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Dynamic Linkages between US Dollar-Ringgit spot, forward and NDF during QE and Post-QE Exit

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This study investigates the information flow between U.S. Dollar-Ringgit spot, forward and Non-deliverable Forward (NDF) exchange rates during the pre and post-U. S. Quantitative Easing (QE) exit. Our results show: First, there is a robust unidirectional causality from NDF to spot and NDF to forward in the post-QE period; Second, Malaysian Government Securities (MGS) has a vital role during the QE period while international reserve precedes the spot, forward and NDF exchange rates in the post-US QE exit. Our results reaffirm the policy measures taken by the Central Bank in regulating the NDF market. Our finding suggests that: First: MGS and Reserve are essential variables that can be used to counter speculation from the offshore NDF market; and Second, right policy stance must be communicated by the Central Bank to the market participants to avoid excessive volatility to the domestic currency which will affect the real economy.

Keyword: *forward market; non-deliverable forward; quantitative easing; emerging market; Federal Open Market Committee*

JEL Classification: F31, G13, C51

Introduction

As an emerging market, the Malaysian currency is under the regime of managed float. In other words, the exchange rate of U.S. Dollar-Ringgit (USD/MYR) is allowed to fluctuate based on supply and demand, but at times, Bank Negara Malaysia will intervene to influence the value. It is not an international currency, and hence its value is derived from the major currencies.

Similar to other emerging economies, Malaysia is vulnerable to the shock from U.S. monetary policy. Empirically, the study by Ahmed and Zlate (2014) and Bhattarai, Chatterjee and Park (2018) show that the U.S. unconventional monetary policy or also known as the Quantitative Easing (QE) policy has a positive impact on the economic performance of emerging economies. The study demonstrates that an expansion in the U.S. QE policy led to an exchange rate appreciation, a reduction in long-term bond yields, stock market boom and inflow of foreign capital into emerging economies.

However, the improvement in the labour market and price level stability in the U.S economy has prompted the U.S. Federal Reserve to call an end to the QE program in October 2014.

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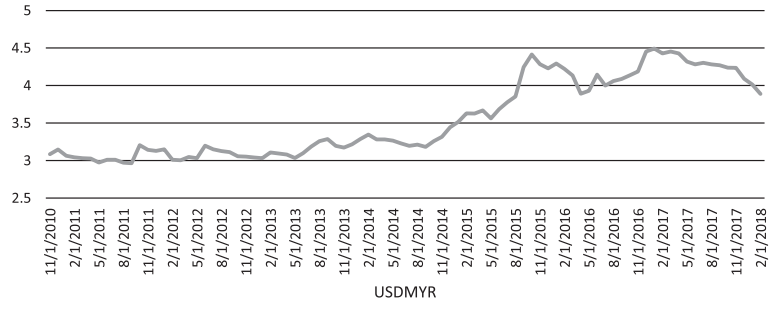
Figure 1. Risk-return relation for all companies with market median as reference point



Source: Bloomberg

This implies that the Fed is on the path of raising the interest rate. Consequently, a higher interest rate would have a bearing on the economic performance of emerging markets. The study by Anstey and Miller (2018) has shown that the MSCI Emerging Markets Index entered a bear market in early September 2015 and followed by a drop in the benchmark index of emerging currencies.

For Malaysia, in the spate 27 months from October 2014 to January 2017 after the Federal Open Market Committee (FOMC) ended the Quantitative Easing (QE) program on 29-30 October 2014, the value of Malaysian currency dropped 26 per cent relative to the US Dollar (Figure 1). While external factors such as the decline of oil price and capital outflow caused the decline of Ringgit, the activities of offshore Ringgit forward has also been cited as one of the causes (The Star, 2016a).

As a non-internationalised currency, the offshore trading of Ringgit, in any form, whether as a non-deliverable forward (NDF) traded out of offshore financial centres or as futures, options and other derivatives contracts on an exchange outside of Malaysia is strictly prohibited (Bank Negara Malaysia, 2017). Furthermore, the rigidity of Ringgit given the fact that it is not fully convertible on the capital account (The Star Online, 2016b) has induced the investor to look for an alternative investment tool to hedge against foreign exchange risk. As a result, the NDF has emerged as a tool for the investors to hedge their currency risk.

Notably, Misra and Behera (2006) argue that due to the non-existence of a natural forward market for non-domestic players, private companies and investors who invest in these Asian economies look for an avenue to hedge their currency risk. Hence, as a derivative instrument, non-delivery forwards (NDFs) of which are available in various currencies, have been widely used for trading in the non-convertible or restricted currencies.

Unlike a forward exchange contract, NDFs do not require physical delivery of the non-convertible currency. The contract is closed at maturity by settling the difference between the contracted forward rate and the prevailing spot rate. It is cash-settled currency forward, which provides an offshore mechanism to hedge currencies, which were previously considered not being to hedge. There is no withholding tax required, and the contracts are settled at a fixed rate.

Generally, NDFs are traded outside the borders of the currency's home jurisdiction. This product enables the investor to avoid restrictions on trading in the home market and limits on the delivery of the home currency (Saravanan and Shanmugam, 2017). Hence, during the episodes of capital outflow, the NDFs provide investors with an alternative instrument to hedge against the restricted currencies. Therefore, the movement in the NDF exchange rate is expected to exert downward pressure on the spot exchange rate when there is a massive capital outflow.

For example, in the case of Malaysia, the NDFs trading in the year 2016 was three times Malaysia's gross domestic product of RM 1.26 trillion and 80% of the volume traded was speculative transactions. Next, the 2016 US presidential election further enlarged the spread between the onshore and offshore rates, with the offshore rates showed a weaker Ringgit and was claimed to exert deprecation pressure on the on-

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shore exchange rate (The Star Online, 2017).

To date, some studies examine the linkages between onshore and offshore exchange rates, Park (2001) pioneered in examining the relationship between Won-Dollar spot and offshore forward. His study reveals that the NDF influences spot currency significantly in the post-Korea exchange rate reform period. Similarly, findings were reported in Hong Kong, in which Izawa (2006) found that the NDF Renminbi is an efficient predictor of the spot and futures exchange rates. In India, the role of NDF in influencing the spot exchange rate has increased since the introduction of the new currency futures (Guru, 2009; Saravanan and Shanmugam, 2017).

Despite the previous studies on the relationship between the NDF and onshore spot exchange rate, there exists some clear research gap. No particular work on the linkages between Dollar-Ringgit NDF and spot has been published in Malaysia, although Ringgit has experienced episodes of depreciation after the end of QE policy. It is interesting to study whether the movement of the NDF exchange rate contributes to the Ringgit depreciation on the back of capital outflow in the post-QE period.

Based on the above discussion, there are many unanswered questions: Is there any information flow from the U.S. Dollar- Ringgit NDF exchange rate to the spot and forward rates in post-U.S. QE? What are the financial variables that influence the NDF, spot and forward U.S. Dollar- Ringgit exchange rates in post-QE period?

This study aims to fill the gap by examining the above questions in both the primary and extended model. The extended model will include other financial variables to reflect the reality of information flow between these variables. The finding would draw some policy implications of the relationship between spot, forward and NDF U.S. Dollar- Ringgit exchange rates.

This study contributes to the existing literature review on two fronts:

First, this study reveals the linkages between U.S. Dollar- Ringgit NDF exchange rate, spot and forward rates in the post-QE period. If the U.S. Dollar- Ringgit NDF exchange rate is found to precede the spot and forward rates in the post-QE period, this will imply that the NDF exchange rate is vital in influencing the movement of spot and future exchange rate. Hence, this suggests to the policymakers in which stricter regulations should be implemented in regulating the NDF market.

Second, this study incorporates financial variables such as international reserve and Malaysian Government Security Yield (MGS) in the model as the means to identify the variables that transmit information to the three exchange rates. This is important because it provides some directions to the policymakers on which financial variable is imperative in stabilizing the Ringgit Malaysia on the back of capital outflow in the post-QE period.

The remainder of the paper is organised as follows. Section II reviews the existing literature and provides the hypotheses for this study. Moreover, section III discusses the research methods. Section IV and V discuss results and show the impulse response analysis, and finally, section VI concludes the paper.

Literature Review

Higgins and Humpage (2005) reveal that international banks have offered the non-deliverable forward (NDF) contracts to investors who need to hedge their exposures in the currencies of emerging-market economies since the 1990s. However, market participants use the information of the exchange rate of the NDF contracts as the predictor of where the emerging market currency is heading. The exchange rates on NDFs is likely to embody a substantial risk premium that interferes with forecasting accuracy. Concerning this, Lipscomb (2005) suggests that NDF prices can be a useful monitoring tool to gauge the market forces that cannot be measured in the onshore market. Furthermore, once a country changes its system to become more convertible in its exchange rate and permit transaction in NDF, NDF market can potentially contribute to the liquidity and volume in the onshore currency market.

Due to the predictability power of the NDF market toward the onshore currency market, the

study of the information flow between the offshore NDF market and the onshore market has gained popularity among researchers. As such, Park (2001) investigates the information flow between Won-Dollar spot and offshore forward. His study reveals that NDF Granger causes spot currency in the post-Korea exchange rate reform period. Moreover, there exists mean and volatility spillover from NDF to the spot market in the post-reform period.

Similarly, Izawa (2006) tests the efficient market hypothesis on the non-deliverable forward (NDF) Renminbi in the Hong Kong market after the Yuan revaluation in 2005. Results indicate that the efficiency hypothesis for the Renminbi NDF market is rejected. Therefore, the NDF rate is an efficient predictor of the future spot rate. The study concludes that the NDF would precede the current spot and future exchange rates.

In the case of India, Guru (2009) examines the dynamic linkages between spot, domestic forward and NDF markets for Indian Rupee with the advent of exchange-traded currency derivatives markets. Results indicate that NDF markets exert increasing influence on the domestic currency markets through spillover effect and provide better information after the introduction of the new currency futures.

Concerning the new currency futures, Saravanan and Shanmugam (2017) provide a comprehensive study on the linkages between the three currency markets in pre- and post- new currency futures. The study found that bidirectional causality exists between the two markets before the introduction of currency futures. However, the NDF market is informationally efficient relative to the spot markets after the launch of currency futures. Thus, the NDF is found to precede the spot market in the post-currency feature period.

Cadarajat and Lubis (2012) pioneer the first study of the information transmission between offshore and onshore Rupiah currency market from 2008 to 2011. Results show that there exists mean and volatility spillover from NDF to spot and NDF to forward rupiah markets. In the information flow, the study found that the NDF precedes the forward rate, but there is no causality can be observed between the NDF and spot rates.

In the Japanese foreign exchange market, Gu and McNelis (2013) found that the speculative movements in the NDF markets have contributed significant influences on the onshore spot exchange rate. Next, Feng and Yang (2016) employ VAR-DCC-MGARCH-BEKK model to examine the dynamic relationship between the onshore and offshore market exchange rate of RMB. Their results show that offshore RMB forward exchange market guide onshore RMB spot and forward exchange rates.

Conversely, a study by Lei and Yulan (2016) show that the onshore spot market exerts an influence on the offshore spot market in Hong Kong. Similar findings are reported in Su, Wang, Zhang and Nian (2019) in which the onshore Chinese Yuan is found to influence the offshore NDF exchange rate.

Based on this, this study develops first two out of eight hypotheses in examining the role of NDF in Malaysia currency market. As mentioned earlier, it is interesting to study whether the movement of the NDF exchange rate contributes to the Ringgit depreciation on the back of capital outflow in the post- U.S. QE period. Hence, it is hypothesised that:

H1: During the post-QE period, NDF will influence the spot the U.S. Dollar- Ringgit exchange rate.

H2: During the post-QE period, NDF will influence the forward U.S. Dollar- Ringgit exchange rate.

Interest Rate Parity Condition

Theoretically, the price of the forward foreign exchange contract is determined by the interest rate parity condition in which equivalent return over a particular period is based on two currency interest rates and the current spot exchange rate (Akram et al., 2008; Baba and Packer, 2009; Della Corte et al., 2011; Ahmad et al., 2012; Cadarajat and Lubis, 2012; Wang et al., 2014). Hence, the interest rate differential between the two currencies would determine

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the forward premium. Generally, the covered interest rate parity holds when there is no arbitrage condition between onshore and offshore currency markets in the absence of capital control (Wang et al., 2014). Therefore, the relationship between onshore and offshore market without the existence of capital control can be drawn from covered interest parity:

$$F = \frac{S(1+r)}{1+r^{us}} \quad (1)$$

Where F is the forward rate, S is the spot rate, r is the interest rate on home currency, and r^{us} is the U.S. Dollar interest rate. However, when some forms of capital control and currency convertibility restriction are applied, non-residents may be restricted from full access to on-onshore currency markets. Hence, NDF applies as a substitute for the forward rate (Cadarajat and Lubis, 2012) as follows:

$$NDF = \frac{S(1+r)}{1+r^{us}} \quad (2)$$

Therefore, with the presence of convertibility restriction among some of the emerging market currencies, investors would use the NDF as a substitution for the forward contract to hedge against the restricted currencies especially during the capital outflow episodes. The least restrictive environment of NDF markets incorporates a substantial set of information into currency exchange markets, suggesting the greater extent to which NDF prices would reflect the spot and forward exchange prices (Kong and Shao, 2010; Maziad and Kang, 2012; Wang et al., 2014).

For Malaysia, the QE exit period is characterised by capital outflow (The Malaysian Reserve, 2017). Given the trading restriction in Ringgit (offshore trading is prohibited, and Ringgit is not fully convertible on capital account), investors would engage in the NDF contract to hedge against the currency uncertainty. Hence it is expected that the offshore NDF U.S. Dollar- Ringgit exchange rate dedicates the rate on the spot and forward market, as stated in hypothesis 1 and 2, respectively.

On the other hand, it is essential to examine the linkages between financial variables and the currency market. This enables the policymaker to identify which indicator contributes to the appreciation or depreciation of the local currency. This study focuses on the international reserve and the government bond yield in predicting the movement of the currency markets.

Generally, central bank intervention in the foreign exchange market can be distinguished between sterilised interventions, which does not affect the money supply and non-sterilized, which does (Mishkin, 2016). In the literature, two main theories explain central bank intervention (whether sterilised or not) affects the exchange rate (Dominguez and Frankel, 1993). Firstly, the portfolio balance channel states that central bank intervention which increases the supply of domestic assets relative to foreign assets, would drive down the domestic asset prices and subsequently increase the domestic interest rate. Higher domestic return prompt investors to substitute foreign assets with domestic assets. Consequently, local currency appreciates.

Secondly, the signalling channel states that central bank intervention provides new information to economic agents, thereby affecting their expectations about the exchange rate. Fluctuation in expectation creates speculation, and therefore any expected appreciation (depreciation) of the domestic currency will motivate speculators to buy (sell) the currency resulting in real appreciation (depreciation) of the currency itself.

A study done by Dominguez and Frankel (1993) suggests that central bank intervention does influence agents' expectation through both the portfolio and signalling channel, thereby affecting the foreign exchange rate. Specifically, central bank intervention to defend the currency from depreciation would decrease the holding of foreign reserves. Lower foreign reserves are indicating that the value of the currency is declining and the currency is exposed to economic uncertainty. As a result, investors will change their composition of the portfolio by selling the domestic asset and purchasing foreign assets. Moreover, investors would exchange domestic

currency to foreign currency. Consequently, the local currency would depreciate.

For Malaysia, the rapid depreciation of Ringgit Malaysia in the post-QE period has caused the Central Bank of Malaysia to initiate a foreign exchange rule to stabilize the currency (Bank Negara Malaysia, 2016). The new foreign exchange rule requires the exporter to convert 75 % of their foreign earnings into Ringgit Malaysia. This intervention, in turn, increases the demand for local currency and the amount of foreign reserve held by the central bank. Higher foreign reserve indicates Ringgit is gaining value relative to the U.S. Dollar. The information of reserve will affect investors' expectation through the signalling channel and subsequently prompt investors to buy Ringgit and sell foreign currency. Hence, in the post-QE period, the international reserve is expected to precede the currency value (spot, forward and NDF). Therefore, the subsequent three hypotheses follow:

H3: During the post-QE period, the international reserve will influence the spot of U.S. Dollar- Ringgit exchange rate.

H4: During the post-QE period, the international reserve will influence the forward of U.S. Dollar- Ringgit exchange rate.

H5: During the post-QE period, the international reserve will influence the NDF U.S. Dollar- Ringgit exchange rate.

The second financial variable is the Malaysian Government Securities (MGS) 10- year yield. Bond yield is an essential determinant of the exchange rate (Clarida and Taylor, 1997; Chen and Tsang, 2013; Yung, 2014). As such, the search-for-yield effect illustrated by Ammer, Claessens, Tabova and Wroblewski (2018) argues that changes in the bond yield will affect investors' portfolio as the low yield assets will be substituted with higher return assets. Hence, higher domestic bond yield induces the investor to demand local assets, thereby the domestic currency will appreciate.

Notably, Clarida and Taylor (1987) and Chena and Tsang (2013) find evidence that variables extracted from the yield curve, the forward premium interest rate differential is imperative in predicting the exchange rate movement. Furthermore, a study by Yung (2014) provides a comprehensive analysis of the interest rate factors explain exchange rate fluctuation. As such, the study reveals that interest rate factors explain about half of the one-year exchange rate fluctuations for different countries during the 1980 to 2016 period. Moreover, the study suggests that the yield curve contains relevant information on exchange rate dynamics and therefore, the bond yield would be an essential determinant for the exchange rate movement. Therefore, hypothesis 6 to 8 are built to test the significance of bond yield in predicting the exchange rate movement in the post-QE period.

H6: During the post-QE period, the MGS will influence the spot the U.S. Dollar- Ringgit exchange rate.

H7: During the post-QE period, the MGS will influence the forward U.S. Dollar- Ringgit exchange rate.

H8: During the post-QE period, the MGS will influence the NDF U.S. Dollar- Ringgit exchange rate.

Research Methods

Data

For the analysis, this paper uses changes in the spot, forward, and NDF, respectively, of which is computed as $Rit = \text{Ln}\,(Pi,\, t \,/\, Pi,\, t\text{-}1)$.

Two models are used in this study: basic and extended models. The first model comprises the daily returns of the spot, forward and non-deliverable forward exchange rates. The second or extended model comprises of monthly data with spot, forward, NDF, Malaysia Government Securities (MGS) 10-year yield and international reserve. These financial variables are included to reflect the actual information flow between these variables.

The sample period is from 3 November 2010

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Table 1. List of variables

Variables	Description	Unit of measurement	Source
First model			
RSP	Percentage return on USD to MYR spot rate	Daily return	Bloomberg
RFWD	Percentage return on 1-month forward USD to MYR rate	Daily return	Bloomberg
RNDF	Percentage return on 1-month NDF USD to MYR rate	Daily return	Bloomberg
Second model			
RSP	Percentage return on USD to MYR spot rate	Monthly return	Bloomberg
RFWD	Percentage return on 1-month forward USD to MYR rate	Monthly return	Bloomberg
RNDF	Percentage return on 1-month NDF USD to MYR rate	Monthly return	Bloomberg
MGS	Malaysia government securities 10- year yield	Interest rate	DataStream
Reserve	International reserve	MYR million	DataStream

Notes: Sample period for the first model: 3/11/2010 to 30/9/2014 and from 30/10/2014 to 21/2/2018.
The sample period for the second model: 10/2010 to 9/2014 and from 10/2014 to 2/2018.

to 21 February 2018. It is further divided into two sub-periods. The first sub-period is from 3 November 2010 to 30 September 2014. The second sub-period is from 30 October 2014 to 21 February 2018, which marks the post-QE period.

The variables used are shown in Table 1.

Unit Root Test

Unit root test will be conducted to check the stationarity of variables. The Augmented Dickey-Fuller (ADF) test has been used to test for a unit root in the series.

The ADF test equation can be explained below:-

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + u_t \quad (3)$$

The hypothesis to be tested is:

H_0: ψ=0
H_1: ψ<0

In order to confirm the result of the unit root test, stationarity tests have also been carried out. In this instance, the KPSS test by Kwaitowski, Phillips, Schmidt, and Shin (1992) is used. Under the null hypothesis, the series y_t is assumed to be stationary. On the contrary, under the alternative hypothesis, yt is non-stationary. So that by default under the null the series will appear stationary.

H_0: y_t~ I(0)
H_1: y_t~ I(1)

Vector Autoregression (VAR)

Vector autoregression model VAR (p) is an extension of the univariate model used to estimate the multivariate time series model. In the case where the k variables are not co-integrated, a VAR model with lag p is defined as

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \varepsilon_t \quad (4)$$

where y_t is defined as $(y_{1,t}, y_{2,t}, y_{k,t})$ of $k\times1$ vector, each c is a $k\times1$ vector of constant(intercept), each A_i is a $k\times k$ coefficient matrix, and ε_i is $k\times1$ error terms vector.

The lag length for the VAR(p) model can be determined by using model selection. Standard practice is based on the Akaike Information Criterion (AIC)

$$\text{AIC} = n\sum \hat{u}_t^2 + 2(k+1) \quad (5)$$

where u_t denoted as residuals are applied in selecting the lag length.

Granger's causality test

Next, causality tests are used to assess the information content of leading indicators. Granger's test used within a bivariate context, states that if a variable x Granger causes the variable y, the mean square error (MSE) of a forecast y based on the past values of both variables is lower than that of a forecast that uses only past values of y. Equation (6) shows the autoregression where the Granger causality test is carried out. However, differencing is only restricted to the variable with unit-roots.

Table 2. Descriptive statistics results

Variable	Mean	Standard deviation	Skewness	Kurtosis	J-B statistic	Observation
First model						
US QE period (3/11/2010 – 30/9/2014)						
RSP	0.0001	0.0040	-0.3626	6.3085	487.5725 (0.000)	1020
RFWD	0.0001	0.0039	-0.1971	6.2743	462.2397 (0.000)	1020
RNDF	0.0001	0.0045	-0.0538	6.4272	499.6829 (0.000)	1020
Post -US QE period (30/10/2014 – 21/2/2018)						
RSP	0.0002	0.0053	-0.1395	5.9325	312.7408 (0.000)	865
RFWD	0.0002	0.0051	-0.5597	8.0551	966.1618 (0.000)	865
RNDF	0.0002	0.0065	-0.3388	6.8069	538.8777 (0.000)	865
Second model						
US QE period (11/2010 – 9/2014)						
RSP	0.0004	0.0204	0.9867	5.2129	17.2184 (0.000)	47
RFWD	0.0004	0.0203	1.0485	5.3125	19.0845 (0.000)	47
RNDF	0.0006	0.0214	1.1909	6.1738	30.8382 (0.000)	47
MGS	3.7801	0.2581	0.0531	1.5198	4.3125(0.1158)	47
Reserve	415,898.4	30,345.52	-2.0594	6.1301	52.4113 (0.000)	47
Post-US QE period (10/2014 – 2/2018)						
RSP	0.0048	0.0295	0.5764	4.1228	4.4246 (0.1094)	41
RFWD	0.0048	0.0294	0.5674	4.1213	4.3479 (0.1137)	41
RNDF	0.0049	0.0279	0.3076	3.7158	1.5224 (0.4671)	41
MGS	3.7632	0.8844	-3.8555	16.82	427.8560 (0.000)	41
Reserve	407,241.5	19,060.34	-0.6561	2.660	3.1377(0.2082)	41

Notes: First model used daily data, second model used monthly data
RSP denotes Percentage return on USD to MYR spot rate,
RFWD denotes Percentage return on one month forward USD to MYR rate,
RNDF denotes Percentage return on one-month NDF USD to MYR rate,
MGS denotes Malaysia government securities ten-year yield,
Reserve denotes International reserve.

$$\Delta y_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta x_{t-1} + \varepsilon_t \quad (6)$$

and testing the joint hypothesis

H_0: $\gamma_1 = \gamma_2 = ... = \gamma_p = 0$
H_1: At least one of them γ_i is not equal to zero

In Granger's causality test, the direction of a causal effect between equity style indices and stock indices, equity style indices and economic indicators, stock indices and economic indicators are tested using restricted *F* test statistic as shown equation (7). Using optimal lag length, the parameter of the model is testeds with a null hypothesis that there is no Granger causality between two series. As proposed by Engle and Granger:

$$F = \frac{\left(RSS_R - RSS_U\right)/p}{RSS_U/(n-2p-1)} \quad (7)$$

where RSS_R is the residual sum of squares of a restricted model while the *RSS* is the residual sum of squares of an unrestricted model;*n* represents sample size and *p* is the number of restricted parameters.

Toda-Yamamoto Level Vector Autoregression

Sims et al. (1990) show that inference based on level VAR is valid since the Wald test used in Granger causality has a limiting chi-square distribution if the time series are cointegrated. However, this approach has a limitation because it requires pre-test for cointegration and its inapplicability to a mixed order of integration processes. A recent method proposed by Toda and Yamamoto (1995) is complementary to the Sims et al. (1990) technique because it allows for causal inference based on augmented level VAR with integrated and cointegrated processes. This method is useful because it bypasses the need for potentially biased pre-test for unit roots and cointegration common to other formulations.

Toda and Yamamoto (1995) use a modified Wald (MWALD) procedure to test restrictions

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Table 3. Unit root and stationary test results for the first model

Variable	ADF test		KPSS test	
	Level	First difference	Level	First difference
US QE period				
RSP	-31.24(0)***		0.03[7]	
RFWD	-31.02(0)***		0.03[10]	
RNDF	-34.09(0)***		0.02[10]	
Post-US QE period				
RSP	-28.54(0)***		0.06[4]	
RFWD	-27.45(0)***		0.06[6]	
RNDF	-29.05(0)***		0.05[11]	

Notes: The ADF and KPSS equations are estimated by including a constant and trend
The optimal lag length selected for ADF is based on SIC
The optimal lag length selected for KPSS based on Newey-West Bandwidth.
Figures in ( ) indicate optimal lag length chosen. Figures in [ ] indicate optimal bandwidth is chosen.
*, ** and **** denote 10%, 5% and 1% significance level, respectively.

on the parameters of the VAR(k) model. This test has an asymptotic chi-squared distribution with k degrees of freedom in the limit when a VAR [k + d(max)] is estimated (where d(max) is the maximal order of integration for the series in the system). Two steps are involved in implementing the procedure. The first step includes the determination of the lag length (k) and the maximum order of integration (d) of the variables in the system. The second step is to apply standard Wald tests to the first k VAR coefficient matrix (but not all lagged coefficients) to conduct inference on Granger causality.

Results and Discussions

Descriptive Statistics

Table 2 below presents the descriptive statistics for all the series. In the first model, it can be observed that the changes of the spot rate, forward rate, and NDF became more volatile with a higher standard deviation in the post- QE relative to the QE period.

For the second model, a similar trend for the spot, forward, NDF and MGS yield. These variables are more volatile in the post-QE exit period relative to the QE period. However, the international reserve is found to be less volatile in the post-QE period relative to the QE period.

Unit Root Test Results

Table 3 presents the unit root and stationarity test results. All series are tested to be in level form. For the first model, ADF and KPSS tests show that all series are stationary at level for both pre and post-US QE period.

For the second model in Table 4, RSP, RWD, and RNDF are stationary at the level in the US QE period. However, MGS and Reserve become stationary after taking the first difference. In the Post-US QE period, RSP, RWD and RNDF are stationary at level. However, both ADF and KPSS test yield inconsistent results for the unit root properties of MGS and Reserve. To be conservative, this study takes the first difference in the two series.

Granger's Causality

Granger's Causality test has been conducted for both models. Based on the Akaike Information Criterion (AIC), the optimal lag length for pre and post-QE models are eight.

In Panel A of Table 5, it is found that during the US QE period, bidirectional causality can be observed between the NDF and spot, NDF and forward, spot and forward. In Panel B of Table 5, for the post-QE period, there is a robust unidirectional causality from NDF to spot and NDF to forward. Hypothesis 1 and 2 is well accepted at 1 per cent significance level. Hence, NDF is found to dictate the movement of Ringgit spot and forward rate. The relationship is depicted in Figure 2 and 3.

The end of U.S. QE has triggered substantial capital outflow from Malaysia, and given the convertibility restriction of Ringgit currency on capital account, the investors would engage

Table 4. Unit root and stationary test results for the second model

Variables/Period	ADF Test		KPSS test	
	Level	First difference	Level	First difference
US QE period				
RSP	-7.28(0)***		0.08[5]	
RFWD	-7.27(0)***		0.08[5]	
RNDF	-7.46(0)***		0.07[4]	
MGS	-1.91(0)	-5.99(2)***	0.20[5]**	0.05[0]
LnReserve	-2.35(0)	-6.39(0)***	0.17[5]**	0.09[3]
Post-US QE period				
RSP	-5.56(0)***		0.06[0]	
RFWD	-5.55(0)***		0.06[0]	
RNDF	-5.26(0)***		0.05[1]	
MGS	-3.26(0)	-7.44(0)***	0.06[3]	
LnReserve	-3.25(0)	-5.97(1)***	0.10[3]	

Notes: The ADF and KPSS equations are estimated by including a constant and trend
The optimal lag length selected for ADF is based on SIC
The optimal lag length selected for KPSS based on Newey-West Bandwidth.
Figures in ( ) indicate optimal lag length chosen. Figures in [ ] indicate optimal bandwidth is chosen.
** and **** denote 5% and 1% significance level, respectively. Ln denotes natural logarithm

Table 5

Panel A: Granger's causality results for first model (US QE)

Dependent Variables	Independent variables		
	RSP	RFWD	RNDF
RSP		67.6448 (0.0000)***	295.9477 (0.0000)***
RFWD	23.8482 (0.0024)***		195.7169 (0.0000)***
RNDF	28.6447 (0.0004)***	28.9196 (0.0003)***	

Panel B: Granger's causality results for first model (Post-US QE)

Dependent Variables	Independent variables		
	RSP	RFWD	RNDF
RSP		49.1076 (0.0000)***	
RFWD	11.0675 (0.1979)		237.3196 (0.0000)****
RNDF	10.9174 (0.2064)	6.8170 (0.5565)	

Notes: The asterisks *, ** and *** denotes significance at 10%, 5% and 1% level respectively.
All estimates are asymptotic Granger Chi-squared statistics. Values in parentheses are p-values.

in NDF to hedge against the currency depreciation. Therefore, the rapid development of the NDF market in this particular period would incorporate abundant information about the currency market, indicating the more significant the extent to which NDF prices reflect spot and forward price (Kong and Shao, 2010; Wang et al., 2014). Hence, there is a robust one-way causality running from NDF to spot, NDF to forward.

Moreover, the spot and forward exchange rate lost its predictive power toward the NDF rate in the post-QE period. This may attribute to the belief of market participants that prices in the offshore market are likely to better reflect global market conditions than the onshore market rate (Maziad and Kang, 2012) and given the convertibility restriction of Ringgit, investors will substitute forward contract with NDF contract (Cadarajat and Lubis, 2012).

As a result, the NDF U.S. Dollar- Ringgit exchange rate is found to dedicate the movement of spot and forward in the post-QE period. This indicates that the depreciation (appreciation) of Ringgit in the NDF market would result in depreciation (appreciation) of the Ringgit spot and forward exchange rates. Notably, the findings concur with earlier studies in developed

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Figure 2. Short-run relationship for the First Model (US QE: 3/11/2010- 30/9/2014)

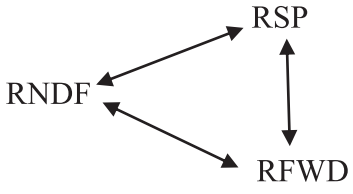


Figure 3. Short-run relationship for the First Model (US QE: 3/11/2010- 30/9/2014)

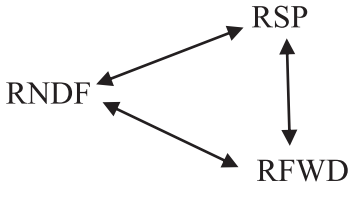


Table 6

Panel A: Granger's causality results for second model (US QE period)

Dependent Variables	Independent variables				
	RSP	RFWD	RNDF	ΔMGS	ΔLnReserve
RSP		4.8972	0.0525	6.4925	0.8405
		(0.0269)**	-0.8188	(0.0108)**	-0.3593
RFWD	4.9669		0.0484	6.4819	0.8555
	(0.0258)**		-0.8259	(0.0109)**	-0.355
RNDF	4.7419	4.6531		5.783	0.8735
	(0.0294)**	(0.0310)**		(0.0162)**	-0.35
ΔMGS	3.9054	3.6763	3.0489		0.1044
	(0.0481)**	-0.0552	-0.0808		-0.7466
ΔLnReserve	0.4858	0.4552	0.2624	0.1513	
	-0.4858	-0.4999	-0.6085	-0.6973	

Panel B: Granger's causality results for second model (Post-US QE period)

Dependent Variables	Independent variables				
	RSP	RFWD	RNDF	ΔMGS	ΔLnReserve
RSP		0.6989	7.8927	6.9324	6.5287
		-0.7051	(0.0193)**	(0.0312)**	(0.0382)**
RFWD	0.672		7.8765	6.8794	6.5498
	-0.7146		(0.0195)**	(0.0321)**	(0.0378)**
RNDF	0.8524	0.9067		8.6659	7.9812
	-0.653	-0.6355		(0.0131)**	(0.0185)**
ΔMGS	1.9425	2.0326	3.8386		2.1656
	-0.3786	-0.3619	-0.1467		-0.3386
ΔLnReserve	0.179	0.2217	3.1367	1.3175	
	-0.9144	-0.8951	-0.2084	-0.5175	

Notes: The asterisks ** and *** denotes significance at 5% and 1% level respectively.
All estimates are asymptotic Granger Chi-squared statistics. Values in parentheses are p-values.
Δ denotes first differenced. Ln denotes natural logarithm

and emerging economies (Park, 2001; Izawa, 2006; Guru, 2009; Saravanan and Shanmugam, 2017), in which the NDF is found to precede the spot and forward exchange rates. Moreover, the results are consistent with the statement put forth by the Governor of Central Bank of Malaysia (The Star Online, 2016a), in which the movement of the NDF exchange rate has a significant influence on the onshore spot and forward exchange rates.

For the results of the second model, as shown in Table 6, Panel A and B, the optimal lag length selected by AIC were one and two for QE and post-US QE periods, respectively.

Figure 4. Short-run relationship for Second Model (US QE: 11/2010- 9/2014)

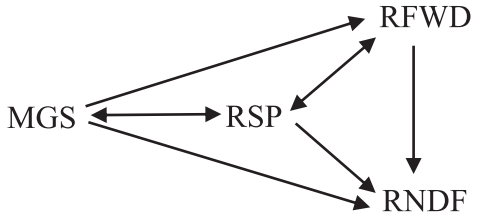
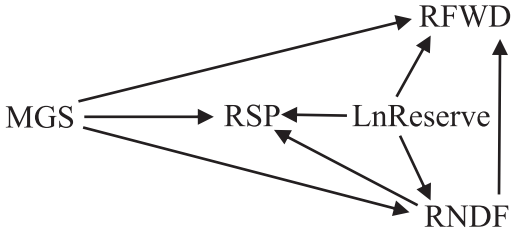


Figure 5. Short-run relationship for Second Model Post-US QE: 10/2014- 2/2018)



As shown in Figure 4 and 5, MGS plays the dominant role in transmitting information to spot, forward and NDF market in pre-and post-US QE period. Next, the impact of the international reserve on exchange rates becomes apparent in the post-QE period. In Figure 5, it can be observed that there is unidirectional causality from the international reserve to spot and forward exchange rate. The reserve also Granger causes NDF exchange rate.

To ensure the robustness of our VAR results for the second model, where monthly data are used, a level VAR model is estimated using the procedure developed by Toda and Yamamoto (1995). The optimal lag length for VAR model was one, and two for US QE and post-US QE period, respectively, a (k+1=2) and (k+1=3) order VAR is estimated with restrictions placed on lagged terms up to the kth lag. Table 7 outlines the results.

Interestingly, the Toda-Yamamoto model in Figure 6 show consistent results with the VAR model shown in Figure 4. It is found that MGS has a vital role in the QE period. However, in the post-QE period, MGS plays no role in influencing the spot, forward and NDF exchange rates.

As mentioned earlier, the Ringgit Malaysia experienced sharp depreciation in the post- QE period and thereby affecting investors' confidence in the stability of the currency. Consequently, changes in the bond yield are insufficient to reverse the Ringgit selling pressure and restore investors' confidence (Dhesi, 2014). Therefore the bond yield would have no impact on the Ringgit value in the post-QE period.

Conversely, Figure 7 shows that there is unidirectional causality from the international reserve to spot U.S. Dollar-Ringgit exchange rate in the post-QE period. Similarly, the reserve also Granger causes the forward and NDF U.S. Dollar-Ringgit exchange rate. These results are consistent with the VAR model shown in Figure 5. Thus, hypothesis 3 to 5 are strongly supported in which international reserve precedes the spot, forward and NDF exchange rates in the post-QE period.

The results suggest that the international reserve is imperative in explaining the movement of NDF, spot and forward U.S. Dollar-Ringgit exchange rate in the post-QE period. Changes in the reserves would affect investors' expectation through the signalling channel, thereby influencing the currency value (Dominguez and Frankel, 1993). The number of foreign reserves held by the central bank indicates the ability of the bank in providing emergency foreign currency funding to stabilise the currency value in the event of financial stress (Fatum and Yetman, 2017). Therefore, lower international reserve implies the lower capacity of the central bank in stabilising the Ringgit value during

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Figure 6. Augmented VAR for Second Model (US QE: 11/2010- 9/2014)

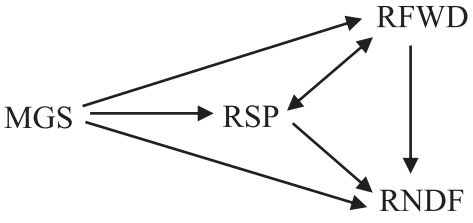


Figure 7. Augmented VAR for Second Model (Post-US QE: 10/2014- 2/2018)

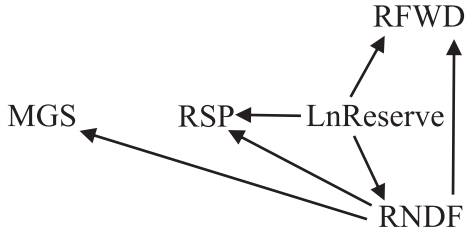


Table 7

Panel A: Toda-Yamamoto Augmented VAR model for second model (US QE)

Dependent Variables	Independent variables				
	RSP	RFWD	RNDF	MGS	LnReserve
RSP		5.447	1.5736	4.6572	0.0696
		(0.0196)**	-0.2097	(0.0309)**	-0.7919
RFWD	5.8006		1.5569	4.6648	0.0691
	(0.0160)**		-0.2121	(0.0308)**	-0.7926
RNDF	5.1067	4.768		3.8901	0.0308
	(0.0238)**	(0.0290)**		(0.0486)**	-0.8606
MGS	2.0059	1.849	2.3459		0.6819
	-0.1567	-0.1747	-0.1038		-0.4089
LnReserve	0.1517	0.1294	0.4122	2.3105	
	-0.6969	-0.719	-0.5209	-0.1285	

Panel B: Toda-Yamamoto Augmented VAR model for second model (Post-US QE)

Dependent Variables	Independent variables				
	RSP	RFWD	RNDF	MGS	LnReserve
RSP		0.4276	10.0025	2.4903	11.4823
		-0.8075	(0.0067)***	-0.2879	(0.0032)***
RFWD	0.3622		9.9979	2.4731	11.5281
	-0.8343		(0.0067)***	-0.2904	(0.0031)***
RNDF	0.8983	0.9764	3.6839		12.2871
	-0.6382	-0.6137	-0.1585		(0.0021)***
MGS	0.7272	0.8667	7.0124		2.2739
	-0.6952	-0.6483	(0.0300)**		-0.3208
LnReserve	0.2076	0.2183	2.73	2.4374	
	-0.9014	-0.8966	-0.2554	-0.2956	

Notes: The asterisks ** and *** denotes significance at 5% and 1% level respectively.
The [k + d(max)]th order level VAR was estimated with d(max) = 1, since the order of integration is 1.
Lag length selection of k = 1 was based on AIC information criteria (Panel A)
Lag length selection of k = 2 was based on AIC information criteria (Panel B)
All estimates are asymptotic Granger Chi-squared statistics. Values in parentheses are p-values.

capital outflow episodes, thereby reducing investors' confidence in Ringgit. Subsequently, lower reserves holding will prompt investors to sell Ringgit and exchange back the foreign currency. Thus, the foreign reserves played an essential role in predicting the movement of the

Figure 8. Response of RSP to RNDF (US QE)

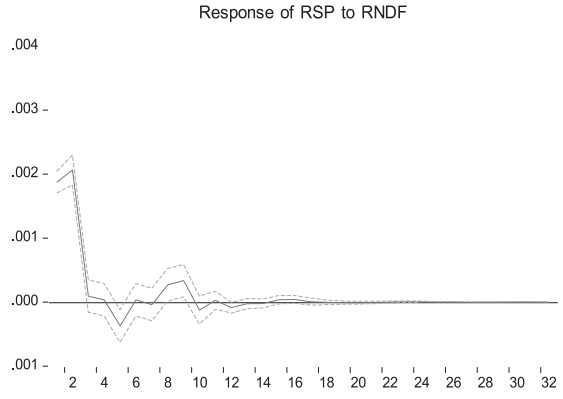


Figure 9. Response of RSP to RNDF (Post- QE)

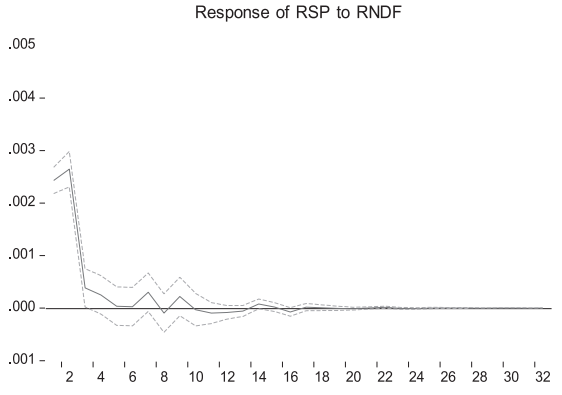


Figure 10. Response of RFWD to RNDF (US QE)

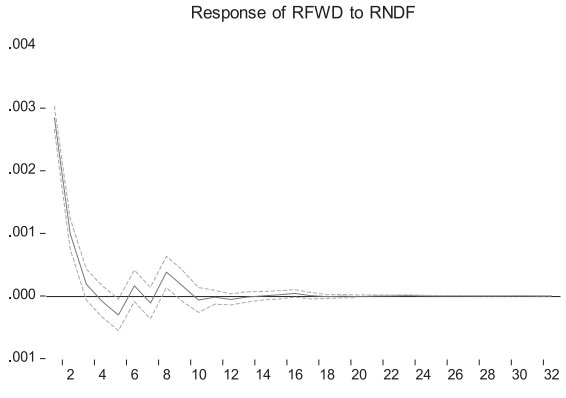
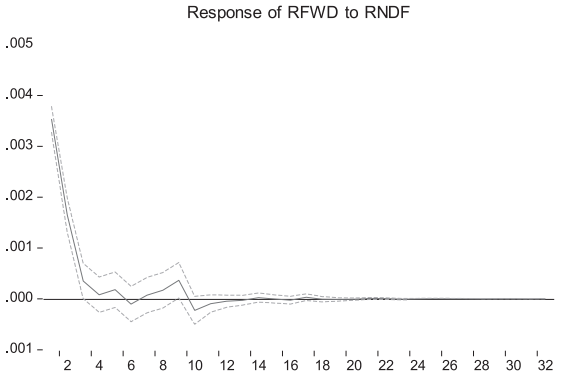


Figure 11. Respond of RFWD to RNDF (Post- QE)



Notes: US QE: 3/11/2010- 30/9/2014
Post-US QE: 30/10/2014- 21/2/2018
RSP denotes a percentage return on MYR to USD spot rate,
RFWD denotes a percentage return on 1-month forward MYR to USD rate,
RNDF denotes Percentage return on 1-month NDF MYR to USD rate

spot, forward and NDF U.S. Dollar- Ringgit exchange rate in the post-QE period.

Further analysis

From the VAR of the first model, generalised impulses have been used to generate the impulse response function. Figure 8, 9, 10 and 11 shows the impulse response function for the first model. The exchange rate is defined as Ringgit per Dollar (USD/MYR). Therefore, an increase in the exchange rate indicates depreciation in the Ringgit currency. Similarly, the higher the return of Ringgit per Dollar, the greater will be the Ringgit depreciation.

Notably, the NDF depreciation shock leads to an initial positive response from the spot rate in pre- and post- QE period (figure 8 and 9). As mentioned above, the positive response of spot rate indicates that Ringgit depreciates against the U.S. Dollar. Furthermore, the initial depreciation of Ringgit in the post- QE period is higher than the QE period. This implies that the NDF exerts higher depreciation pressure on the Ringgit spot rate in the post- QE period.

Likewise, the depreciation shock in NDF rate will also lead to an initial positive response from the forwarding rate in both pre- and post- U.S. QE period (figure 10 and 11). Similarly, the forward Ringgit rate exhibits more depreciation concerning the shock of decline in NDF during the post-QE period.

The impulse responses justify the hypothesis 1 and 2 that there is strong unidirectional causality from NDF to spot and NDF to forward the U.S. Dollar- Ringgit exchange rates in the post-QE period. Besides, the results are consistent with the argument put forth by Kong and

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Shao (2010) and Maziad and Kang (2012) that the development in the offshore market would incorporate a higher set of information on the currency markets and therefore would have the greater extent to which NDF influence the spot and forward prices.

Conclusion

This study has revealed some essential relationships of the financial variables during the pre- and post-period of QE exit. Based on daily exchange rate on the spot, forward and NDF U.S. Dollar-Ringgit exchange rate from November 2010 to February 2018, our results show: Firstly, during the U.S. QE period, bi-directional causality can be observed between the NDF and spot, NDF and forward, spot and forward.

Secondly, there is a robust unidirectional flow from NDF to spot U.S. Dollar-Ringgit exchange rate in the post-QE exit period. Hypothesis 1 is well supported. Our result concurs with earlier studies which examine the information flow between the NDF and spot rate in advanced and emerging economies (Park, 2001; Misra and Behera, 2006; Feng and Yang, 2016; Lei and Yulan, 2016).

Likewise, the above scholars also found there exists a transmission channel between the NDF and forward rates in both advanced and emerging economies. Hence, hypothesis 2 is in line with other studies concerning information flow from NDF to forward rate in the Malaysian market.

Thirdly, our results distinguish from the prior research in this field by adding the international reserve, and Malaysia government securities yield to access the information transmitted to the NDF, forward and spot U.S. Dollar- Ringgit exchange rate in pre- and post-QE.

Our results indicate that MGS plays a vital role in influencing the spot, forward, and NDF U.S. Dollar- Ringgit exchange rate in the U.S. QE period. Moreover, the international reserve is a variable that provides feedback to spot, forward and NDF U.S. Dollar- Ringgit exchange rate in the post-QE exit period. Robustness check with Toda-Yamamoto procedure shows consistent results of the VAR model.

This study provides two important policy implications: Firstly, the study reveals the role of the NDF in predicting the spot and forward U.S. Dollar- Ringgit exchange rate in the post-QE period. Notably, the results from impulse responses show that the depreciation shock in NDF will exert more depreciation pressure on the U.S. Dollar- Ringgit spot and the forward rate in the post-QE period. Therefore, regulation of the trading activities in the offshore NDF market is needed to prevent a further drop in the Ringgit value. Our results reaffirm the policy measures taken by the Central Bank of Malaysia to address the effect of offshore NDF market activities on the domestic spot market; Secondly, the study discovers that the foreign reserves are the key to stabilise the Ringgit from depreciation pressure in the post- QE period. Therefore, the Central Bank of Malaysia should closely monitor international reserve to improve investors' confidence in Ringgit Malaysia.

As a policy suggestion, the Central Bank of Malaysia should maintain a sufficient amount of foreign exchange reserve to mitigate the foreign exchange risk. With the significant accumulation of foreign reserve, the country will be able to withstand massive capital outflow from the banking system by absorbing the currency shock. Besides, the Central Bank can reduce the fluctuation of local currency if the banking system can defend the currency from the pressure of depreciation on the back of higher stock of foreign reserve. In conclusion, this will improve the resilience of the currency and investors' confidence in Ringgit Malaysia in the long run.

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