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Modeling Dynamic Causalities between the Indonesian Rupiah and Forex Markets of ASEAN, Japan and Europe

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ABSTRACT

Historically, the Indonesian Rupiah (IDR) has fluctuated throughout the years, and its fluctuations have been very much interrelated with other forex markets. Since the IDR fluctuations impact national economic growth, investigating the movements of forex markets with respect to the IDR provides important policy implications. Due to limited previous studies investigating the interactions between the IDR and forex markets, this study explores the dynamic causality over both the short and long run between the IDR and the forex markets of ASEAN (Association of South East Asian Nations), Japan and Europe. The study utilizes the daily nominal exchange rates of Indonesia, Thailand, Malaysia, Singapore, the Philippines, Japan, the U.S., and Europe spanning from January 1, 2008, to December 31, 2015. These data were then analyzed using the cointegration and vector error correction (VECM) techniques. The study found that the IDR was cointegrated with the forex markets of ASEAN, Japan, and Europe. The IDR was found to be the most dependent market compared to the other ASEAN forex markets since those forex markets appeared to have close causal linkages between them. For multivariate causalities, the Philippine Peso was found to be the only forex market that was independent of both the Japanese and European forex markets. Additionally, the ASEAN forex markets were more influenced by the forex markets of Japan rather than those of Europe. Since the forex markets become more integrated regionally, there is a need for policy synchronization among those countries in order to manage the impacts of forex fluctuations.

KEY WORDS: Integration; Granger causality; Forex trading benefits; Forex markets; ASEAN

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1. Introduction

Of late, there have been many empirical studies focusing on the relationships among exchange rates using various types of statistical analyses. For example, correlation coefficient analysis was adopted by Baig and Goldfajn (1998); the cointegration method was adopted by Baillie and Bollerslev (1989), Caporale, Cipollini, and Demetriades (2005), Park and Song (2000), and Nieh and Lee (2001); the Granger causality approach was adopted by Khalid and Kawai (2003) and Sander and Kleimeier (2003); and finally the error correction model (ECM) was adopted by Reside and Gochoco-Bautista (1999). These various

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methods were all employed in order to empirically explore the comovements among the national forex markets. Among those methods, cointegration was the most commonly used technique to investigate the relationships between exchange rates. Aggarwal and Mougoue (1996), for instance, explored the relative influence of Japanese and U.S. exchange rates on the currencies of Asian countries. They found that these two economies' forex markets, which were the most developed in the world, were cointegrated with the Asian forex markets. Similarly, Tse and Ng (1997) found cointegration among the forex markets of Japan, Singapore, the Philippines, Malaysia, and Thailand.

In contrast to previous studies that focused on the relationships between the forex markets of the developed and the emerging markets of Asia, studies focusing on the Indonesian Rupiah (IDR) are scarce. The present study extends the existing empirical literature to address the question of whether the IDR is cointegrated with other forex markets of ASEAN and the forex markets of the developed economies of Japan and Europe. This study varies from previous studies on the relationships across forex markets in at least three aspects. First, unlike the work of Aggarwal and Mougue (1996) and Tse and Ng (1997), this study incorporates the IDR in its analysis. Second, although the IDR was included in the study by AuYong, Gan and Treepongkaruna (2004) as one of 13 Asian forex markets during the 1990s financial crisis, their study only used cointegration, bivariate Granger causality, and impulse responses analyses, while this study utilizes the cointegration and VECM techniques to identify both short- and long-term relationships and multivariate causalities among the forex markets. Finally, apart from investigating the interactions among the national forex markets of the five ASEAN economies (i.e., Indonesia, Malaysia, Thailand, Singapore, and the Philippines), this study also includes the Japanese Yen and the European Euro in its analysis.

Considering the rapid growth of the Indonesian economy, studies on the interactions between the IDR and forex markets of the other Asian emerging and developed economies are insufficient. There has been only one study focusing on the IDR's movements (Triyono, 2008). That study, however, did not investigate the relationships between the IDR and the other ASEAN, Japanese and European forex markets. Rather, its analysis only focused on the effects of the macroeconomic determinants of the money supply, inflation, interest rates, and imports on the national currency of Indonesia using the cointegration technique. Thus, this study fills this gap in the research by empirically exploring both the short- and long-run equilibrium relationships and multivariate causalities among the forex markets of Indonesia, Malaysia, Singapore, Thailand, the Philippines, Japan and Europe.

Historically, the IDR exchange rate has fluctuated throughout the years, and its volatility amplified following the 2008 global financial crisis. During the 2008 financial crisis, the IDR weakened from IDR10,048 per U.S. dollar (USD) in October 2008 to IDR11,711 just one month later (Secretariat of the Republic of Indonesia, 2009). By the end of September of that year, the IDR depreciated to its lowest level of IDR14,802 per USD. The weakening of the IDR against the USD became a serious problem for Indonesia. It prompted Indonesia's economic growth to decrease from 5.41% in 2014 to 4.71% in 2015. More than 43,085 workers have been retrenched and imported food prices increased by 0.54% from 2014 to 2015.

According to the former Minister for the Economic Coordination of Indonesia, Chairul Tanjung, the weakening of the IDR has been contributed to three internal factors (Azhar, 2014). The first factor that led to the decline of the IDR was caused by foreign companies that paid biannual dividends to foreign investors. That activity resulted in a higher demand for foreign currencies. The second factor was due to an increase in imported goods equal to 59 billion USD in the first quarter of 2014. The final factor was the tendency of national companies in Indonesia to pay their debts in USD, thus leading to the appreciation of the USD and the continued depreciation of the IDR.

Further weakening of the IDR against foreign currencies was related to the economic activity of the people of Indonesia. For example, at the end of the year, for Christmas and the New Year, most Indonesian business people at the high-end of the income groups went on vacations overseas. Their travels abroad during this time resulted in a greater demand for the USD and other foreign currencies, thus leading to the appreciation of foreign currencies and the weakening

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of the IDR. The IDR has further weakened due to the government's desire to quickly raise interest rates.

In 2014, the European Euro (EUR) and Japanese Yen (JPY) depreciated by 13% and 12%, respectively. The depreciation of those currencies positively impacted the IDR (Bank Indonesia, 2014), thus indicating that the fluctuation of foreign currencies plays a pivotal role in the fluctuation of the IDR.

Building upon previous research, this study empirically investigates both the short- and long-run equilibrium relationships between the IDR and the changes in the forex markets of ASEAN, Europe and Japan using cointegration and the VECM. The extent to which changes in the IDR were Granger-caused by changes in the exchange rate of foreign currencies is also empirically explored. Additionally, this study attempts to empirically examine the accuracy of the VECM models in measuring the effects of changes in the selected forex markets on the IDR's stability.

The impacts of the movements of foreign currencies on the IDR have numerous policy implications for businesses, the government, and the economy as a whole. For businesses, predicting the movements of exchange rates would be beneficial for determining investment strategies in the local economy and abroad. Having identified the nature of interactions between national and foreign currencies, the government would be better equipped to design proper economic policy to stabilize its currency and promote economic growth.

The study is outlined as follows. Section 2 highlights the estimation techniques and data, Section 3 discusses the empirical findings, and Section 4 concludes the study.

2. Empirical Framework

2.1. Stationarity Test

A majority of macroeconomic variables are nonstationary (Serletis, 1993), which leads to spurious regressions. Thus, the first step of this study was to conduct the unit root test in order to ensure that all variables are stationary. Thomas (1997) asserts that findings from regression analysis become invalid when applied to nonstationary variables. Stationarity shows that for each series, the mean, variance, and covariance do not change over a period of time. This study employs the standard Augmented Dickey Fuller tests (ADF) (Dickey & Fuller, 1979; 1981) to test for stationarity using the following model:

$$\Delta y_t = \beta_1 + \beta_{2t} + \delta y_{t-1} + \gamma_i \sum_{i=1}^{m} \Delta y_{t-1} + \varepsilon_t \quad (1)$$

where Δy_t is the first difference of y, β_1 is the intercept, β_2 is the predicted coefficient for a trend, δ is the estimated coefficient for the lagged y, γ is the estimated coefficient for the difference of the lagged y, ε is the error term, m is the number of lags, and t is the time period. In testing the stationarity, if the null hypothesis (H_0: $\delta = 0$) of the unit root is rejected, the variables are stationary. If the null hypothesis (H_1: $\delta \neq 0$) is not rejected, the variables are nonstationary.

2.2. Cointegration Test

In the next step, the cointegration analysis is conducted to see if all nonstationarity variables are found to have a similar order of integration. The maximum likelihood approach adopted by Johansen (1988) and Johansen and Juselius (1990), which is henceforth called the JJ cointegration technique, is utilized in this study to test for the presence of long-run equilibrium relationships among exchange rates. Essentially, the JJ is based on the vector autoregressive (VAR) model as follows:

$$Y_t = \delta + \prod_i Y_{t-1} + \ldots + \prod_k \Delta Y_{t-k} + \varepsilon_t \quad (2)$$

where Y_t, δ and ε_t are an $n\ x1$ vector of the nonstationary variables that are integrated of the same order, the intercept terms, and the white noise error terms, respectively. Meanwhile, Π_i is an $n\ x\ n$ matrix of the coefficients and k is the order of the autoregression. Since this study explores the interactions among seven exchange rates, n is equal to seven. To test for the number of cointegrating vectors, the study utilizes the $\hat{\lambda}_{trace}$ statistics and the $\hat{\lambda}_{max}$ eigenvalue statistics of Osterwald-Lenum (1992) that have been adjusted for the degrees of freedom as follows:

$$\hat{\lambda}_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i) \quad (3)$$

$$\hat{\lambda}_{max}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1}) \quad (4)$$

where $\hat{\lambda}_i$ are the approximated eigenvalues ranked from the largest value to the smallest. The $\hat{\lambda}_{trace}$ in Equation (3) and the $\hat{\lambda}_{max}$ in Equation (4) are called

the trace statistics and maximal eigenvalue statistics, respectively. $\hat{\lambda}_{trace}$ is a probability ratio statistic test for the hypotheses that there are at most r cointegrating vectors, while $\hat{\lambda}_{max}$ is used to examine the hypothesis of r cointegrating vectors in opposition to the hypothesis of $r - 1$ cointegrating vectors. Additionally, the rank of Π is equal to the number of eigenvalues that are different from zero. If the eigenvalues of $\hat{\lambda}_i$ are all zero, then $\hat{\lambda}_{trace}$ and $\hat{\lambda}_{max}$ are zero.

2.3. Multivariate Causalities Test based on the VECM

Furthermore, if all forex markets are found to be nonstationary and integrated of the same order, after differencing at time d or $I(d)$, there might be a linear combination among the forex markets. In other words, if cointegration exists between Y_{it} and X_{it}, an error correction model (VECM) would be used to explore the long-run relationships and the multivariate causalities among the forex markets. In this case, the following VECM was adopted:

$$\Delta Y_{1t} = \alpha_0 + \delta_1(Y_{1t-1} - \gamma X_{1t-1}) + \sum_{i=1}^{k} \alpha_{1i}\Delta Y_{1t-1} + \\ + \sum_{i=1}^{k} \alpha_{2i}\Delta X_{2t-1} + \varepsilon_{it} \quad (5)$$

$$\Delta X_{1t} = \beta_0 + \delta_2(Y_{1t-1} - \gamma X_{1t-1}) + \sum_{i=1}^{k} \beta_{1i}\Delta X_{1t-1} + \\ + \sum_{i=1}^{k} \beta_{2i}\Delta Y_{2t-1} + \varepsilon_{it} \quad (6)$$

where δ_i are the adjustment speeds. The presence of the cointegration, according to Engle and Granger (1987; 1991), implies causality among the exchange rates as manifested by $|\delta_1| + |\delta_2| > 0$. Failing to reject H_0: $\alpha_{21} = \alpha_{22} = ... = \alpha_{2k} = 0$ and $\delta_1 = 0$ implies that the IDR exchange rate does not Granger-cause the exchange rates of other countries, whereas failing to reject H_0: $\beta_{11} = \beta_{12} = ... = \beta_{1k} = 0$ and $\delta_2 = 0$ denotes that the exchange rates of other countries do not Granger-cause the IDR.

2.4. Mean Absolute Percentage Error (MAPE)

Finally, this study evaluates the accuracy of the VECM for the future prediction of exchange rate movements by using the mean absolute percentage error (MAPE). MAPE has become popular as a performance measure in forecasting (Flores & White, 1989; Gunter & Aksu, 1989; Mui & Chu, 1993). One of the main reasons for its popularity is due to its validity for forecasting in applied economics, finance and business. MAPE is also easy to interpret and understand (Lam, Mui & Yuen, 2001). Thus, this study adopts MAPE to measure the forecasting accuracy of the model as follows:

$$MAPE = \frac{100}{n}\sum_{t=1}^{n}\left|\frac{X_t - F_t}{X_t}\right| \quad (7)$$

where X_t is the actual value, and F_t is the estimated values. The smaller the MAPE, the more accurate and the better the model is for forecasting the future movements of the exchange rates.

2.5. Data

The study uses data of daily nominal exchange rates of the Indonesian Rupiah (IDR), Malaysian Ringgit (MYR), Philippine Peso (PHP), Singaporean Dollar (SGD), Thai Baht (THB), Japanese Yen (JPY), United States Dollar (USD) and European Euro (EUR) spanning from January 1, 2008, to December 31, 2015. The data were gathered from the official website of the Indonesian central bank, Bank Indonesia (http://www.bi.go.id). All currencies were transformed into the natural logarithmic forms. The cross-rate currency of the respective foreign currencies towards the USD was calculated.

3. Empirical Findings and Analysis

3.1. Descriptive Statistics

The IDR has become volatile in recent years, particularly after the 1997 and 2008 economic crises. Before the 1997 East Asian economic turmoil, the IDR was relatively stable. However, the economic crisis sent the IDR to its lowest level in history. The IDR depreciated by 68.76% from IDR2,275 per USD during the 1997 economic turmoil. Although the IDR recovered from the 1997 economic crisis a few years later, the 2008 world economic crisis that followed adversely affected the world economy, including Indonesia. The IDR depreciated by 37.31% from IDR10,098,5 per USD during the period of 2008-2015 (Bank Indonesia, 2016). The episodes of IDR depreciation were closely related to the changes in other economies and the movements of their exchange rates since the world economy has become more globalized.

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Due to the volatility of the IDR compared to other foreign exchange rates, IDR transactions have decreased lately. Bank Indonesia (2016), reported that the IDR was the lowest transacted currency in the ASEAN markets, amounting to only 5 trillion USD daily at the end of 2015. Meanwhile, the transactions of THB and MYR have reached USD12 trillion daily. These facts indicate that the IDR was the lowest demanded currency among the ASEAN countries.

Table 1 reports the descriptive statistics of the exchange rates of Indonesia, ASEAN, Japan, and Europe. Table 1 shows that, on average, the IDR against the USD was IDR10,398.236 with a maximum value of IDR14,468, a minimum value of IDR8,574.790 and a standard deviation of IDR1,548.111. On average, the cross rates of other foreign currencies were MYR3.308, PHP44.334, SGD1.328, THB32.250, JPY95.785, and EUR0.756. Compared to other currencies in the region, the currency of Indonesia was found to be the most volatile currency, as suggested by its large standard deviation of IDR1,548.111. The standard deviation of the IDR is followed by Japan (JPY13.517), the Philippines (PHP2.159), Thailand (THB1.692), Malaysia (MYR0.281), Singapore (SGD0.084), and finally Europe (EUR0.066).

3.2. Correlation Coefficients

Before assessing the stationarity of the variables as the basis for determining the model specification, the correlation between the currencies was tested. Table 2 reports the correlation coefficients between the IDR and other foreign exchange rates.

Table 2 shows the level of correlation among the currencies. Within the ASEAN region, the IDR and MYR were found to have the highest coefficient of correlation at 0.857, given that the two countries are geographically close. The lowest coefficient of correlation is 0.235 between the IDR and SGD. The geographically close countries' markets exhibit high interdependence (Janakiramanan & Asjeet, 1998) and trade bilateral dependencies (Abdul Karim & Majid, 2010; Pretorius, 2002). Additionally, the forex markets of Indonesia and Malaysia were highly interconnected during the 1997 Asian financial crisis due to their contagion effect (Majid & Kassim, 2009; Kassim & Majid, 2010).

Furthermore, the findings indicate that changes in the IDR were strongly and positively correlated to the changes in the MYR, and vice versa. This result could be due to Malaysia being one of the major trading partners of Indonesia and to the fact that most foreign workers in Malaysia are from Indonesia. Additionally, the IDR was also found to be strongly correlated to the EUR with a correlation coefficient of 0.707, and the SGD is the least correlated to the EUR with the coefficient of 0.172. These findings were in line with the study by Aggarwal and Mougoue (1993) that asserts that the changes of the currencies in the most developed markets in the world relate to the ASEAN currencies.

As for the correlation between the ASEAN forex markets and those of the developed countries of Japan and Europe, the ASEAN countries were closely related with Japan with the coefficients of correlation ranging from 0.287 to 0.818. The IDR was found to be most correlated with the JPY and PHP was found to be the least correlated with Japan, and these findings are consistent with the study by Kim, Kim and Min (2011). These findings also imply that the currencies of the ASEAN market are positively related to the currencies of the most developed markets worldwide. However, to accurately measure the extent to which the change in one currency affects the changes in other currencies, the study estimates the VECM, which is reported in the following section.

3.3. Stationarity Tests

To reach a robust finding, all estimated variables should be stationary. Table 3 summarizes the findings from the stationarity test based on the Augmented Dickey Fuller (ADF) framework. The cross rates of all currencies against the USD were found to be nonstationary at the level, while they become stationary after taking the first difference. All currencies were confirmed to have the same order of integration, $I(1)$, thus fulfilling the necessary condition for the study to conduct the cointegration analysis. The cointegration technique is used empirically explore the presence of long-run equilibrium relationships among the variables, and the findings are reported in the next section.

3.4. Cointegration Analysis

Table 4 reports the findings for the cointegration test based on the trace and max eigenvalues of the JJ cointegration framework. Four models of cointegration

Table 1. Descriptive Statistics of the Forex Rates against the USD, 2008-2015

Currency	IDR	MYR	PHP	SGD	THB	JPY	EUR
Mean	10,398.236	3.308	44.334	1.328	32.250	95.785	0.756
Minimum	8,574.790	2.984	39.121	1.209	29.047	76.716	0.634
Maximum	14,468.000	4.310	49.180	1.530	36.003	123.671	0.930
Median	9,693.940	3.223	44.147	1.297	32.309	94.850	0.750
Kurtosis	-0.469	3.263	-0.427	-0.787	-0.586	-0.698	0.760
Skewness	0.862	1.658	0.168	0.573	0.391	0.438	0.810
Std. Dev.	1,548.111	0.281	2.159	0.084	1.692	13.517	0.066

Table 2. Coefficients of the Pearson Correlation between the IDR and Other Forexes, 2008-2015

Currency	IDR	MYR	PHP	SGD	THB	JPY	EUR
IDR	1.000	-	-	-	-	-	-
MYR	0.771***	1.000	-	-	-	-	-
PHP	0.362***	0.670***	1.000	-	-	-	-
SGD	0.235***	0.661***	0.781***	1.000	-	-	-
THB	0.593***	0.857***	0.845***	0.803***	1.000	-	-
JPY	0.818***	0.709***	0.287***	0.346***	0.543**	1.000	-
EUR	0.707***	0.595***	0.157***	0.172**	0.291**	0.477***	1.000

Note: *** and **indicate significance at the 1% and 5% levels, respectively.

Table 3. Augmented Dickey Fuller Test for Stationarity

Variable	I(0)	Remarks	I(1)	Remarks
IDR	0.852	Nonstationarity	0.012***	Stationarity
MYR	0.991	Nonstationarity	0.014***	Stationarity
PHP	0.473	Nonstationarity	0.015***	Stationarity
SGD	0.955	Nonstationarity	0.011***	Stationarity
THB	0.827	Nonstationarity	0.016***	Stationarity
JPY	0.785	Nonstationarity	0.019***	Stationarity
EUR	0.432	Nonstationarity	0.013***	Stationarity

Note: *** indicates significance at the 1% level.

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Table 4. Results of the Cointegration Tests of the IDR and Foreign Currencies

Forex Market	H_0	H_1	Trace Statistics	Max-Eigen Statistics
IDR, ASEAN, JPY, and EUR	r ≤ 0	r > 1	123.461*	56.469**
	r ≤ 1	r > 2	77.293	41.291
	r ≤ 2	r > 3	49.911	32.912
	r ≤ 3	r > 4	27.054	21.053
	r ≤ 4	r > 5	14.424	10.427
	r ≤ 5	r > 6	4.355	1.458
	r ≤ 6	r > 7	0.000	0.000
IDR, ASEAN, and EUR	r ≤ 0	r > 1	88.567*	42.231**
	r ≤ 1	r > 2	43.561	38.212
	r ≤ 2	r > 3	23.982	23.134
	r ≤ 3	r > 4	11.487	11.520
	r ≤ 4	r > 5	2.879	1.203
	r ≤ 5	r > 6	0.184	0.000
IDR, ASEAN, and JPY	r ≤ 0	r > 1	97.191**	43.129**
	r ≤ 1	r > 2	61.160	37.017
	r ≤ 2	r > 3	35.022	21.084
	r ≤ 3	r > 4	14.834	10.015
	r ≤ 4	r > 5	4.526	1.876
	r ≤ 5	r > 6	0.197	0.000
IDR and ASEAN	r ≤ 0	r > 1	67.422*	38.129**
	r ≤ 1	r > 2	32.586	26.654
	r ≤ 2	r > 3	13.065	12.543
	r ≤ 3	r > 4	5.262	9.762
	r ≤ 4	r > 5	2.134	0.000

Notes: ** and * indicate significance at the 5% and 10% levels, respectively, and *r* indicates the number of cointegrating vectors. The Akaike Information Criteria (AIC) is used to determine the optimal lag length. Since the study used daily data, the optimal lag-length that was considered in the study was 30.

were estimated, namely, the cointegration among the following currencies: (i) Indonesia, other ASEAN markets, Japan, and Europe; (ii) Indonesia, other ASEAN markets, and Europe; (iii) Indonesia, other ASEAN markets, and Japan; and (iv) Indonesia and other ASEAN markets. Table 4 shows that there is cointegration among the currencies in all models at the one cointegrating vector with at least 10% significance. These findings imply that the IDR is not only cointegrated with other ASEAN currencies, but it is also cointegrated with the currencies of Japan and Europe. In other words, there is a long-run equilibrium among the currencies of Indonesia, the ASEAN markets, Japan and Europe. The long-run movement of one currency could predict the changes in other currencies since they are cointegrated.

Consequently, the implication of our findings on the ASEAN forex markets' cointegration is that forex traders looking for arbitrage opportunities across the forex markets of ASEAN, Japan and EUR could not completely benefit from long-run arbitraging benefits. However, it is important to note that the presence of cointegration among the ASEAN forex did not rule out the opportunity for arbitrage profits through their trading across these forexes in the short-term, which might last for quite a while (Kassim, Majid & Hamid, 2011; Yang & Siregar, 2001). The documentation of cointegration among the forex markets of ASEAN, Japan and Europe also signifies a common stochastic trend in those forex markets (Jang & Sul, 2002; Lee & Jeon, 1995). Since each of the ASEAN forex markets contained information on the common stochastic trends that jointly connected all the markets, the predictability of one forex market might be improved by adopting information on the other forex markets. The existence of common stochastic trends among these forex markets signifies that once new information on a forex market is available before other forex markets, the other forex would diverge from that trend through a transitory element. An individual forex could not stray too far from one over time (Masih & Masih, 1999).

3.5. Multivariate Dynamic Causalities Based on the VECM

Having ensured that all currencies were stationary at the same level of integration $I(1)$ (see Table 3) and cointegrated (see Table 4), the data sufficiently fulfilled the necessary conditions for the study to proceed to estimating the multivariate dynamic causalities among the currencies using the VECM. However, before the model was further estimated, the VECM should incorporate the past values into the model. Thus, this study incorporated the optimal lag based on the Akaike (1969) information criterion (AIC). Based on the AIC test, the number of lag-lengths to be included in the model was 9 since this lag-length produced the smallest final prediction error.

Table 5 presents the findings for the short- and long-run relationships among the forex markets of Indonesia, ASEAN, Japan, and Europe based on the VECM. The study documents that at least one channel of Granger causality was active, either in the short-run through joint F-tests of the lagged differences or in the long-run via significant t-statistics of error correction terms (ECTs). Unlike the insignificance of the ECTs for the THB and JPY, all other ECTs in the system were statistically significant at least at the 10% level of significance with the coefficients ranging from -0.0001 to -0.0015, thereby denoting that the burdens of short-term adjustments to long-term equilibrium relationships were borne by the significance of ECTs' forex markets. Specifically, the significant estimated coefficients of the error correction terms in the forex markets of Indonesia, Malaysia, the Philippines, Singapore and Europe suggest that the last period of disequilibrium in these markets were corrected by 0.01 to 0.15% on the following day.

Moreover, although the ECTs were insignificant in the forex markets of Thailand and Japan, one could not presume that these markets were noncausal since the short-run channels were active (Masih & Masih, 1999; Majid, Meera, Omar, & Abdul Aziz, 2009; Majid & Kassim, 2010; Mohd Yusof, Kassim, Majid, & Hamid, 2011). Our findings further implied that when there was a divergence from the cointegrating relationships in a forex market as measured by the ECTs, it was mainly due to the changes in other forex markets that adjust to clear the disequilibrium. At this point, however, it is important to note that the findings of cointegration among the forex markets simply represented their long-run relationships and implied causality but failed to disclose the causational directions among the forex markets.

Table 5 illustrates that, among the ASEAN forex markets, the IDR was found to be the most dependent on other ASEAN forex markets. All other forex markets have significant effects on the IDR with the estimated coefficient ranging from 1.983 to 7.061 and all F-statistics being significant at least at the 5% level. The IDR, MYR, PHP, and THB appeared to have close causal linkages running between them. Meanwhile, the SGD only unidirectionally Granger-caused the IDR, but not the other ASEAN forex markets. These findings implied that the changes in the forex market of the small, open economy of Singapore could not be transmitted to other ASEAN forex markets since Singapore has not been a significant trading partner of the major ASEAN countries. In all the models, except for the THB, the rest of the ASEAN forex markets appeared to be the essential bearers of short-run adjust-

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Table 5. Results for Multivariate Causalities based on the VECM

Variable	ΔIDR	ΔMYR	ΔPHP	ΔSGD	ΔTHB	ΔJPY	ΔEUR	ECT_{t-1}
ΔIDR	-	4.350*** [0.000]	2.280** [0.015]	2.362** [0.011]	7.061*** [0.000]	2.268** [0.015]	1.983** [0.037]	-0.0015** (-1.400)
ΔMYR	1.777* [0.067]	-	1.676* [0.089]	0.980 [0.454]	4,026*** [0.000]	1.856* [0.055]	1.832* [0.057]	-0.0013*** (-1.455)
ΔPHP	1.846* [0.055]	6.486*** [0.000]	-	0.639 [0.763]	6.810*** [0.000]	0.884 [0.538]	0.936 [0.468]	0.0006* (0.845)
ΔSGD	11.111 [0.350]	17.987*** [0.000]	13.535*** [0.000]	-	14.264*** [0.000]	2.836*** [0.002]	4.497*** [0.000]	-0.0006** (-1.515)
ΔTHB	5.264*** [0.000]	11.712*** [0.000]	3.943*** [0.000]	15.884 [0.112]	-	2.333** [0.012]	13.041 [0.229]	0.0033 (5.121)
ΔJPY	1.673* [0.089]	2.412** [0.010]	2.515*** [0.007]	3.029*** [0.001]	3.086*** [0.001]	-	1,137 [0.332]	0.0002 (-0.184)
ΔEUR	1.764* [0,070]	4.377*** [0.000]	4.406*** [0.000]	2.188** [0.020]	7.553*** [0.000]	14.842 [0.147]	-	-0.0001* (0.058)

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The values in the squared parentheses [.] indicate the probability of F-statistics, while the values in the brackets (.) are the t-statistics.

ments to a shock in the long-run cointegrated relationships of the ASEAN forex markets.

As for the multivariate causalities among the forex markets of ASEAN, Japan and Europe, we identified that except for the PHP, changes in the JPY Granger-caused all ASEAN forex markets. Meanwhile, the JPY was found to be totally dependent on all ASEAN forex markets. Similarly, the PHP and THB were found to be independent of the EUR, while the rest of ASEAN forex markets were Granger-caused by the EUR. Among the ASEAN forex markets, the PHP was found to be the only forex market that was independent of both JPY and EUR. However, compared to the forex markets of the developed economies of the JPY and EUR, the ASEAN forex markets were more influenced by the JPY than the EUR. Surprisingly, the JPY was totally independent of the EUR. This finding implies that for economically and geographically close markets such as ASEAN and Japan, forex markets are highly linked. This finding is in line with that of Janakiramanan and Asjeet (1998) who documented that economically and geographically close markets exhibited high interdependence. The different findings over the study period could be due, *inter alia*, to dissimilarities in the economies' external capital controls (Cheung & Mak, 1992), financial deregulation (Chowdhury, 1994), financial factors (Ibrahim, 2003), and trade bilateral dependencies (Abdul Karim & Majid, 2010; Pretorius, 2002). The countries with strict capital controls were not receptive to innovations in the overseas markets (Sheng & Tu, 2000). Our findings of causalities between the IDR, SGD, THB, and JPY were very much in line with a previous study by AuYong et al. (2004). The Asian forex and stock markets were highly interconnected during the 1997 Asian financial crisis due to their contagion effect (Majid & Kassim, 2009; Kassim & Majid, 2010).

Finally, our empirical evidence on the extent of cointegration or interdependencies among these forex markets provides important implications for the macrostabilization policies of each ASEAN member. The degree of the efficacy of the macroeconomic policies of each ASEAN market in dealing with its forex markets' insta-

Table 6. Predicted Values of the IDR for the Month of December 2015

Date	IDR		MAPE (%)
	Actual Value	Predicted Value	
1	13,831.3	14,224.98	2.85
2	13,831.3	14,100.67	1.95
3	13,850.4	14,062.87	1.53
6	13,850.4	14,106.17	1.85
9	14,025.2	14,155.48	0.93
12	13,955.0	14,346.71	2.81
15	14,104.4	14,393.04	2.05
18	14,025.2	14,382.08	2.54
21	13,812.2	14,298.85	3.52
24	13,661.2	14,020.57	2.63
27	13,650.0	13,919.44	1.97
Average	13,897.85	14,151.67	1.83

bilities would strongly depend on the extent of financial integration of each ASEAN forex market with the rest. In particular, since the ASEAN forex markets were integrated, the economy of a country could not be insulated from overseas shocks, thereby reducing the scope for independent macroeconomic policy. Additionally, an effectual diversification among worldwide forex markets could not be attained and the integrated forex markets could be deemed as one market set by long-run forex traders. The integration of the ASEAN forex markets in the long-run indicates the restrictions associated with the quest for a mutually dependent policy, especially the forex policy. Rather, as the ASEAN forex markets become more integrated regionally, there is a call for policy synchronization among ASEAN countries to manage the impact of forex fluctuations as the markets become more interdependent. Ultimately, greater policy harmonization in conjunction with the reduction or elimination of investment and trade barriers would be fundamental if these countries are to take advantage of greater forex and economic interdependence (de Bruyn, Gupta & Stander, 2013; Kotorri & Korbi, 2009; Majid, Meera & Omar, 2008). The knowledge of forex market integration could be used by governments or policy makers to agree upon a forex union, which is a current topic of debate.

Similarly, the degree of integration among the ASEAN forex markets would have essential bearings on the formulation of a single currency in the region. During episodes of economic crisis periods, both the currency and stock markets would be impacted since these markets are highly interlinked. The 1999 Nobel Laureate Mundell (2000) stated that forex volatility is the most important threat to worldwide affluence that causes superfluous instability in capital markets. Thus, identifying the equilibrium relationships among the forex markets would provide a foundation for assessing investment risks among the economies. Such information could, therefore, assist forex traders to mitigate worldwide risks and manage economic, forex, translation and transaction risks (Majid et al., 2008).

3.6. Prediction Accuracy of the VECM

In this final section, the study examines the accurate prediction of the estimated VECM. Table 6 reports the accuracy of the prediction of movements of the IDR against the USD during the month of December 2015.

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From Table 6, we find that the cross rate of the IDR against the USD tended to rise from the first week until the third week of December 2015. It then declined toward the end of month. By comparing the actual and predicted values of the IDR, we found that the MAPEs were relatively small, ranging from 0.93% (December 9, 2015) to 3.52% (December 21, 2016). On average, the MAPE was 1.83%. The low value of MAPE that is documented in the study provides evidence that the estimated VECM that is adopted in this study was accurate enough to predict future changes in the forex markets since the predicted values closely resemble the actual data (Achsani, Holtemöller & Sofyan, 2005; Schulz, Sofyan, Werwatz & Witzel, 2003).

Additionally, to ensure the robustness of the findings from the estimated VECM, the study also conducted a series of diagnostic tests, which were comprised of the normality, serial correlation, autocorrelation, and heteroscedasticity tests. The Jarque-Bera (JB) statistic was used to test normality while the Breusch-Godfrey (BG), the Ljung-Box Q (LBQ), and the autoregressive conditional heteroscedasticity-Lagrange multiplier (ARCH-LM) statistics were utilized to test for serial correlation, autocorrelation, and heteroscedasticity, respectively. The study documents that the residuals are normally distributed, thereby reflecting the insignificance of the JB statistics. The study also documents that the estimated variables in the VECM are free from serial correlation, autocorrelation, and heteroscedasticity problems as reflected by the significant BG, LBQ and ARCH-LM statistics.

Based on the above tests, this finding further proved that the estimated empirical models that were adopted in the study were acceptable and produced robust findings and thus could be used as a basis for deriving reliable policy recommendations.

4. Conclusion

This study empirically explored both the short- and long-run dynamic causality between the Indonesian Rupiah and the forex markets of ASEAN, Japan and Europe. The daily nominal exchange rates of Indonesia, Thailand, Malaysia, Singapore, the Philippine, Japan, the U.S. and Europe spanning from January 1, 2008, to December 31, 2015 were utilized. The data were gathered from the official website of the Indonesian central bank, Bank Indonesia and were analyzed using the cointegration and the vector error correction (VECM) techniques.

The study found that the Indonesian Rupiah was cointegrated with the forex markets of ASEAN, Japan and Europe. The study also documented that the Indonesian Rupiah was found to be the most dependent on other ASEAN forex markets since these forex markets appeared to have close causal linkages running between them. For multivariate causalities between the forex markets of ASEAN, Japan and Europe, the Philippine Peso was found to be the only forex market that was independent of both the Japanese and European forex markets. Additionally, the ASEAN forex markets were more influenced by the forex market of Japan rather than that of Europe.

Since the forex markets become more integrated regionally, there is a need for policy synchronization among the countries in order to manage the impact of forex fluctuations. Greater policy harmonization in order to regulate the forex markets would be crucial if these economies are to take advantage of greater forex and economic interdependence. The knowledge of forex market integration could be used by the government or policy makers in order to design a forex union in the ASEAN region, which is a current topic of debate.

To add to the present literature on the forex market integration in the region, future empirical studies on the topic could cover broader areas of forex markets and investigate factors contributing to forex market integration. Another likely extension of the study is to compare and quantify the forex trading benefits that are earned with the different forex risks by the forex traders when holding combinations of ASEAN foreign currencies. Since cointegrated tests are only capable of detecting linear equilibrium relationships and fail to measure nonlinear cointegration (Okunev & Wilson, 1997), in the future, a more sophisticated empirical test should be applied to uncover the presence of nonlinear cointegration among the forex markets of ASEAN and developed economies.

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