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Exchange Rate Misalignment in the Inflation Targeting Regime

The Case of ASEAN-3

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Abstract

This paper aims at analyzing the exchange rate misalignment in the inflation-targeting regime. Different from the previous studies, the exchange rate misalignment is based on the purchasing power parity. We use the ASEAN-3, i.e. Indonesia, the Philippines, and Thailand as the case of the inflation-targeting countries. By applying probit and logit models for the monthly data over the period of 2001(1) to 2022(12), we found that central bank intervention is effective to correct exchange rate misalignment in Indonesia and the Philippines, not for Thailand. More specifically, the selling intervention enables to reduce Indonesian Rupiah overvaluation. Similarly, the Philippines Peso undervaluation can be effectively adjusted by the purchasing intervention. The symmetric behavior of purchasing and selling holds for the two countries. These findings suggest that the central banks in the two countries should be careful in managing foreign reserves in relation to their interventions. Without sterilizing them, any purchase/sale of foreign currency could affect the domestic money supply and thereby undermine the credibility of inflation targeting monetary policy. Further research is advisable to differentiate foreign reserves into sterilized and unsterilized states to analyze the exchange rate misalignment so that the currency stabilization will be more effective.

Keywords: Inflation-targeting, Exchange rate misalignment, Purchasing power parity, Foreign reserves, Market intervention

JEL: E52, E58, F31, G15

1. Introduction

The role of exchange rate in the inflation targeting (IT) policy is slightly challenging. The standard IT regime proposes that inflation at a low and stable rate should be the main target, so at the same time it cannot be accompanied by the exchange rate objective (Obstfeld *et al*., 2005). Despite that the fluctuations of exchange rate increase with IT as a consequence of removing the managed float exchange rate into the flexible exchange rate systems (Edwards, 2006), IT remains providing the best outcomes in the form of lower exchange rates volatility (Berganza and Broto, 2012).

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However, the low exchange rate pass-through in the IT countries leads foreign prices to destabilize the home currency value (Kuncoro, 2015). The exchange rate shocks cannot be fully accommodated in the policy rate, which primarily is to anchor future inflation expectation (Kuncoro, 2020). The actual inflation continuously stays away from the target level (Hartmann *et al*., 2020). Accordingly, the emerging markets with IT have more managed exchange rate arrangements, resulting in the frequency of market intervention being higher (Sikarwar, 2020). Moreover, the market intervention stimulates the exchange rates to be misaligned (Yeyati *et al*., 2013) as the IT countries suffer 'fear of floating' rather than 'fear of capital flight' (Calvo and Reinhart, 2002).

While exchange rate misalignment in general refers to the fundamental (Williamson, 1994) and behavioral equilibrium exchange rates (Clark and MacDonald, 1998), how market interventions address the real exchange rate deviation from purchasing power parity (PPP) is not well-understood. A large number of empirical studies that have examined the efficacy of central bank intervention on the exchange rate misalignment in IT countries is not robust yet (Daude *et al*., 2016; Krušković, 2017). On the one hand, the central bank's interventions induce the exchange rate to return to the long-run PPP-based levels (Kuncoro and Santoso, 2022). The impact of market interventions is also advantageous to mitigate the exchange rate from temporary excessive movements rather than to drive it away from fundamental values (Sandri, 2023).

On the other hand, the huge foreign exchange intervention accompanies less exchange rate appreciation in reaction to gross inflows (Blanchard *et al*., 2015). Market interventions could encourage the exchange rate to be overvalued (Fatum, 2008; Hansen and Morales, 2019). When the domestic currency is highly undervalued, capital inflows have a destabilizing impact in developing countries (Grossmann and Orlov, 2022). Market interventions when currency undervaluation also boosts inflation and real interest rates, which may retard the stability of the domestic financial market (Steiner, 2017). Hence, there is no uniform agreement on the effects of market intervention in the IT regime on the exchange rate misalignment reduction, which needs to be investigated.

Investigating the exact link between market intervention in the IT regime and the exchange rate misalignment is crucial. For monetary policymakers, the failure of market intervention to improve exchange rate deviation from its equilibrium level may have adverse impacts on the resources allocation (Engel, 2014), export diversification (Sekkat, 2016), labor absorption (Chipeta *et al*., 2017), probability of currency crises (Heriqbaldi *et al*., 2021), or even political circumstances (Ambaw and Sim, 2021). Taking into account various issues emerging from the above studies will help the central bank in developing countries under IT regime to correct exchange rate misalignment more effectively by implementing an active monetary measure (Cabral *et al*., 2020).

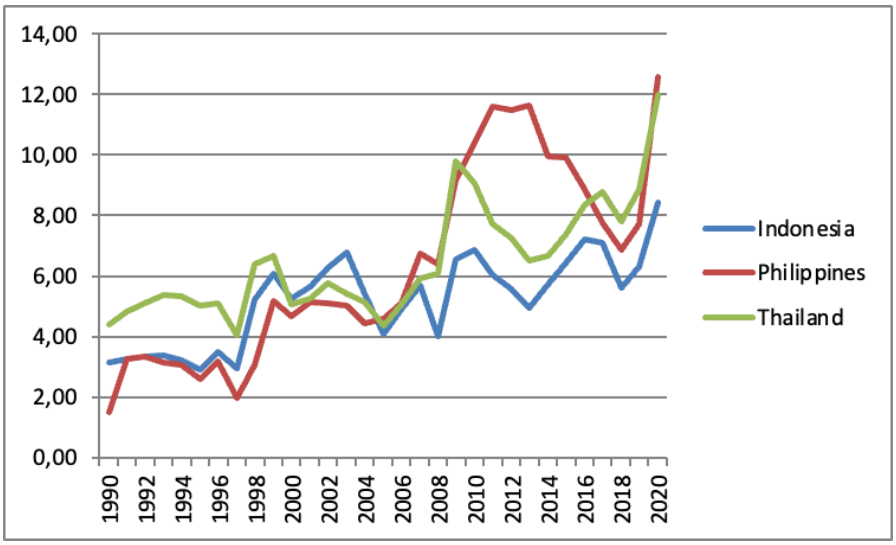
Indonesia, the Philippines, and Thailand are not an exception. The three emerging countries in south east Asia suffered adverse impacts of the monetary crisis. The skyrocketing inflation rate, deep economic contraction, and sharp currency depreciation in relation to the Asian monetary crisis in 1997/1998 had forced the central banks of those countries to carry out the economic rescue and stabilization programs. In the 2007/08 global financial crisis, the monetary authorities again undertook various monetary

action measures to recover economic activity against the adverse impacts.

As a result, having implemented an IT regime in the early 2000s, they enjoyed solid economic growth, low inflation rates, and stable exchange rates (Fermo and Lemence, 2014; Toulaboe, 2017; Raksong, 2021). The stable currency in those countries is also supported by large foreign reserves. The international reserves held by the central bank of Indonesia, the Philippines, and Thailand have steadily increased since 1998 (see Figure 1). In the 2000s, the stocks of foreign reserves were 8-month imports, higher than the international standard of 3-month import adequacy.

However, the question here is whether the stable exchange rates are aligned or mismatch to the long-run PPP in nature. Implementing a floating exchange rate regime makes the three countries' currencies sensitive to the imported inflation. Meanwhile, as many emerging Asian economies, they encounter tremendous global risks in the medium-term so it would be risky to cut back foreign reserves (in terms of imprudent market intervention) to make more space for speculative attacks. The answer to the above question returns to the discussion on exchange rate behavior.

This paper contributes to the empirical literature on open monetary policy in the three IT countries. First, we identify the exchange rate misalignment based on the PPP. Second, we estimate the effectiveness of central bank intervention on the exchange rate mismatch correction. Finally, we test the symmetric behavior of the central bank purchasing and selling foreign exchange in the foreign exchange market. The symmetric behavior enables the central bank to improve the effectiveness of market intervention strategy to minimize the exchange rate mismatch. The remaining paper is organized as follows. After introduction, we present the literature review and research methods. Empirical results and discussion are delivered in Section 4. Finally, Section 5 draws conclusions and policy implications.



Source: IMF

Figure 1. The adequacy of Foreign Reserves

2. Literature Review

Exchange rate misalignment can be defined as the deviation of the actual exchange rate from its equilibrium. International monetary economic literature provides various measurements of the exchange rate misalignment. The different measurement depends on how to identify the unobservable exchange rate equilibrium. The exchange rate equilibrium in the empirical studies generally refers to the fundamental aspects (Williamson, 1994). According to this approach, the fundamental equilibrium exchange rate (FEER) is determined by macroeconomic fundamentals, among others, such as terms of trade, degree of openness, productivity, and interest rate differential.

The FEER is consistent with macroeconomic balance, in which the exchange rate remains unchanged as long as the internal and external balance are undisturbed. The internal balance refers to the full employment of output level and low and sustainable inflation rate. The external balance is characterized by a sustainable current account and capital account. Accordingly, the FEER exchange rate measure is normative with ideal economic conditions (Williamson, 1994). However, the FEER calculation model neglects the effects of variables that have been considered affecting the actual exchange rate. To articulate the FEER, the behavioral equilibrium exchange rate (BEER) is proposed.

The BEER argues that the exchange rate equilibrium is determined by competitiveness differential, productivity differential between tradable and non tradable sectors, relative fiscal stance, and the stock of net foreign assets (Clark and MacDonald, 1998). The practical advantage of the BEER compared to the FEER is that it offers a direct econometric analysis of the real effective exchange rate behavior model to assess the current value of the exchange rate. In the reduced-form equation, instead of simultaneous equations as in the FEER, the BEER allows an easy evaluation of exchange rate misalignment by comparing the current level with the estimated value.

Furthermore, the root of FEER and, therefore, BEER models is the PPP. The PPP doctrine takes in the two forms, absolute and relative. The absolute PPP postulates that the bilateral exchange rate should be proportional to the ratio of aggregate price levels between the two countries, such that a unit of currency of one country will be equal to the purchasing power in the counterpart country (Taylor and Taylor, 2004). Hence, the PPP exchange rate equilibrium model offers little economic insights, but has good predictive power (Zorzi *et al*., 2020), implying that it produces a better exchange rate misalignment measurement.

In the real world, the absolute PPP does not always hold for a number of reasons, such as transaction costs and trade barriers. The other variant of absolute PPP is its relative form. This model is associated with the rate of growth in the exchange rate in a manner that deviations in bilateral exchange rate proceed in an opposite direction with the bilateral inflation differentials. Although the relative PPP refers to nominal exchange rate in two pair countries, it can be extended for multiple countries. Therefore, the relative PPP also depicts the global competitiveness of a country's goods/services (Obstfeld and Rogoff, 2009).

Among the three approaches, Daude *et al*. (2016) and Krušković (2017) point out that most empirical studies regarding the central bank's market intervention rely on the PPP exchange rate misalignment. In this sense, the central bank's purchases and sales of

foreign exchange on the market is intended to correct exchange rate mismatches. As a result, the central bank's market intervention may stimulate the exchange rate to return to the PPP-based levels or/and to move faster to its long-run PPP equilibrium level (Sweeney, 1999). Which one holds is a matter of empirical nature rather than theoretical one.

A number of studies in advanced and emerging markets have been conducted to prove the PPP doctrine. Nevertheless, empirical analysis of the PPP doctrine in relation to market intervention in the IT regime is limited. Robertson *et al*. (2014) explore the PPP between the US and Mexico. Based on the monthly data, their results confirm weak-form PPP, but less support for strong-form PPP. Giannellis and Kouretas (2014) use the two-regime threshold model to assess China's price competitiveness. They obtain that PPP equilibrium was valid in periods of relatively high rate of real Yuan appreciation, compared to the estimated threshold. He *et al*. (2014) discover the validity of long-run PPP in fifteen Latin American countries, with the exception of Honduras.

In relation to exchange rate misalignment, Toulaboe (2017) investigates the size of real exchange rate mismatch in seven emerging Asian markets and Japan. The estimation results of equilibrium real exchange rates model present that real exchange rates have been mismatched in most of the Asian countries during the sample period. Dudzich (2022) in the case of 10 former Soviet Republics indicates that the exchange rate misalignments tended to increase before the crises and visibly reduced after, thus serving as potentially viable predictors of such events. Nakorji *et al*. (2021) examine the Nigerian Naira exchange rate misalignment. Referring to US Dollar, UK Pounds, and Chinese Yuan, they confirm that the absolute PPP approach to exchange rate determination is unrealistic but revealed empirical support for the relative PPP approach.

Cuestas *et al*. (2020) appraise the effect of PPP exchange rate deviation on economic activity in nine central and eastern European economies. In measuring exchange rate misalignment, they use open macroeconomic models, relying interest rate differentials and country-specific determinants as the main factors. The result indicates a significant reduction in exchange rate misalignment. The overvaluation of exchange rates has an adverse impact on economic performance and has a greater impact than undervaluation. Accordingly, Grossmann and Orlov (2022) conclude that, when the domestic currency is highly undervalued, capital inflows have a stabilizing impact on exchange rate volatility in advanced economies but a destabilizing impact in emerging market countries.

Regarding the market intervention, Echavarría *et al*. (2010) in the case of Colombia show that the central bank bought foreign exchange in order to compensate for day-to-day revaluations and to correct 'excessive' trends. Sandri (2020) carries out the impact of market intervention through the swaps mechanism on the exchange rate. He finds that swaps are profitable in expectation, suggesting that foreign exchange intervention is used to stabilize the exchange rate in the face of temporary excessive movements rather than to manipulate it away from fundamental values. Yan *et al*. (2014) observe that despite capital inflows appreciating the home currency in emerging market countries, large scale of foreign exchange market intervention to design even higher capital outflows has kept the home currencies in emerging market countries factually undervalued.

Purely in the IT regime country, Sidiq and Herawati (2016) show that Indonesian Rupiah against the US Dollar is undervalued during the free floating exchange rate regime and, the PPP theory of Rupiah against the US Dollar is not valid in the period of their study. Rasbin *et al*. (2021) find evidence of Rupiah misalignment as the currency was undervalued for most periods. Kuncoro and Santoso (2022) point out that the central bank's interventions induce the exchange rate to return to the long-run PPP-based levels. In the case of the Philippines, Fermo and Lemence (2014) reveal that there is evidence of lower exchange rate volatility during the inflation targeting period compared to the pre-inflation targeting period. Raksong (2021) finds that the foreign reserves had significant long-run impact variables on real effective exchange rate in Thailand. However, market interventions could encourage the exchange rate to be overvalued both in Canada (Fatum, 2008) and Chile (Hansen and Morales, 2019).

3. Research Method

The survey of the literature above briefly presents some potential linkages between exchange rate misalignment and market intervention. First, studies using long-span time series data primarily in emerging markets tend to support the presence of PPP exchange rate misalignment. Second, on the contrary, studies employing the wide range panel data based on fundamental and behavioral equilibrium exchange rates yield relatively homogenous conclusions. Third, the foreign reserves are directed to maintain the level and volatility of exchange rate, instead of exchange rate misalignment. Hence, the empirical results in the case of IT developing countries, primarily in Indonesia, the Philippines and Thailand, cannot be generally accepted yet.

To address some empirical issues above, the change in nominal exchange rate (*ER*) is a certain portion of the change in foreign reserves (*FR*). Following Lin and Wang (2009), the operation of central bank intervention is expressed by an equation as follows:

$$\Delta ER_t = ER_t - ER_{t-1} = k\,\Delta\, log\, FR_t \quad (1)$$

As previously stated, exchange rate misalignment (ER^m) can be defined as the deviation of the actual exchange rate (ER^a) from its equilibrium (ER^{eq}).

$$ER^m = ER^a - ER^{eq} \quad (2)$$

Hence, the real exchange rate misalignment (RER^m) is specified by the deviation actual real exchange rate (RER^a) from equilibrium real exchange rate (RER^{eq}) (Elbadawi *et al*., 2012):

$$RER^m = RER^a - RER^{eq} \quad (3)$$

The first issue arising here is how to define the equilibrium real exchange rate. The FEER (Williamson, 1994) and BEER (Clark and MacDonald, 1998) potentially are used to identify the medium-term equilibrium exchange rates. However, the two approaches require many macroeconomic variables which may be beyond this paper.

Alternatively, one can employ the PPP notion as reference to calculate the long-run equilibrium exchange rates. Regarding bilateral PPP, the actual real exchange rate refers to the relative prices between the two countries.

$$RER^a = \left(ER \times \frac{Pf}{Pd}\right) \quad (4)$$

where *Pf* is foreign prices level, and *Pd* is domestic prices level.

The equilibrium real exchange rate is unobservable. Accordingly, the second issue

is how to identify it. To calculate the equilibrium real exchange rate, we use Hodrick-Prescott (*HP*), which is widely employed to generate a smooth estimate of the long-term trend component of a series. Technically, the HP filter is a two-sided linear filter that computes the smoothed series *t* of *y* by minimizing variance *y* around *t* subject to a penalty that constrains the second difference of *t*. That is, the HP filter chooses *s* to minimize:

$$HP: \sum_1^T (y_t - \tau_t)^2 + \lambda \sum_2^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \quad (5)$$

The penalty parameter *l* controls the smoothness of the series *t*. The larger the *l*, the smoother the *t*. As *l* = ¥, *t* approaches a linear trend. The default value of *l* in Eviews is set to be 14,400 for monthly data.

Therefore,

$$ERM = RER^a - RER^{HP} \quad (6)$$

The real exchange rate misalignment can be classified into overvalued (*ERM* > 0), undervalued (*ERM* < 0), and aligned (*ERM* = 0).

Substituting (6) to (1), we obtain

$$ERM_t = \alpha + \beta \, \Delta \, log \, FR_t + \gamma \, IT + \varepsilon_t \quad (7)$$

where *b* = *k* and *a* and *b* are the unknown parameters to be estimated. *e* is a disturbance. The inclusion of *IT* is a dummy variable to characterize the inflation targeting adoption.

The third issue is how to measure market intervention. Given the absent intervention data, the change in foreign reserves depicts the central bank intervention (Berganza and Broto, 2012; Daude *et al*., 2016). Since the foreign reserves are held by central banks, they are a reliable proxy for central bank intervention (Suardi and Chang, 2012). Buying foreign exchange increases reserves and selling foreign exchange reduces reserves. Therefore, the sign of *b* is expected to be negative. The increase in foreign reserve means the central bank absorbs the foreign exchange availability in the market and, therefore, the price of foreign hikes toward the aligned level.

The aligned real exchange rate is rarely met in the real world. The remaining states are overvalued and undervalued exchange rates. Since we are concerned with the successfulness of market intervention, instead of its magnitude, the associated variable is then converted into binary (*b*) form as Echavarría *et al*. (2010) used:

$$ERM_t^b = \begin{cases} Overvalued; 1 \\ Undervalued; 0 \end{cases} \quad (8)$$

Furthermore, we set the central bank intervention in the foreign exchange market into purchasing and selling states:

$$d_1 = \begin{matrix} 1 - if \Delta \, log \, FR_t > 0 \\ 0 - if \Delta \, log \, FR_t \leq 0 \end{matrix}$$

$$\text{and } d_2 = \begin{matrix} 1 - if \; \Delta \, log \, FR_t < 0 \\ 0 - if \; \Delta \, log \, FR_t \geq 0 \end{matrix} \quad (9)$$

where *d* is a dummy variable.

Substituting Equations (9) and (8) into (7), we have:

$$ERM_t^b = \alpha + \beta_1 \, [d_1 \times \Delta \, log \, FR_t] + \beta_2 \, [d_2 \times \Delta \, log \, FR_t] + \gamma \, IT + \varepsilon_t \quad (10)$$

The symmetric impact of buying or selling states on the exchange rate misalignment ($b_1 = b_2$) can be carried out by using the Wald test. Equation (10) could also solve the asymmetric and non-linearity problems which often arise in the financial markets.

Equation (10) will be run by logit and probit methods. The logit model uses the logistic probability distribution to estimate the parameters of the model. Although seemingly nonlinear, the log of the odds ratio, called the logit, makes the logit model linear

in the parameters. The marginal effect of a regressor in the logit model depends not only on the coefficient of that regressor but also on the values of all regressors in the model. An alternative to the logit model is the probit model. The underlying probability distribution of probit is the normal distribution (independent variables in the model). The difference lies in the fact that logistic function has harder "fat tails". The parameters of the probit model are usually estimated by the method of maximum likelihood. Similar to the logit model, the marginal effect of a regressor in the probit model involves all the regressors in the model.

For this empirical study, the nominal exchange rate is measured by the price of US Dollar against domestic currency (Rupiah, Peso, and Baht respectively). The real terms of those variables are derived from the price levels. The price levels refer to the CPI (consumer price index). The foreign price level is represented by the US CPI. All of the price indices are stated in the 2012 base year (2012 = 100). Transforming all variables into real terms means that our model inherently incorporates inflation rates.

The reserve basket involves various foreign financial assets, which are under control of the central bank. Stated in billion US Dollar, they are readily available for any balance of payments financing. The corresponding variable is presented in the logarithmic form. The sample periods cover from 2001(M1) to 2022(M12) due to data availability. They capture the periods of pre- and post-IT regime adoption except for Thailand. Indonesia and the Philippines have been implementing IT since July 2005 and January 2002, respectively. Thailand has been adopting IT since May 2000. The total observation is 264 sample points. Most of the monthly data are taken from the central bank of each country. Other data come from Bloomberg and the IMF.

4. Result and Discussion

Exchange rate misalignment could be under- and over-valuation. Table 1 reports the descriptive statistics of the two types of exchange rate mismatch. The mean value of the real exchange rate misalignment is close to zero, suggesting that the real exchange rate is aligned to the PPP. The positive mean value of the real exchange rate misalignment in the case of Indonesia implies that the exchange rate is undervalued which is consistent with the positive value of skewness. Moreover, the undervaluations are 164 cases and the overvaluations are 100 cases respectively. Accordingly, there is evidence that Indonesian Rupiah misalignment is undervalued for most periods we observed. These results are in line with Rasbin *et al*. (2021).

For the case of the Philippines and Thailand, the distance between maximum and minimum values is relatively low when we compare them to the case of Indonesia. The lower standard deviation (1.45 and 1.21) suggests that the real exchange rate in both countries is more well-aligned. The real exchange rate aligned to its PPP in the Philippines and Thailand is supported by the frequency of undervaluation cases (116 and 124) exceeding the overvaluation cases (148 and 139). However, only in the case of Thailand, the PPP exchange rate misalignment is normally distributed. The Jarque-Bera test proves that the distribution of the PPP exchange rate misalignment in Thailand is bell-shaped, the lower tail is proportional to the upper tail.

Table 1. Descriptive Statistics of the PPP Exchange Rate Misalignment

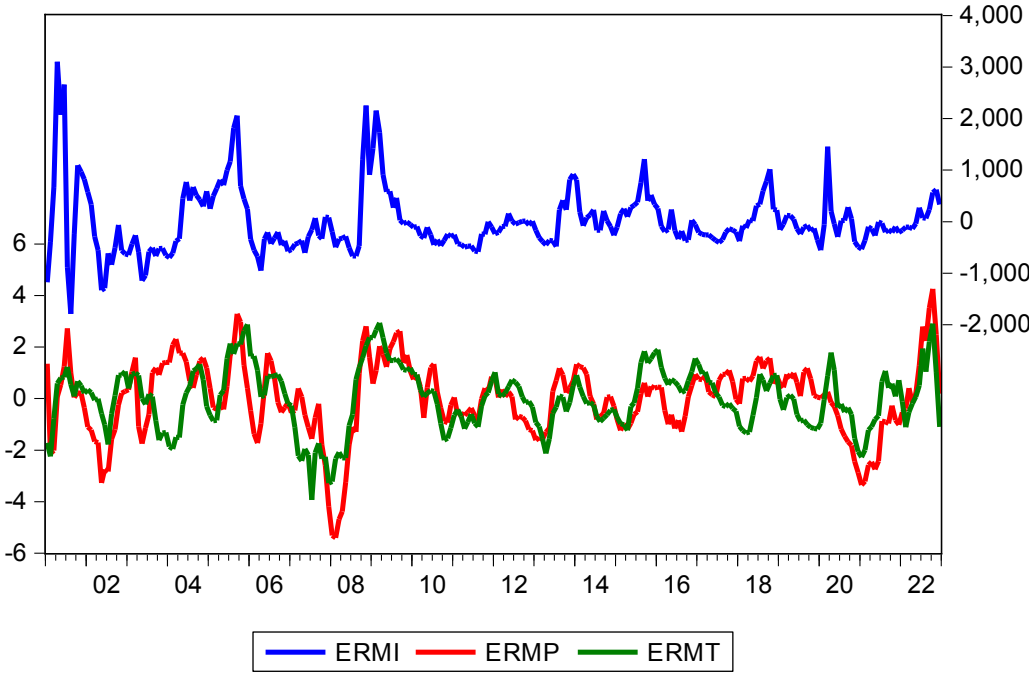
	Indonesia	The Philippines	Thailand
Mean	0.0002	-0.0002	-0.0003
Median	-117.0950	0.1150	0.0700
Maximum	3103.9100	4.2600	2.9400
Minimum	-1787.7500	-5.4000	-3.9300
Std. Dev.	621.5216	1.4537	1.2090
Skewness	1.5669	-0.6159	-0.1709
Kurtosis	7.6839	4.4760	3.0369
Jarque-Bera	349.3592	40.6578	1.3006
Probability	0.0000	0.0000	0.5219
Observations	264	264	264

Source: Author's calculation

It seems that the magnitude of domestic currency to foreign currency exchange rate matters in the analysis of real exchange rate misalignment. Regardless of the magnitude, the movement of the real exchange rate misalignment in the three countries seems to be synchronous, primarily after 2008. As presented in Figure 2, there is a moderate co-movement among real exchange rate misalignment for the three countries. The positive correlation of exchange rate misalignment for the Philippines and Thailand is the highest (0.59) compared to Indonesia-Thailand (0.45) and Indonesia-the Philippines (0.36).

The high overvalued exchange rate in the three countries took place in the early 2000s in relation to the adoption of the IT regime. In around 2006, the high overvalued exchange rate arose in accordance with the peak of commodity boom. As a natural resources exporter country, the peak commodity boom triggered the foreign exchange revenues, making the domestic currency relative to foreign currency increased. The high overvalued exchange rate took place again in around 2008 associated with the global financial crisis. The capital outflows induced the lack of foreign exchange in the domestic financial market, resulting in the exchange rate being overvalued.

In contrast, the deep undervalued exchange rate was experienced in around 2007, particularly in the Philippines and Thailand. Some structural adjustment policies implemented by the two countries successfully improved the economic structure which in turn the exchange rate to be undervalued. However, the real exchange rate misalignment in the three countries during the pandemic Covid-19 substantially differed. The Thailand Baht-US Dollar and the Philippines Peso-the US Dollar that were undervalued in the early 2020 sharply became overvalued in the subsequent months. Meanwhile Indonesian Rupiah-the US Dollar misalignment moved gradually toward overvalued.



Source: Author's calculation

Figure 2. Exchange Rate Misalignment

After describing the dependent variable, we proceed by explaining the independent variable. Table 2 presents the descriptive statistics regarding the central bank market intervention. Since the market intervention is defined in the relative change in the foreign reserves, instead of the absolute terms as in the real exchange rate misalignment, the performance of central bank intervention for the three countries is slightly similar. The mean values of market intervention is positive, indicating that the central bank in the three countries purchases more rather than sells the foreign exchange. The number of cases of purchasing and selling states in Indonesia is relatively more balanced (127 and 136) than the Philippines and Thailand (111 and 152, respectively).

However, comparing Table 1 to Table 2 provides an interesting result. In the case of Indonesia, the amount of under- and over-valued cases have an opposite pattern with those of buying and selling cases. In contrast for the Philippines and Thailand, there are no different patterns among under- and over-valued cases and buying and selling states. This preliminary raises a hypothesis that the selling intervention is to reduce the exchange rate overvalued and the purchasing intervention is to improve the exchange rate undervalued. This will be checked using econometric models in the preceding section.

To ascertain the causal relationship between exchange rate mismatch and foreign reserves, we conduct the pairwise-Granger causality test. As presented in Table 3, the test confirms a unidirectional causality. Using 4, 5, and 6 lags, based on the LR (Log-likelihood Ratio), FPE (Final Prediction Error), and AIC (Akaike Information Criterion) optimum

Table 2. Descriptive Statistics of Market Intervention

	Indonesia	The Philippines	Thailand
Mean	0.0009	0.0052	0.0055
Median	0.0008	0.0022	0.0058
Maximum	0.1418	0.1088	0.0838
Minimum	-0.1259	-0.0620	-0.0774
Std. Dev.	0.0324	0.0251	0.0228
Skewness	0.0635	0.7682	0.0835
Kurtosis	5.7977	5.2596	4.0792
Jarque-Bera	85.9480	81.8200	13.0675
Probability	0.0000	0.0000	0.0015
Observations	263	263	263

Source: Author's calculation

Table 3. Granger Causality Test

Null Hypothesis:	Lag	Obs	F-Stat	Prob.
Indonesia				
Δ log FR does not Granger Cause ERM	5	258	2.6048	0.0256
ERM does not Granger Cause D log FR			0.6941	0.6284
The Philippines				
Δ log FR does not Granger Cause ERM	6	257	2.0645	0.0581
ERM does not Granger Cause D log FR			1.7950	0.1007
Thailand				
Δ log FR does not Granger Cause ERM	4	259	7.1583	0.0000
ERM does not Granger Cause D log FR			1.5921	0.1769

Source: Author's calculation

criteria, the causal relationship flows from foreign reserves to exchange rate mismatch, which supports most empirical literature in developing countries (Toulaboe, 2017).

However, the causality does not hold in the opposite direction. The exchange rate mismatch does not Granger cause exchange rate misalignment. In other words, foreign reserve is the cause, and otherwise, exchange rate misalignment is the effect. This conclusion holds for 4, 5, and 6 lags respectively. Considering the causal relationship, our question then is how large and what is the direction (positive or negative) of the impact of foreign reserves on the exchange rate mismatch. Those questions will be answered later employing econometric methods.

Prior to estimating the econometric models, we examine first the properties of the underlying data whether the data series have unit roots or are stationary. The existence

Table 4. Unit Roots Test

ADF	ERM		Δ log FR	
	t-stat	Prob	t-stat	Prob
Indonesia	-6.5226	0.0000	-13.1188	0.0000
The Philippines	-5.5840	0.0000	-12.8668	0.0000
Thailand	-5.3136	0.0000	-12.3593	0.0000

Source: Author's calculation

of unit roots of each series data is required to avoid spurious regression. The presence of unit roots is examined by conducting an Augmented Dickey-Fuller (ADF) test. The results of both tests are presented in Table 4. The test shows that the exchange rate misalignment series data for the three countries have unit roots in level or integrated in degree zero (*I(0)*). It means that the real exchange rate misalignments in the long-run will revert to the mean, suggesting that they are temporary in nature and in the long-run will return to the steady-state.

The foreign reserves series data do not have unit roots in level but stationary in first-differences at 5 percent significance level. It implies that the change in foreign reserves is stable in accordance with a disequilibrium process. The two tests suggest that the impact of any shock will eventually vanish and the two series data will move together to its long-run mean. Furthermore, the two variables tend to evolve towards the long-run equilibrium relationship as predicted by the relevant theory. Hence, the central bank intervention in the foreign exchange market expectedly enables to curb the short-run real exchange rate misalignment.

In the preceding section, we focus on the empirical results of this study. Table 5 presents the estimation results of Equation (7). The probit and logit regressions indicate that the market intervention coefficients estimate of -0.08 to -0.20 are significant at a 1 percent significance level. It has the expected sign and therefore serves as a preliminary endorsement of the effectiveness of central bank intervention in the foreign exchange market to improve the real exchange rate misalignments. This finding is not much different from the previous empirical results as outlined in the literature review section (i.e. Toulaboe 2017). However, the real exchange rate misalignment in Indonesia and the Philippines are slightly similar between pre- and post-IT policy implementation.

For Thailand, the corresponding coefficients estimate is quite low and statistically insignificant. This result is in line with the descriptive analysis as provided in Table 1. The amount of cases under- and over-valuation of US Dollar over Thailand Baht (124 and 139 cases respectively) is the most proportional. Therefore, the Thailand' real exchange rate is relatively well-aligned compared to the Indonesia and the Philippines ones. This finding suggests that the efficacy of central bank intervention diverges depending on the degree of exchange rate misalignment.

Splitting up the central bank intervention component with respect to purchasing and selling foreign exchange in the market produces an interesting result. As presented in Table 6, the probit and logit regression results show that the selling foreign exchange (Δ *log FR < 0*) for Indonesia significantly affects the

Table 5. Estimation Results of the Basic Binary Model

	Indonesia		The Philippines		Thailand	
	Probit	**Logit**	**Probit**	**Logit**	**Probit**	**Logit**
C	-0.20	-0.33	0.68	1.14	0.08	0.13
Δ log FR	-0.08***	-0.13***	-0.12***	-0.20***	-0.01	-0.01
IT	-0.13	-0.22	-0.48	-0.83	-	-
McFadden R^2	0.03	0.03	0.04	0.04	0.00	0.00
SD Dep. Var.	0.49	0.49	0.50	0.50	0.50	0.50
Obs with Dep = 0	163	163	116	116	123	123
Obs with Dep = 1	100	100	147	147	140	140

Note: *** denotes significance at 1% level.

Source: Author's calculation

probability of success of the undervalued exchange rate adjustment process to be aligned for about 0.1. This result confirms the study of Fatum (2008) for Canada and Sandri (2023) for Brazil.

For the Philippines, on the contrary, the probit and logit regression results indicate that the central bank purchases foreign exchange (*Δ log FR > 0*) in the market significantly affects the probability of success of an overvalued exchange rate adjustment process to be aligned for about 0.1-0.2. This finding supports Hansen and Morales (2019) in the case of Chile. Based on the two cases above, we infer that the selling intervention is effective to reduce the overvalued exchange rate and the purchasing intervention is appropriate to improve the undervalued exchange rate.

The separation between buying and selling foreign exchange unfortunately does not change the initial conclusion that there is no difference in the real exchange rate misalignment behavior after implementing IT. The IT coefficients are not statistically significant in the two countries observed. Inflation targeting requires the central bank to have information about future inflation trends. Put too much emphasize on stabilizing the domestic inflation results in the exchange rate being influenced by foreign inflation (Kuncoro, 2015), which in turn the central bank intervention being ineffective.

Furthermore, is there any different exchange rate mismatch behavior between purchasing and selling states? Table 6 also presents the symmetric impact of buying or selling states on the exchange rate misalignment. The Wald tests confirm that there is no different impact of selling and buying states on the exchange rate misalignment. It seems that central bank interventions operate in the linear manner. Hence, market interventions run by the three central banks are not reactive to respond to the exchange rate misalignment, either the exchange rate is undervalued or overvalued.

As a robustness check, we re-estimate Equation (10) by incorporating the global uncertainty index and world pandemic uncertainty index to accommodate the global financial turbulence (*UGFT*) over the observation period and pandemic Covid-19 (*UPCOV*). Both data for each country are taken from Ahir *et al*. (2022). The data which are presented in a quarterly basis

Table 6. Estimation Results of the Extended Binary Model

	Indonesia		The Philippines		Thailand	
	Probit	**Logit**	**Probit**	**Logit**	**Probit**	**Logit**
C	-0.22	-0.34	0.91**	1.49*	0.13	0.21
Δ log FR < 0	-0.09**	-0.14**	-0.02	-0.04	0.03	0.05
Δ log FR > 0	-0.07	-0.12	-0.18***	-0.28***	-0.03	-0.05
IT	-0.14	-0.23	-0.60	-0.99	-	-
McFadden R^2	0.03	0.03	0.05	0.04	0.00	0.00
SD Dep. Var.	0.49	0.49	0.50	0.50	0.50	0.50
Obs with Dep = 0	163	163	116	116	123	123
Obs with Dep = 1	100	100	147	147	140	140
Symmetric test	0.07	0.04	2.14	2.00	0.29	0.29

Note: *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

Source: Author's calculation

are then transformed linearly into monthly basis. As seen in Table 7, unfortunately, the global uncertainty index is insignificant for Indonesia. Good policy implemented in that time successfully stabilized the major macroeconomic variables (Basri and Rahardja, 2011), including the exchange rate. Meanwhile, the policy mix designed by the central bank of Indonesia can dampen the exchange rate fluctuations and, hence, the exchange rate misalignment during the pandemic Covid-19 was controllable.

For the Philippines, uncertainties generated by the global financial turbulence (as found in the case of Thailand) and pandemic Covid-19 are statistically significant with the relatively higher *p*-values. Those results are consistent with the behavior of exchange rate misalignment as presented in Figure 2. The Philippines Peso-the US Dollar was undervalued in the global financial crisis. The Thailand Baht-US Dollar was undervalued in the early 2020 and sharply became overvalued in the subsequent months. However, the asymmetric behavior of the Philippines central bank market intervention tends to change at the lower *p*-value after incorporating the two additional explanatory variables.

Overall, the results do not alter the major conclusion. The central bank intervention in the foreign exchange market is successful to improve exchange rate misalignment for both Indonesia and the Philippines, instead of Thailand. These results are consistent with the unit roots tests. The real exchange rate misalignments in the long-run will revert to the mean, suggesting that they are temporary in nature and in the long-run will return to the steady-state. Although structural break exists, the real exchange rate misalignments are stable in accordance with a disequilibrium process. The IT regime adoption in Indonesia and the Philippines seems to be effective to manage the exchange rate misalignment. Accordingly, our conclusions are robust, independently of the additional explanatory variables to be used in the econometric model.

Table 7. Robustness Test

	Indonesia		The Philippines		Thailand	
	Probit	**Logit**	**Probit**	**Logit**	**Probit**	**Logit**
C	-0.12	-0.17	0.77***	1.27	-0.06	-0.09
Δ log FR < 0	-0.09**	-0.14***	-0.00	-0.01	0.03	0,04
Δ log FR > 0	-0.08	-0.14	-0.19*	-0.31*	-0.02	-0.04
IT	-0.13	-0.22	-0.61	-1.01	-	-
UGFT	-0.21	-0.35	1.41**	2.29**	0.96**	1.52**
UPCOV	-0.11**	-0.19**	-0.07*	-0.11*	0.00	0.00
McFadden R^2	0.05	0.05	0.08	0.08	0.01	0.01
SD Dep. Var.	0.49	0.49	0.50	0.50	0.50	0.50
Obs with Dep = 0	163	163	116	116	123	123
Obs with Dep = 1	100	100	147	147	140	140
Symmetric Test	0.02	0.00	3.15***	2.82***	0.22	0.22

Note: *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

Source: Author's calculation

5. Conclusion

The role of exchange rate in the IT policy is slightly challenging. This paper aims at analyzing the real exchange rate-PPP misalignment in the IT regime in the case of Indonesia, the Philippines, and Thailand. Different from other researchers, we use probabilistic models to appraise the success of central bank intervention in foreign exchange market based on the purchasing and selling states. Our approaches enable not only to extract a signal of market intervention success but also to gauge the appropriateness of which strategy is more effective.

By adopting probit and logit models for the monthly data over the period 2001(1) to 2022(12), we obtain that central bank intervention is effective to correct exchange rate misalignment only in Indonesia and the Philippines. Conversely, the market intervention in Thailand is completely ineffective on the exchange rate adjustment, which denies empirically what the standard economic theory approved of. It seems that the movement of Thailand Baht against the US Dollar is not only relatively stable but also aligned to its long-run PPP, resulting in the market intervention being ineffective. Interestingly, there is no different exchange rate misalignment between pre- and post-IT regime adoption.

Partitioning central bank intervention into purchasing- and selling-states provides an important result. While selling-state in Indonesia improves the exchange rate misalignment, purchasing-state in the Philippines significantly affects the improvement of exchange rate. It seems that the selling intervention enables to reduce Indonesian Rupiah overvaluation. Similarly, the Philippines Peso undervaluation can be effectively adjusted by the purchasing intervention. The symmetric behavior of purchasing and selling holds for the two countries, suggesting that market intervention

run by the two central banks are not excessive to respond to the exchange rate misalignment.

However, those findings imply that the central banks in Indonesia and the Philippines should be careful in managing foreign reserves in relation to their interventions. Any purchase/sale of foreign currency needs to be sterilized. Without particular treatments, market interventions seriously affect the domestic money supply, and thereby undermine the credibility of IT monetary policy. Further research is advisable to differentiate foreign reserves into sterilized and unsterilized states to analyze the exchange rate misalignment so that the currency stabilization (in terms of inflation and exchange rates) will be more effective.

References

Ahir, H., Bloom, N. & Furceri D. (2022), The world uncertainty index, NBER Working Paper No. w29763, DOI: 10.3386/w29763.

Ambaw, D.T. & Sim, N. (2021), Real exchange rate misalignment and civil conflict: evidence from sub-Saharan Africa, *Oxford Economic Papers*, 73(1), 178–99, https://doi.org/10.1093/oep/gpz059.

Basri, M.C. & Rahardja, S. (2011). Mild crisis, half hearted fiscal stimulus: Indonesia during the GFC. in T. Ito and F. Parulian, (edt.), *Assessment on the Impact of Stimulus, Fiscal Transparency, and Fiscal Risk*, ERIA Research Project Report 2010-01, 169-211.

Berganza, J.C. & Broto, C. (2012), Flexible inflation targets, forex interventions and exchange rate volatility in emerging countries, *Journal of International Money and Finance*, 31(2), 428-44, https://doi.org/10.1016/j.jimonfin.2011.12.002.

Blanchard, O., Adler, G., & Filho, I.C. (2015), Can foreign exchange intervention stem exchange rate pressures from global capital flow shocks?, NBER Working Paper No. 21427.

Cabral, R., Carneiro, F.G., & Mollick, A.V. (2020), Inflation targeting and exchange rate volatility in emerging markets. *Empirical Economics*, 58, 605–26. https://doi.org/10.1007/s00181-018-1478-8.

Calvo, G.A. & Reinhart, C.M. (2002). Fear of floating. *Quarterly Journal of Economics*, 117(2), 379-408, DOI: 10.1162/003355302753650274.

Chipeta, C.D., Meyer, F., & Muzindutsi, P.F. (2017), The effect of exchange rate movements and economic growth on job creation, *Studia Universitatis Babeș-Bolyai Oeconomica*, 62(2), 20-41, DOI: 10.1515/Subboec-2017-0007.

Clark, P. & MacDonald, R. (1998), Exchange rates and economic fundamentals: a methodological comparison of BEERs and FEERs, IMF Working Paper No. WP98/67, Washington: International Monetary Fund.

Cuestas, J.C., Mourelle, E., & Regis, P.J. (2020), Real exchange rate misalignments in CEECs: have they hindered growth?, *Empirica*, 47, 733–56, https://doi.org/10.1007/s10663-019-09454-5.

Daude, C., Yeyati, E.L., & Nagengast, A. (2016), On the effectiveness of exchange rate intervention in emerging markets, *Journal of International Money and Finance*, 64, 239–61. https://doi.org/10.1016/j.jimonfin.2016.01.004.

Dudzich, V. (2022), Real exchange rate misalignments and currency crises in the former Soviet Union countries". *Comparative Economic Studies*, 64, 384-416, https://doi.org/10.1057/s41294-021-00178-9.

Echavarría, J.J., Vasquez, D., & Villamizar, M. (2010), Impact of exchange rate interventions on the level and volatility of the Colombian exchange rate, *Ensayos Sobre Politica Economica*, 62(1), June, 12-69.

Edwards, S. (2006), The relationship between exchange rate and inflation targeting revisited, NBER Working Paper, No. 12163, Cambridge, MA.

Elbadawi, A.I., Kaltani, L., & Soto, R. (2012), Aid, real exchange rate misalignment, and economic growth in sub-Saharan Africa, *World Development*. 40(4), 681–700, https://doi.org/10.1016/j.worlddev.2011.09.012.

Engel, C. (2014), Exchange rate stabilization and welfare, *Annual Review of Economics*, 6(1), 155–77, DOI: 10.1146/annurev-economics-080213-041417.

Fatum, R. (2008), Daily effects of foreign exchange intervention: evidence from official bank of Canada data, *Journal of International Money and Finance*, 27(3), 438-54, https://doi.org/10.1016/j.jimonfin.2008.01.003.

Fermo, L.B. & Lemence, R.A.E. (2014), Inflation targeting, reserve accumulation, and exchange rate volatility in the Philippines", *Bangko Sentral Review*, 1-20.

Giannellis, N. & Kouretas, G. (2014), Does China's international competitiveness fluctuate in consistency with PPP equilibrium?, International Symposia in Economic Theory and Econometrics, in *Macroeconomic Analysis and International Finance*, 23, 153-183, Emerald Group Publishing Limited, DOI: 10.1108/S1571-038620140000023006.

Grossmann, A. & Orlov, A.G. (2022), Exchange rate misalignments, capital flows, and volatility, *North American Journal of Economics and Finance*, 60, April, DOI: 10.1016/j.najef.2022.101640.

Hansen, E. & Morales, M. (2019), When does the central bank intervene the foreign exchange market? estimating a time-varying threshold intervention function. *International Review of Finance*, 21(5), 1-11, https://doi.org/10.1111/irfi.12288.

Hartmann, M., Herwartz, H., & Ulm, M. (2020). Inflation targeting under inflation uncertainty — multi-economy evidence from a stochastic volatility model. *Macroeconomic Dynamics*, 1–36. https://dx.doi.org/10.1017/S1365100520000565.

He, H., Chou, M.C. & Chang, T. (2014), Purchasing power parity for 15 Latin American countries: panel SURKSS test with a fourier function, *Economic Modelling*, 36, 37–43, DOI: 10.1016/j.econmod.2013.09.012.

Heriqbaldi, U., Widodo, W., & Ekowati. D. (2020). Real exchange rate misalignment and currency crises, *Bulletin of Indonesian Economic Studies*, 56(3), 345–62, https://doi.org/10.1080/00074918.2019.1662885.

Krušković, B.D. (2017), Exchange rate and interest rate in the monetary policy reaction function, *Journal of Central Banking Theory and Practice*, 1: 55-86, DOI: 10.1515/jcbtp-2017-0004.

Kuncoro, H. (2015), Inflation targeting, exchange rate pass-through, and monetary policy rule in Indonesia, *International Journal of Business, Economics and Law*, 7(3), 14-25.

Kuncoro, H. (2020), Interest rate policy and exchange rates volatility, lessons from Indonesia, *Journal of Central Banking Theory and Practice*, 2, 19-42, https://doi.org/10.2478/jcbtp-2020-0012.

Kuncoro, H. & Santoso, T. (2022), Re-examining the relative price-exchange rate nexus, *Economic Computation and Economic Cybernetics Studies and Research*, 56(4), 243-58, DOI: 10.24818/18423264/56.4.22.15.

Lin, M.Y. & Wang, J.S. (2009), Foreign exchange reserves and inflation: an empirical study of five east Asian economies, *Empirical Economics Letters*, 8(5), May, 487-93.

Nakorji, M., Agboegbulem, N.T.I., Gaiya, B.A., & Atoi, N.V. (2021), Purchasing power parity approach to exchange rate misalignment in Nigeria, *CBN Journal of Applied Statistics*, 12(1), June, 45-75.

Obstfeld, M. and Rogoff, K. (2009), *Foundations of International Macroeconomics*, Cambridge, MA: MIT Press.

Obstfeld, M., Shambaugh, J.C., & Taylor, A.M. (2005), The tri-lemma in history: tradeoffs among exchange rates, monetary policies, and capital mobility, *Review of Economics and Statistics*, 87, 423-38, DOI: 10.1162/0034653054638300.

Raksong, S. (2021), Econometric analysis of the determinants of real effective exchange rate in the emerging ASEAN countries, *Journal of Asian Finance, Economics and Business*, 8(3), 731-40.

Rasbin, Ikhsan, M., Gitaharie, B.Y., & Affandi, Y. (2021), Real exchange rate misalignments: the case of the Indonesian rupiah, *Bulletin of Monetary Economics and Banking*, 24(3), 441-64, https://doi.org/10.21098/bemp.v24i3.1268.

Robertson, R., Kumarb, A. & Dutkowsky, D.H. (2014), Weak-form and strong-form purchasing power parity between the US and Mexico: a panel cointegration investigation", *Journal of Macroeconomics*, 42, December, 241–62, https://doi.org/10.1016/j.jmacro.2014.08.005.

Sandri, D. (2023). FX intervention to stabilize or manipulate the exchange rate? inference from profitability, *Journal of International Money and Finance*, 131, March, https://doi.org/10.1016/j.jimonfin.2022.102786.

Sekkat, K. (2016). Exchange rate misalignment and export diversification in developing countries, *Quarterly Review of Economics and Finance*, 59, 1–14, https://doi.org/10.1016/j.qref.2015.08.001.

Sideris, D.A. (2008), Foreign exchange intervention and equilibrium real exchange rates, *International Financial Markets, Institutions, and Money*, 18, 344–57, DOI:10.1016/j.intfin.2007.04.001.

Sidiq, S. & Herawati, (2016), Validity test of purchasing power parity doctrine: an Indonesian case study, *Economic Journal of Emerging Market*, 8(2), October, 120-7, DOI: https://doi.org/10.20885/ejem.vol8.iss2.art4.

Sikarwar, E. (2020), Forex interventions and exchange rate exposure: evidence from emerging market firms. *Economic Modelling*, 93, 69–81, https://doi.org/10.1016/j.econmod.2020.07.010.

Steiner, A. (2017). Does the accumulation of international reserves spur inflation?", *North American Journal of Economics and Finance*, 41, 112–32, https://doi.org/10.1016/j.najef.2017.03.007.

Sweeney, R. (1999). Intervention strategy and purchasing power parity. In R.J. Sweeney, C.G.Wihlborg, and T.D. Willett, (eds.), *Exchange-rate Policies for Emerging Market Economies*. Boulder and Oxford: Westview Press, 195-225.

Taylor, A. & Taylor, M. (2004), Purchasing power debate, *Journal of Economic*

Perspectives, 4, 135-58, DOI: 10.1257/0895330042632744.

Toulaboe, D. (2017), Real exchange rate misalignment of Asian currencies, *Asia Pacific Economic Literature*, 31(1), 39-52, https://doi.org/10.1111/apel.12173.

Williamson, J. (1994). Estimates of FEERS. In: J. Williamson (edt). *Estimating Equilibrium Exchange Rates*, Washington: Institute for International Economics.

Yan, H.D., Chen, L.J., & Tseng, Y.H. (2014), Capital inflow, foreign exchange intervention, and currency misalignment in emerging market countries, *China Economic Policy Review*, 3(2), 1-30, https://doi.org/10.1142/S1793969014500101.

Yeyati, L.E., Sturzenegger, F., & Gluzmann, P.A. (2013), Fear of appreciation, *Journal of Development Economics*, 101, 233–47, https://doi.org/10.1016/j.jdeveco.2012.11.008.

Zorzi, M.C., Cap, A., Mijakovic, A., & Rubaszek, M. (2020), The predictive power of equilibrium exchange rate models, ECB Working Paper Series No 2358, January.