchange rate volatility. On the other hand, the NDF return has a positive impact on the on-shore exchange rate return. Therefore, it is important for the central bank to introduce a new policy called JISDOR (Jakarta Interbank Spot Dollar Rate) to reduce the role of NDF in driving on-shore exchange rate. Either way, further research is needed in order to see other relevant factors that have significant impact on foreign exchange rate volatility.

Policy implications

There are some policy implications regarding the findings of the empirical results, such as:

a) High fluctuation of exchange rate in short horizon is obviously making economic activity more risky as uncertainty rises. Moreover, volatile exchange rates also make commodity prices, interest rates and a host of other variables more volatile as well. Although changes in long-run exchange rates tend to undergo relatively gradual shifts, in the shorter horizon, the exchange rate might be very volatile. Then there should be a systematic and measured policy to mitigate the foreign exchange fluctuations and to minimize the fluctuations as well as to drive it to its fundamental value. In this part, USD/IDR volatility is investigated using TGARCH approach. The results reveal that, USD/IDR volatility in Indonesia is persistent.

   As a policy recommendation, the foreign-exchange volatility should be minimized through some measures. Foreign-exchange interventions would be the possible and relevant measure to solve the problem within a short horizon. While ITF requires free floating exchange rate regime to increase the central bank's monetary policy independence, there are some reasons why monetary authorities prefer some degree of control over the exchange rate. Among them, firstly, a high degree of exchange rate pass-through into domestic prices meaning that exchange rate movements have important implications for monetary policy. In this respect, inflation targeting is not necessarily inconsistent with exchange rate intervention. Secondly, domestic currency depreciation might lead to currency mismatches on domestic balance sheets increase in cases where there is a large amount of external debt held by various sectors of the economy. Thirdly, high exchange rate volatility is also ignited by sharp reversals of capital flows that may cause fear-driven momentum in exchange rate movements, leading to possible overshooting and potentially damaging volatility. A managed float design could solve it.

   However, there are some circumstances where attempting to actively limit movements in the exchange rate may not be the optimal policy response. Allowing nominal exchange rate movements as a response to sustained capital inflows, for instance, helps to contain the local currency prices of imported/exported goods and insulate the domestic supply of money and credit, mitigating inflationary pressures in the domestic economy.

b) Even though foreign-exchange sale interventions by the Central Bank has been effective to halt depreciation of USD/IDR where the foreign-exchange intervention have led to a slight decrease of return on the USD/IDR. However, the results of Bank Indonesia's efforts to exert a stabilizing effect of foreign-exchange intervention, are inconclusive.

   As a policy recommendation, there should be a better strategy in implementing the policy such as appropriate strategy when entering the foreign-exchange market. Bank Indonesia should take into account factors such as market liquidity conditions, transaction turnover, and market psychology whenever entering the domestic foreign-exchange market. The execution of foreign currency intervention policy should consider both timing and magnitude, in order to avoid predictability. Intervention operations should also be conducted in a measured and careful manner, recognizing the importance of foreign exchange reserve adequacy. The sale of US dollars in the domestic foreign exchange market should be structured so as to provide a resistance level for the

currency, with the objective of reducing the probability of exchange rate movements beyond that level.

c) In inflation targeting framework, inflation target is the main objective. However, it is known that inflation is determined by several factors. One of the significant factors is exchange rate through its power of pass-through effect. Therefore, it is important for the central bank to set the optimal level of the exchange rates. The effort to set optimal exchange rate is also the main duty of the monetary authority in every country. In this regard, the exchange rate dynamics of USD/IDR has a significantly positive relationship with domestic interbank o/n interest rate as a proxy of central bank's interest rate. The increase of the USD/IDR (depreciation) will then push domestic interbank o/n interest rate to increase, in order to prevent further depreciation of the USD/IDR.

   As a policy recommendation, setting appropriate policy interest rate to drive the exchange rate isan important task for the central bank in driving the actual inflation to its target and implicitly desired economic growth. Short-term policy interest rate is one of monetary operation instruments chosen by Bank Indonesia. The policy interest rate, in this regard, has a causal effect on exchange rate. Besides being determined by exchange-rate changes, the interest rate may also have a significant role in driving the exchange rate to its desired level. As exchange rate has a significant influence on inflation and economic growth, the central bank has a duty to manage it properly. Improved by other monetary instruments, the objective would be reached more effectively.

d) For a small open economy like Indonesia, exchange rate movement does not always reflect a fundamental value. Increasing USD/IDR exchange rate volatility often occurs as a result of volatile capital flows, irrational behavior of market players, the microstructure conditions of the market, and offshore market influence.

   As a policy implication, relying solely on Bank Indonesia's interest rate policy to achieve the inflation target and maintain stability is not always sufficient. The central bank's strategy is to include exchange rate policy in the monetary and macro-prudential policy mix consisting of five policy instruments, i.e. interest rate policy, exchange rate policy, management of capital flows, macro-prudential policy, and monetary policy communication.

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