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Interest Rate Policy and Exchange Rates Volatility Lessons from Indonesia

Abstract: Whether or not inflation targeting adoption leads to increased volatility of exchange rates is controversial. The volatility increases with inflation targeting as a result of the flexible exchange rate regime. Others argue that inflation targeting delivers the best outcomes in terms of lower exchange rate volatility. The purpose of this paper is to investigate whether interest rate policy in inflation targeting frameworks – that is subjected to control inflation rate – may reduce the volatility of exchange rates. To test the hypothesis, we use monthly data in the case of Indonesia over the period 2005(7)-2016(7). Several control variables are introduced in the regressions. The result of the autoregressive distributed lag model proves the interest rate policy and foreign exchange intervention fail to reduce the exchange rates volatility. It seems inflation targeting in Indonesia puts too much emphasis on stabilizing the domestic currency thus leading to benign neglect of stabilizing its external value, ultimately resulting in increased exchange rate volatility. These findings suggest that central bank credibility plays an important role in conducting inflation targeting policy which operates primarily through a signalling effect.

Keywords: Inflation Targeting, Interest Rate Policy, International Reserve, Exchange Rates Volatility, ARDL

JEL Code: E42, E52, E58, F31

1. Introduction

Whether or not inflation targeting (IT) adoption leads to an increase in the volatility of exchange rate is controversial. In an economy with free mobility of capital flows, the independence of the monetary policy cannot coexist with the pegged exchange rate. Conventional theory prescribes that an ideal IT regime should have an inflation target as its primary objective and, therefore, should not simultaneously pursue an exchange rate goal (Obstfeld et al., 2005). Hence, the volatility increases with IT as a result of the flexible exchange rate regime (Edwards, 2006).

In contrast, IT delivers the best outcomes in terms of lower exchange rates volatility. The implicit trade-off between inflation and exchange rate stabilization goals in the "impossibility of the holy trinity" has pushed economists to reformulate their policy ingredients. The higher volatility of exchange rates is one of the costs of IT (Sek and Ooi, 2012). Therefore, IT is not necessarily accompanied by the higher volatility of exchange rates due to foreign exchange market intervention. As a result, there is still no consensus on the size or even the sign of the effects of IT on the exchange rates volatility.

While industrial countries adopt "strict" or "pure" IT, IT in developing countries, by and large, is "flexible". Rose's (2007) description of inflation as Bretton Woods "in reverse" is the departure point. Emerging market economies with IT generally have less flexible exchange rate arrangements, intervene more frequently in foreign exchange markets than their advanced economy counterparts, and have a greater response to real exchange rate movements (Chang, 2008; Aizenman and Hutchison, 2011, Kurihara, 2013).

However, IT in emerging market economies has experience higher exchange rates volatility (see for example: Berganza and Broto, 2012). While exchange rate under IT poses some challenges for emerging economies, the exchange rate is a more important monetary policy tool for emerging economies that have adopted IT than it is for IT advanced economies (Stone et al., 2009). Hence, floating exchange rate mechanisms have become increasingly more prevalent in emerging markets.

Recognizing the exact link between IT and the exchange rate stabilization is crucial. For policy maker, the exchange rate plays a significant role in the development process of an economy. It is also a critical element especially for small open economies as both its level and stability are important in increasing exports and private investment which are the main sources of growth in developing countries. Exchange rate is a more significant transmission mechanism than the interest rate (Krušković, 2017). Reconsidering issues arising from studies connecting interest rates to exchange rates will also help the central bank in emerging markets to avoid exchange rates volatility better by using an active monetary policy (Cabral et al., 2018).

Indonesia provides a unique opportunity to assess the nature of monetary policy and exchange rates stabilization. Experience of a dramatic depreciation in accordance with Asian financial crisis in 1997/98 has directed the monetary authority to focus on the economic recovery and stabilization. Accordingly, since 1999, Indonesia has been implementing a new law for the central bank. By Act No. 23/1999, the central bank of Indonesia has to be independent of any interventions. Also, refer to Act No. 3/2004, since July 2005 the central bank of Indonesia has been officially adopting IT in the monetary policy frameworks relying on BI Rate as the main interest rate policy[1]. After that, gradually Indonesia in the 2010s is one of the largest developin g countries to implement various economic liberalization reforms that produce strong economic growth (Abdurohman and Resosudarmo, 2017). Accordingly, lessons from Indonesia will be useful to develop a better exchange rates stabilization policy design for developing countries.

This paper enriches the literature on monetary policy in the context of exchange rate stabilization with a focus on Indonesia. The motivation for this approach associates to the fact that Indonesia is a small-open economy in the international context so the scope for actively stabilizing international monetary conditions remains limited. Moreover, under the free-floating exchange rate system, Indonesia consistently conducts some prudent macroeconomic policies to face possible depreciation in the short- and medium-terms so it would be suboptimal to cut back international reserve to make more room for speculative attacks. Therefore, implementing pro-balancing monetary measures is likely to require an increase in the size of the international reserve. This brings us back to the challenge for dominant IT theories, which are typically silent about the role of foreign exchange reserves, and therefore warrant further attention (Hviding et al., 2004).

The rest of the paper is divided into five sections. The second section is on the theoretical framework as well as the related empirical studies. This is followed by the third section which explains the econometric procedure and data used. The proceeding section exposes the empirical findings along with the robustness checks. The last section provides some concluding remarks of this paper.

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[1] Since August 2016, BI Rate has been replaced by BI 7-day Reverse Repo Rate as the policy rate.

2. Literature Review

The role of interest rate policy -- as the key instrument in IT -- in exchange rate fluctuations could be analysed in three ways. The first is exchange rate pass-through (ERPT) that measures the change in local currency domestic prices resulting from 1 per cent change in the exchange rates. In the IT regime, the monetary authorities are assumed to have the ability in forecasting inflation so the degree of ERPT into domestic prices is low. In contrast, the inability of monetary authorities in forecasting inflation could be in the presence of high ERPT into domestic prices. The positive relationship between the expected inflation rate and exchange rate leads the success of inflation targeting strategy (Bulut, 2018).

Economic literatures offer some reasons why the high degree of ERPT exists in the IT regime. Taguchi and Sohn (2014) argue the backwards-looking manner loses the inflation-responsive rule under IT adoption, thereby showing the unclear linkage between the loss of inflation-responsive rule and the pass-through. Pontines and Siregar (2012) point out the IT framework of monetary policy tends to adopt a form of asymmetrical exchange rate behaviour, wherein appreciation pressures are restrained more substantially than depreciation pressures. The backwards-looking manner and asymmetrical exchange rate behaviour induce domestic economy is highly influenced by external factors, making the central bank is difficult to prescribe the effective monetary policy.

Uncovered interest parity (UIP) is the second way to study the relationship of the exchange rate and monetary policy. UIP theory states the difference in interest rates between two countries will equal the relative change in currency foreign exchange rates over the same period (Madura and Fox, 2014). UIP conditions consist of two return streams, from the foreign money market interest rate on the investment and from the change in the foreign currency spot rate. UIP assumes foreign exchange equilibrium, implying the expected return of a domestic asset will equal the expected return of a foreign asset after adjusting for the change in foreign currency exchange spot rates.

By the ex-ante UIP condition, higher-yielding currencies are expected to depreciate against the (foreign) lower paying counterpart. In practice, however, this condition is often violated and confirms the theoretical notion that exchange rates are determined by much more than interest rate differentials. In emerging markets, where the UIP condition is not observed (ex-post), a persistent positive term on the interest rate differentials coefficient implies a stronger currency (Frankel and Poonawala, 2010). Accordingly, the central bank will incorporate such factors in determining interest rate policy in order to stabilize the domestic financial market.

A high degree of ERPT and a persistent positive term on the interest rate differentials coefficient are often a reason for a country to ‘fear’ floating exchange rate and is thus a given rationale for the intervention in the foreign exchange market (Ball and Reyes, 2008; Junior, 2007). The domestic financial conditions of emerging economies react faster and strongly to global financial shocks than to the changes in domestic monetary policy rates (Calvo and Reinhart, 2002). Hence, conducting timely and quick monetary policy become a serious challenge (Bruno and Shin, 2015; Georgiadis and Mehl, 2016). Eventually, the autonomy in monetary policy can be achieved only by managing the capital account, irrespective of the exchange rate regime (Rey, 2018).

The third one is the inclusion of exchange rate term in the policy reaction function. While the exchange rate improves the performances of monetary policy rules (Senay, 2001), the central banks should concern the effects of exchange rate fluctuations on inflation and output gap rather than giving an independent role for the exchange rate in the policy reaction (Mishkin and Schmidt-Hebbel, 2002). The exchange rate already has the indirect effects on inflation and output in the policy reaction function so giving a direct role to exchange rate in the Taylor rule may add volatility to the monetary policy (Taylor, 2001). Hence, IT may reduce exchange rates volatility, if central bank can manage both domestic and foreign shocks.

Furthermore, the impact of interest rate policy on exchange rates volatility in the IT regime depends on the types of the exchange rate (Pontines, 2013), i.e. nominal and real effective exchange rates. Similarly, Pétursson (2009) notes the important functions of the exchange rate. He shows no systematic relationship between IT and excessive exchange rates volatility. The floating exchange rates not only serve as a shock absorber but are also an independent source of shocks suggesting that adopting IT does not by itself contribute to excessive exchange rates volatility.

However, many developing countries are reluctant to allow their currencies to float (Gagnon and Ihrig, 2004). The phenomena of ‘dollarization’ have suggested foreign exchange market interventions to reduce exchange rates volatility, whereas others have found that interventions have a limited effect on volatility (Petreski, 2012). Osawa (2006) argues intervention of the policy maker in the exchange rate movements may generate the risk of converting the exchange rate into a nominal anchor that takes over the inflation target. The unpredictable changes in financial dollarization strongly affect the nominal exchange rate (Fabris and Vujanović, 2017). As a result, IT regime has a little effect on the exchange rate stability.

The adoption of a free-floating exchange rate implied by the IT regime does not necessarily imply more effective of nominal and real exchange rate floating (Hausmann et al,, 2004). Many emerging countries that officially announce themselves to be free floaters are in fact managed exchange rate regimes (Adolfson, 2007). Under those circumstances, the monetary authority is likely to place an additional constraint on their monetary policy by smoothing the exchange rate floating. Sek (2009) and Aizenman and Hutchison (2011) also argue IT in emerging markets appears to follow a "mixed strategy" whereby both inflation and real exchange rates are important determinants of policy interest rates.

The IT regime accompanied by a free-floating exchange rate system affects the exchange rates volatility through capital mobility. Akyurek and Kutan (2008) found the developments in risk premium played a very significant role in the path of policy rates. By estimating a Taylor rule, they arrived at the proposition that during the IT period ERPT to inflation declined, and while capital inflows strengthened the real exchange rate, the nominal exchange rate and the financial markets in general, were affected by the occasional reversal of capital inflows.

The limited impact of interest rate policy on the exchange rates stabilization may be attributed to the lack of credibility monetary authority. Conventional wisdom holds that policy should respond to the exchange rate one step removed, only after fluctuations in the rate affect inflation or real output (Taylor, 2001). The credibility of a commitment to IT may be unstable. So, the credibility of the central bank's targeting regarding macroeconomic stabilization is important (Salle et al., 2013) to help to reduce unexpected shocks by making monetary policy transparent and predictable (Choudhri and Hakura, 2006). In addition, the credibility problem is an answer to the singular behaviour of the exchange rates volatility of emerging countries (Rocha and Curado, 2011).

In the case of Indonesia, the related studies have been conducted, for example Kuncoro and Sebayang (2013), Juoro (2013), and Adenan (2014). In general, they focused on the movement of exchange rate and inflation rate. Recently, some researchers incorporate bitcoin price growth (Narayan et al., 2019), oil prices (Narayan, Falianty, and Tobing, 2019), and financial technology (Narayan and Sahminan, 2018) to explain the volatility of exchange rates. However, none of them exploits the interest rate policy as explanatory variable.

3. Research Method

The previous researches outlined above provide some important factors to analyze exchange rates volatility in the context of IT regime. It seems the results regarding IT and exchange rates volatility are inconclusive since they focus on the inflation rate as the main actor. In our view, the use of the inflation rate as the main explanatory variable is not suitable. The inflation rate is the ultimate goal, not the policy instrument. As suggested by the IT regime, the interest rate is the primary monetary policy tool for influencing economic activity in particular prices stabilization including exchange rates.

We propose the use of interest rate policy as the main explanatory variable instead of the inflation rate. As noted by Kuncoro and Sebayang (2013), the respond of monetary policy to exchange rate was marginal. Also, Adenan (2014) presents that exchange rate did not significantly affect the inflation rate. Moreover, Juoro (2013) finds there was no bi-direction causal relationship between exchange rate and inflation rate. In the econometric point of view, the introduction of interest rate policy is to control potential endogeneity problems, particularly arising from exchange rate and inflation rate.

Besides interest rate policy, several control variables are introduced in the regressions to account for other factors affecting exchange rates volatility. The first is foreign exchange reserves. There are two classes of benefits arising from a high level of reserves (Hviding et al., 2004). Most prominently, a high level of reserve adequacy has been shown to reduce the likelihood of currency crises or a "sudden stop". The second beneficial effect is that higher reserve adequacy tends to be associated with lower external borrowing costs.

Those effects work both directly through improved confidence and indirectly through improved credit ratings on sovereign foreign currency debt since the government's default risk is perceived to diminish with higher reserves. With regard to the market confidence, we also incorporate market sentiment in the financial sectors to explain the exchange rates volatility. Moreover, the higher foreign exchange reserves can be understood as a good signal for foreign exchange market players. The change in foreign exchange reserves can also be interpreted as market intervention conducted by the monetary authority.

Eventually, we can construct the exchange rates volatility *(VER)* model that is a function of interest rate policy *(IRP)*, international reserve *(IRES)*, and volatility of financial market sentiment *(VMS)* in the linear form:

$$\text{VER} = \alpha + \beta \text{ IRP} + \gamma \log \text{IRES} + \delta \text{ VMS} + \varepsilon \qquad (1)$$

Equation (1) presents the long-term relationship. In the short-term relationship, we prefer to use the restricted ARDL (auto-regressive distributed lag) model to accommodate some adjustments. The use of ARDL model makes possible to easily assess VER both in the short- and long-run. Moreover, bearing in mind that standard unit root tests are susceptible to misleading results, Pesaran and Shin (1999) show ARDL models yield consistent estimates of the coefficients irrespective of whether the underlying regressors are I(1) or I(0), thus providing robustness to the results.

The model takes the restricted form as follows:

$$\Delta \text{VER}_t = \alpha + \beta_1 \Delta \text{IRP}_t + \beta_2 \text{IRP}_{t-1} + \gamma_1 \Delta \log \text{IRES}_t + \gamma_2 \log \text{IRES}_{t-1} + \delta_1 \Delta \text{VMS}_t + \delta_2 \text{VMS}_{t-1} + \varphi \text{ VER}_{t-1} + \varepsilon_t \qquad (2)$$

where φ is coefficient of partial adjustment, $0 \le \varphi \le 1$.

The Wald test is computed to test the null hypothesis, H_0: $\beta_2 = \gamma_2 = \delta_2 = \varphi = 0$ against the alternative hypothesis, H_a: $\beta_2 \neq \gamma_2 \neq \delta_2 \neq \varphi \neq 0$. If the Wald test value falls outside the upper bound, the null hypothesis of no co-integration is rejected. In other words, VER, IRP, log IRES, and VMS are said to be co-integrated. If the Wald test value falls below the lower bound, the null hypothesis of no cointegration cannot be rejected.

As suggested by Pontines (2013), we use 3 types of exchange rates volatility: (1) bilateral exchange rate, i.e. Rupiah against US dollar (USD), (2) nominal effective exchange rate (NEER), and (3) real effective exchange rate (REER) by assuming ERPT holds. The volatility of each exchange rate is measured by the coefficient of variation (CV), the standard deviation (SD) to the mean value ($\overline{X}$) ratio for 4 consecutive months.

$$\text{VER} \equiv \text{CV} = (\text{SD} / \overline{X}) * 100 \qquad (3)$$

Alternatively, we exploit the ARCH (autoregressive conditional heteroscedasticity) to observe the behaviour of the exchange rate. ARCH is a suitable tool to describe the variance of the current error term or innovation as a function of the actual sizes of the previous time periods' error terms; often the variance is related to the squares of the previous innovations:

$$\varepsilon^2_t = \alpha + \beta \, \Sigma \, \varepsilon^2_{t-p} \qquad (4)$$

If an autoregressive moving average model (ARMA) model is assumed for the error variance, the model is a generalized autoregressive conditional heteroscedasticity (GARCH) model. GARCH model addresses the issues of heteroscedasticity and volatility clustering by specifying the conditional variance to be linearly dependent on the past behaviour of the squared residuals and a moving average of past conditional variance:

$$\sigma_t^2 = \omega + \alpha \Sigma \varepsilon^2_{t-p} + \beta \Sigma \sigma^2_{t-q} \quad (5)$$

We employ the following indicators. The interest rate policy is represented by the BI Rate as the main operational target in the short-run. The measure of foreign exchange market intervention is constructed by the international reserves. In the case of Indonesia, the change in international reserves reflects the movement of capital and financial accounts. The composite of stock price index performed in Indonesian Stock Exchange is utilized to capture market confidence factor that may affect the market sentiment. The VMS is calculated in a similar way to the exchange rate as (3).

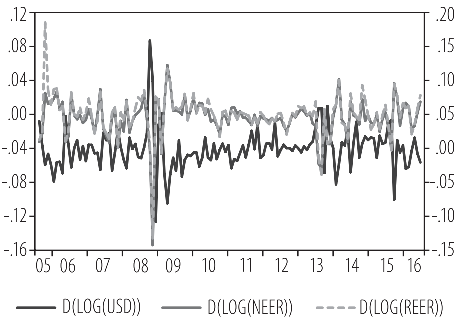
The sample periods extend from 2005(M7) to 2016(M7), i.e. the periods of BI Rate implementation. Ideally, the discussion of exchange rates volatility covers daily data. Unfortunately, the BI policy rate is determined on the monthly basis. Hence, we explore monthly data to evaluate the exchange rates volatility with cautions. Most of the monthly data are taken from the central bank of Indonesia. The data of NEER and REER are taken from the publications of Bank of International Settlement). Both the effective exchange rates data are stated in 2010 base year.

4. Result and Discussion

Figure 1 delivers the log-differenced exchange rates in the three measurements. It seems there is strong co-movement between fluctuations of NEER and fluctuations of REER. The correlation between the two variables of interest is 0.93. In contrast, the correlation between fluctuation of USD and two other measurements of exchange rates fluctuation is negative (-0.72 and -0.66 respectively). This result is plausible. The USD is calculated by US Dollar in term of Rupiah, implying the local currency is the denominator. The higher value of USD is the lower value of Rupiah.

The fluctuations as plotted in Figure 1 can be modelled as the conditional standard deviation. Some criteria imposed on GARCH model suggest that

Figure 1: The Growth Rate of USD, NEER, and REER



α = 1 and β = 1. Therefore, we conclude the GARCH(1,1) volatility model is adequate. Table 1 performs the behaviour of exchange rates fluctuations. The Wald test clearly indicates that the volatility process does not return to its mean mainly in the case of REER. The probability values of t, F, and χ^2 are 0.03 respectively. Those are enough to reject the null hypotheses that α + β = 1.

Because the volatility process of REER does not return to its mean value, the conditional standard deviation graph contour of REER rather fluctuates without a clear basic pattern. For USD, the coefficient β even is insignificant at 5 per cent confidence level. This means that the model can be used only to describe short-term USD volatility in order to predict in the near future. On the contrary, even though also fluctuates, the conditional standard deviation graph contour of NEER quite rather flats based on the basic value α = 1. Consequently, the standard deviation of USD and NEER is relatively more predictable than that of REER.

Table 1: GARCH Model Estimates

	USD		NEER		REER	
	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
Constant	-0.0823	0.3166	-0.0710	0.4084	0.1239	0.0511
ω	0.0002	0.0042	0.0001	0.0155	0.0000	0.0696
α	1.0069	0.0000	1.0760	0.0000	0.7792	0.0000
β	0.1451	0.0849	0.1860	0.0445	0.4276	0.0000
α + β = 1	Value	Prob.	Value	Prob.	Value	Prob.
t-stat	0.8015	0.4243	1.6009	0.1119	2.1430	0.0340
F-stat	0.6425	0.4243	2.5628	0.1119	4.5926	0.0340
χ^2-stat	0.6425	0.4228	2.5628	0.1094	4.5926	0.0321

In the next section, we explore the exchange rates volatility using the alternative measurement. Table 2 presents the basic statistics covering the mean, median, and extreme (maximum and minimum) values for all variables of interest. Each the median value is not too far from the respective mean (in particular IRP and VMS). The closeness of median to the mean value preliminary indicates that all of the variables of interest are normally distributed. The symmetric distribution of the three variables is confirmed by the moderate value of skewness. The skewness value of log IRES is slightly greater than 0 which indicates the series is normally distributed.

Furthermore, the range (distance from minimum to maximum) values vary. The range values of VNEER and VREER are relatively almost the same (9.3 and 8.5). In contrast, the range value of VUSD and VMS are the two highest (13.3 and 27.4). Other independent variables have the similar range value (7.0 to 9.0). They are consistent with the configuration of standard deviation. At this point, we can say VMS and IRES contributions to the VUSD, VNEER, and VREER variability are higher than that of IRP.

Table 2: Descriptive Statistics

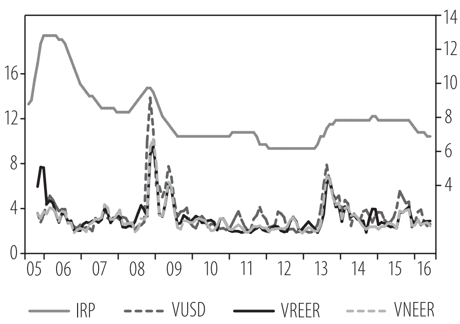
	VUSD	VNEER	VREER	IRP	log (IRES)	VMS
Mean	2.1053	1.5992	1.7567	7.7077	11.2554	5.1400
Median	1.6541	1.2103	1.3417	7.5000	11.4669	3.9657
Maximum	13.5935	9.4850	8.7166	12.7500	11.7332	27.9529
Minimum	0.2509	0.1709	0.2178	5.7500	10.3935	0.5192
Std. Dev.	1.9418	1.4859	1.5377	1.8122	0.3876	4.0575
Skewness	2.9307	2.8641	2.2484	1.4325	-0.5629	2.9875
Kurtosis	14.7125	13.2098	8.7568	4.5022	1.8721	14.6854

Figure 2 offers the exchange rates volatility and IRP. At the beginning of observations, the exchange rates volatility was remarkably high in relation to the high-interest rate. Even though still fluctuated, the exchange rates volatility was decreasing in the next 3 years. The exchange rates volatility rose again in 2008 in accordance with the global financial crisis. Those raise a preliminary hypothesis that the IRP that is subjected to manage the inflation rate at the same time cannot reduce the exchange rates volatility.

When we divide the sample period into pre- and post-global financial crisis, the conclusion does substantially change. In a pre-period of the global financial crisis, the correlation coefficient is +0.12 and that of the whole period is +0.66 respectively. The statistical evaluation above confirms the moderate co-movement between exchange rates volatility and IRP. This creates a positive correlation in the long-run and might dominate the short-run contemporaneous correlation. We, therefore, need to control for this long-run correlation in order to derive a more accurate estimate of exchange rates volatility to further analysis.

In the proceeding section, we focus on the time series properties of each series. We examine the existence of a unit roots using Augmented Dickey-Fuller (ADF)

Figure 2: Exchange Rates Volatility and Interest Rate Policy



and Phillip-Perron (PP) tests. The ADF unit root tests are biased toward a false unit root null when the data are trend stationary with a structural break. The structural break arises around 2008/09 when the global financial crisis erupted. This holds for the exchange rates volatility and VMS. Meanwhile, IRP and IRES experience a structural break around 2011 in relation to the end of commodity boom. Therefore, PP tests are used to check whether the unit root tests remain valid in the presence of a break.

The test is conducted 4 times for the level and the first-difference data respectively. The results of ADF and PP tests are reported in Table 3. Both tests conclude that all the variables are not entirely stationary in their level. Hence, the ADF and PP tests are applied again to the transformed series of each variable to check for the possibility of stationary in first differences. The tests confirm the stationary of all series on the first difference. In other words, in the first-difference forms, all the variables become stationary.

Table 3: Unit Roots Tests

	Level			First Difference		
	ADF	Breakpoint	PP	ADF	Breakpoint	PP
VUSD	-3.3129**	2009M02	-3.5528**	-10.1133*	2008M10	-18.6468*
VNEER	-4.2414*	2009M03	-4.1224*	-10.1504*	2008M11	-15.0186*
VREER	-2.1796	2009M05	-3.7666**	-9.9367*	2008M11	-14.4480*
IRP	-2.3041	2008M10	-1.5896	-4.5393*	2011M11	-4.3992*
log IRES	-3.1475**	2009M02	-2.1253	-9.5668*	2011M09	-9.6860*
VMS	-3.9615**	2009M12	-4.0530*	-11.4508*	2008M10	-9.2914*

(*) and (**) indicate significant at 1 and 5 per cent respectively

The null hypotheses of non-stationary can be rejected which does not demonstrate the existence of a common trend in those series. All of the series in all cases were found to be stationary at 5 or even 1 per cent significance level, implying the series data have a unit roots. It also implies that the behaviour of the variables varies around to the mean value and invariant over time (Enders, 2004). The occurrence of unit roots in the series gives a preliminary indication of shocks having a permanent or long-lasting effect, thus making it very difficult for traditional stabilization policies to survive.

To prove our hypothesis, we estimate the ARDL model as equation (2). The estimation results as in Table 4 reveal the coefficients of lagged independent variables are not entirely statistically significant. But the coefficient of the lagged dependent variable is highly significant. These preliminary perform the presence of co-integration, consistent with the error correction term (ECT) coefficient is 0.29, 0.46 and 0.46 respectively which are statistically significant. To ensure the presence of co-integration, then we test the possibility of co-integration by implementing the bound test. The result is presented in Table 5.

The result of Wald test values falls outside the upper bound in the lower probability value. The null hypothesis of no co-integration is rejected, suggesting the presence of co-integrating relation among exchange rates volatility, IRP, log IRES, and VMS. Alternatively, using Johansen's maximum likelihood approach (Johansen, 1988; 1991), we test the bi-variate between the three variables. The trace statistics together with maximum eigenvalue (λ max) for testing the rank of co-integration are shown in Table 5. The results confirm to the bound test. Hence, the three tests perform the presence of the co-integrating equations between the non-stationary (or stationary at the different levels) series which means that the linear combinations of them are stationary and tend to move towards the equilibrium relationship in the long-run.

Table 4: Bound Tests of ER Volatility Co-Integration Model

Test		Value	df	Prob.	Conclusion
VUSD	F	8.9961	(4, 121)	0.0000	Co-integrated
	χ^2	35.9843	4	0.0000	
VNEER	F	25.1115	(4, 121)	0.0000	Co-integrated
	χ^2	100.4459	4	0.0000	
VREER	F	26.3683	(4, 121)	0.0000	Co-integrated
	χ^2	105.4731	4	0.0000	

Table 5: Johansen Co-Integration Tests

Hypothesized No. of CE(s)	Eigen-value	Trace Statistic	0.05 Critical Value	Prob.
Unrestricted Co-integration Rank Test (Trace): VUSD				
None *	0.2523	81.6337	54.0790	0.0000
At most 1 *	0.1679	45.2848	35.1928	0.0030
At most 2 *	0.1136	22.3072	20.2618	0.0258
At most 3	0.0562	7.2348	9.1645	0.1146
Unrestricted Co-integration Rank Test (Trace): VNEER				
None *	0.2263	75.4194	54.0790	0.0002
At most 1 *	0.1716	43.3539	35.1928	0.0053
At most 2	0.0980	19.8214	20.2618	0.0574
At most 3	0.0539	6.9310	9.1645	0.1301
Unrestricted Co-integration Rank Test (Trace): VREER				
None *	0.2263	75.4194	54.0790	0.0002
At most 1 *	0.1716	43.3539	35.1928	0.0053
At most 2	0.0980	19.8214	20.2618	0.0574
At most 3	0.0539	6.9310	9.1645	0.1301

Trace test indicates 5 co-integrating equation(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

The empirical results show in the short run the IRP, surprisingly, fails to reduce the exchange rates volatility indicated by the positive sign of the corresponding coefficients. Statistically, they are significant for all cases. Looking at the magnitudes, they are far from each other (0.9, 1.1, and 2.1), indicating that VREER is the most responsive to the changes in IRP. The changes in IRP in the short-run create the REER volatility much higher than NEER and USD. This result confirms the finding obtained from GARCH analysis.

The same result is found in the lagged period of IRP for effective exchange rate specification models. It seems the behaviour of exchange rates volatility in the long run cannot be systematically reduced by IRP. This finding does support Prasertnukul et al. (2010) that adopting IT is less clear to help reducing the exchange rates volatility. These results confirm to the visual inspection of Figure 2 as explained above.

The particularly interesting about those results above is the effect of IRP changes on the exchange rates volatility appears to be permanent. Kuncoro (2015) confirms the implementation of IT has been rarely satisfied either in decreasing inflation rate or in directing the actual inflation rate to its target. It seems the central bank cannot predict well the actual inflation rate due to the existence of low degree of ERPT. The gap between the actual inflation rate and its target generates uncertainty in the current period then transformed into risk in the exchange rate. Eventually, the behaviour of exchange rates volatility tends to increase in the long-run.

In the short-run, the market intervention potentially has the beneficial effect to reduce the bilateral exchange rates volatility indicated by the negative sign of the coefficient of log IRES. Unfortunately, it statistically is insignificant at the 5 per cent confidence level. The other models even induce the exchange rates volatility. The free capital movement required by IT implies that the exchange rates volatility is strongly affected by the occasional reversal of capital inflows. Therefore, the market intervention will be ineffective. This result confirms to the limited effect of market intervention on the exchange rates volatility as surveyed by Petreski (2012).

In the long-run, the IRES has significant impact on the exchange rates volatility. This is verified by the coefficient of lagged IRES which is statistically insignificant at the 5 per cent confidence level. The capability to intervene foreign exchange market would increase the exchange rates volatility. This is plausible result since (1) the relatively low of international reserve (12 per cent of GDP). (2) The new financial assets emerge in the domestic market, such as bitcoin and financial technology. Therefore, the foreign exchange market intervention conducted by central bank is not powerful. This basically do not confirm to the conventional wisdom as suggested by Hviding et al. (2004) and Kandil and Morsy (2014).

Similar with IRP, the VMS has a positive impact on the short-run exchange rates volatility. In the central bank's point of view, the market sentiment would be considered as a surprise that should be anticipated since it would stimulate the exchange rates volatility pressure. This holds in the case of VUSD and VNEER, implying that the foreign exchange market players in the short-run more concern with the nominal value rather than the real one. In contrast, an increase in 1 point of VMS leads to decline 0.1-0,2 standard deviations to mean ratio of VUSD and NEER. In the long-term, the foreign exchange market players relatively pay much attention to all of the three types of exchange rates volatility.

Given those results, we can say the use of BI Rate together with market intervention create confusion for the market players since they give the same impacts. For the central bank, they basically substitute for each other. It seems IT puts too much emphasis on stabilizing the domestic value of the currency thus leading to benign neglect of stabilizing its external value, ultimately resulting in increased exchange rates volatility. This analysis confirms to Taguchi and Sohn (2014) that showed the weak linkage between the loss of inflation-responsive rule and the pass-through.

The estimation of the lagged dependent variable gives the significant coefficients. The associated coefficient displays the degree of persistence. The coefficient of lagged dependent variables is quite the same, suggesting that a change in the exchange rates volatility between month *t-1* and *t* drives up the exchange rates volatility process in *t* only 0.28 to 0.45 per cent partial adjustments to respond to the tolerated volatility. Consequently, the exchange rates volatility tends to be less persistent than to respond to economic conditions in the short-run.

Table 6 also presents the long-run estimation by removing all of the lag variables. Taking the residual, we get the ECT in the dynamic model (Engle and Granger, 1987). The significance of the lagged ECT indicates that our estimated exchange rates volatility model is well specified. The ECT acts as a force which causes the integrated variables to return to their long-run relation when they deviate from it. Overall, the VUSD model can be used for prediction and policy simulation purposes. Nevertheless, in the longer perspective, a considerable attention should be paid to the fluctuation of NEER and REER instead of merely focused on USD. Monetary policy based on the bilateral exchange rate could be misleading meanwhile monetary policy referred to NEER and REER will relatively effective to achieve the broader goals.

Table 6: The ARDL Model Estimation Results of Exchange Rates Volatility

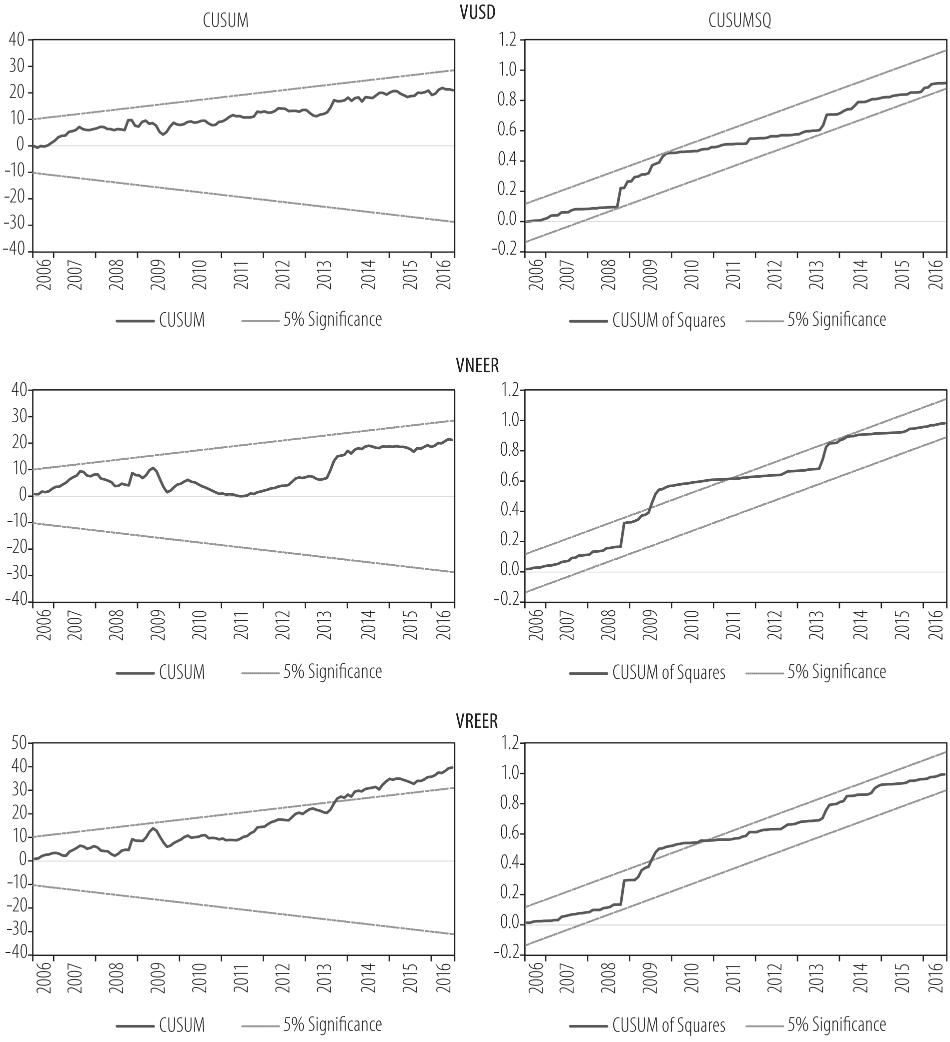
Dependent Variable:	Δ VUSD		Δ VNEER		Δ VREER	
	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
C	-10.7690	0.0280	-12.3987	0.0029	-7.6973	0.0627
Δ IRP	0.9309	0.0079	1.1497	0.0003	2.1533	0.0000
IRP(-1)	0.1367	0.0681	0.1541	0.0165	0.1523	0.0210
Δ log IRES	-2.4159	0.2900	3.9657	0.0490	3.9636	0.0508
log IRES(-1)	0.8412	0.0302	0.9633	0.0034	0.5719	0.0805
Δ VMS	0.2944	0.0000	0.1041	0.0001	0.0392	0.1372
VMS(-1)	0.1766	0.0000	0.2053	0.0000	0.1725	0.0000
Lagged	-0.2884	0.0000	-0.4320	0.0000	-0.4494	0.0000
R^2		0.5897		0.5147		0.5172
R^2-adj		0.5659		0.4867		0.4893
SEE		0.8431		0.7471		0.7527
F		24.8418		18.3350		18.5199
DW		1.7298		1.5513		1.6183
Normality	2.6320	0.2682	23.8716	0.0000	5.1425	0.0764
Serial Correlation (1)	3.4616	0.0653	9.7113	0.0023	6.9491	0.0095
	3.6169	0.0572	9.6581	0.0019	7.0614	0.0079
Heteroscedasticity	1.3673	0.2252	3.1094	0.0047	2.3393	0.0283
	9.4562	0.2215	19.6670	0.0063	15.3767	0.0315
ARCH	2.2463	0.0436	8.8349	0.0000	6.4171	0.0000
	12.8034	0.0463	38.5788	0.0000	30.6521	0.0000
	VUSD = -24.25 + 0.37 IRP + 1.92 log (IRES) + 0.37 VMP		VNEER = -6.04 + 0.17 IRP + 0.47 log (IRES) + 0.21 VMP		VREER = -1.57 + 0.28 IRP + 0.04 log (IRES) + 0.14 VMP	
ECT(-1)	-0.2946	0.0000	-0.4643	0.0000	-0.4626	0.0000

5. Robustness Checks

The estimation results as presented in Table 6 primarily in VNEER and VREER models violate some classical assumptions. Reestimating the basic model using OLS with breakpoints suggests that structural break exists around 2008 as found in the unit roots test. Moreover, the OLS estimators are sensitive to the presence of observations that lie outside the norm for the regression model of interest. The sensitivity of conventional regression methods to these outlier observations can result in coefficient estimates that do not accurately reflect the underlying statistical relationship.

As a robustness measure for empirical results, we use the cumulative sum (CUSUM) tests for the stability of the model. The plots of the CUSUM in Figure 3 fall within the 95 per cent confidence bands, which verify the stability of estimated parameters only in VUSD case. Another robustness approach including dummy variable for the global financial crisis in the models as a control variable for external shocks does not affect the sign and significance of our estimators, indicating VUSD model encompasses to the other models. However, they support the presence of failure effects of IRP on the exchange rates volatility.

Figure 3: CUSUM and CUSUMSQ of Robustness Tests



6. Concluding Remarks

The aim of this paper was to provide direct empirical evidence on the relationship between inflation targeting adoption and exchange rates volatility in the case of Indonesia over the period 2005–2016. To the best our knowledge, this is the first study that investigates the effectiveness of inflation targeting policy by linking interest rate policy and exchange rates volatility. We use the ARDL model and conduct both bound and Johansen co-integration tests. We analysed monthly data on interest rate policy and its impact on the exchange rates volatility comprising bilateral exchange rate, nominal effective exchange rates, and real effective exchange rates.

The motivation behind this paper is that the theory and empirics do not clearly explain whether inflation targeting can induce or reduce exchange rates volatility. Our pragmatic approach does prove that the interest rate policy in the inflation targeting framework fails to reduce the exchange rates volatility pressure in the short-run. Our results confirm while interest rate policy has a positive pressure on the bilateral exchange rates volatility in the short-run, the effectiveness of interest rate policy to stabilize the real effective exchange rates remains considerable in the long-run. In the short-term, the ability of the central bank to intervene foreign exchange has no significant impact on the exchange rates volatility pressure. With respect to exchange rates volatility, the volatility of market pressure has a significant impact for volatility of US Dollar, nominal effective exchange rates, and real effective exchange rates fluctuations.

These findings provide some important economic implications for BI 7-Day Reverse Repo Rate. They suggest that credibility factor remains the main obstacle in the short-run for the central bank to operate through a signalling effect in the exchange rate market. The sound and prudent monetary policy management are necessary to avoid possible dramatic change in the exchange rate in the long-term in relation to the financial market sentiment. As a consequence, to maintain exchange rate stabilization, the monetary policy should be conducted based on the monetary rule incorporating explicitly or implicitly either the nominal effective exchange rates or real effective exchange rates as the target instead of discretionary policy.

This paper considers mainly financial factors to analyse the exchange rates stabilization. Further studies are advisable to integrate monetary policy and fiscal policy frameworks. Using higher frequency data (hopefully monthly fiscal data, if any), the future research can re-check the effectiveness of monetary policy relative to fiscal policy in order to stabilize exchange rates in the long-run. Indeed, the stable exchange rate is one of the hottest issues in most developing countries and Indonesia is not an exception. Refer to Pétursson (2009), hopefully, joining the ASEAN Economic Community membership in 2015 will have significantly reduced the exchange rates volatility. More importantly, incorporating the new financial assets potentially leads the monetary policy will be more effective to manage the excessive exchange rates.

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