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The Relationship of Chinese Yuan Renminbi, US Dollar, Australian Dollar, and Euro Exchange-Rate Against Rupiah Using Vector-Autoregression Method

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ABSTRACT
This study analyses the relationship between Chinese Yuan Renminbi, US Dollar, Australian Dollar, and Euro exchange-rate to Rupiah using the Vector-Autoregression (VAR) method from January 2017 to December 2019. The results of this study show that each variable has a good correlation in long and short-term. This is supported by the results of Granger Causality test which states that several variables are influentially interrelated at certain period. In addition, the results on IRF and FEVD find that each variable has an impact on the shock in the currency of one country.

Keywords: Exchange-Rate, VAR

1. INTRODUCTION

As a country with massive rate of production and consumption, Indonesia is greatly potential to participate in international trade, not only since it has abundant natural resources, but also Indonesian population is well known to favor imported goods than local production. Many countries would like to take advantage of this fact, in addition to require Indonesia's natural products, they also aim to choose Indonesia for their target market share. For international trade that gives impact on the revenues and expenditures of a country, this importance leads Indonesia to take part in the flow of international trade by accomplishing the requirements, which one of these is the payment of any transaction value should adhere to the exchange-rate of one nation's currency.

Participating in the flow of international trade, Indonesia would experience directly and indirectly the impact of a shock in the currency of countries that cooperate with Indonesia by causing alteration in the exchange-rate against Rupiah. Moreover, if the shock derives from a country that is the main partner of Indonesia in international trade, it would certainly be followed by the alteration in its exchange-rate against Rupiah.

A deep study on this topic is neccesary, since some previous studies only examined the relation between exchange-rates with different objects, for example, the research conducted by [1] [2] [3]. The variables will distinguish this research with the previous one. This study used the exchange-rates of currency of Republic of China, United States of America, Australia, and Spain for the period from January 2017 to December 2019, with Vector Autoregression method. Therefore, this research aimed to determine the relationship between countries and how the perceived impact of the shock that occurred from one of the partner countries, would impact another.

2. LITERATURE REVIEW

Exchange-rate is the value of a country's currency opposite to other currencies. While the exchange-rate includes two currencies, the balance point is determined by supply and demand of those two currencies. In other words, the amount of money of a certain currency which can be exchanged with one unit of another country's currency, will become the exchange-rate between those two nations.

According to [4], there are several factors regulating the movement of exchange-rates, namely:

a. Differences in Inflation-Rates Between Countries
   The differences in inflation-rates between countries linked in global trade can be a catalyst, because a country with a consistently low inflation-rate will have a stronger exchange-rate than the one with higher inflation-rate.
b. Interest-Rate
   Higher interest-rate will demand the currency of a country to increase, and vice versa.
c. Trade Balance
   A country with deficit trade needs more currency of its trading partner, which causes the exchange-rate of that country's currency against its partner country to weaken.
d. Public Debt
   The higher the public debt of one country is, the worse the impact on the exchange rate of its currency will be.

e. Import-Export Price Ratio
 If the export price increases faster than the import price, then the currency exchange-rate of the country tends to strengthen.
f. Politics & Economics
 Stable political and economic conditions will more easily attract investors' confidence, so that the exchange-rate will strengthen.

Exchange-rate is an agreement on current or future payments between two currencies of each country or region. International trade relations can affect the currency exchange-rate of a country against those of other countries, or known as the contagion effect. The Vector Auto-Regressive (VAR) method is a method used to detect this effect [5]. The research conducted by [6] and [7] mentioned that based on the results of Granger-Causality Test, the trade war between America and People's Republic of China caused a decrease in the dominance of US trade in Asia, especially in Indonesia and Singapore. The test results were supported by the results of Impulse Response Function (IRF) analysis on variable index values of JCI, DJIA, Nikkei 225, Shanghai 50 and STI, which presented that after the trade war between United States of America and Republic of China, a continued impact arose on its trading partners (Japan, Indonesia and Singapore) compared to United States of America, because the index reached a steady-rate after more than twenty periods against shock from the trade war between the United States of America and Republic of China. Meanwhile, [8] concluded that by using F-test, the variables of interest-rates, money supply, inflation, and exports simultaneously have a significant effect on Rupiah exchange-rate against USD. By using t-test, the interest-rate variable has a positive effect on Rupiah exchange-rate against USD in Indonesia. Meanwhile, the variables of money supply, inflation, and exports have no significant effect on Rupiah exchange-rate against USD.

3. RESEARCH METHOD

This research is the quantitative research. Secondary data was be used in the form of numbers, which represents the value of one studied-variable. The data has been examined by parties, which are competent in providing the required data, namely Bank of Indonesia (BI) and Central Statistics Agency (BPS). As the fundamental of assessment, the data collected for this research is weekly time-series recorded from January 1st, 2017 to December 31st, 2019 with actual and current considerations. The variables in this study are CNY, USD, AUD, and EUR exchange-rate.
The analytical method used in this study is the Vector Autoregression (VAR). If the variable is stationary at level, the data can be processed by VAR. However, if the variable is non-stationary at level, the analysis will be adjusted using the Vector Error Correction Model (VECM) or Vector Autoregression Level Differentiation method. It is important to adjust the data, since regressing the non-stationary variables will lead to the phenomenon of spurious regression (false regression). The use of this method is expected to represent how the exchange-rate variable in a country can affect the same variable in another country and vice versa. In this study, the author analysed the data using EViews econometric program. To arrive at the results of the processing with the EViews 9 Program, there are several steps that must be followed, namely:
a. Unit Root Test – Stationary Test
 Stationary data can be seen using the Augmented Dickey-Fuller (ADF) method with the decision criteria for probability value that is smaller than or equal to the probability standard of 5% (or 0.05). The data is stationary, if H_0 is rejected.
b. Cointegration Test (Johansen's Cointegration Test)
 This test is carried-out using Johansen's Cointegration Test to find out how much cointegration occurs between variables.
c. Lag-length determination, Estimation and Check Model
 Optimum lag selection procedure in VECM could employ the Akaike Information Criteria (AIC) and Schwarz Criteria (SC).
d. Causality Analysis
 The analysis on the relationship between variables in VECM model in long-term, can be identified by the coefficients of Error Correction Model (ECM), originated from the sign and the results of the coefficient significance test by using the t-test, while short-term causality analysis for each variable can use the Granger Causality Test.
e. Forecasting Analysis and Structural Analysis
 The structural analysis on VECM model includes the Impulse Response Function (IRF) analysis, the Forecast Error Variance Decomposition (FEVD), and the percentage of forecasting errors using VECM Forecasting.

4. RESULTS

4.1. Unit Root Test - Augmented Dickey-Fuller Method

Stationary data can be seen using the Augmented Dickey-Fuller (ADF) method, with the decision criteria for the probability value smaller than or equal to probability standard of 5% (or 0.05). If H_o is rejected, then the data is stationary. The following is the output of each variable.

Table 1 The Stationary-Test Result using Augmented Dickey-Fuller Test

No	Variable	Level		1st Difference Level	
		Probability Value (p-value)	S / NS	Probability Value (p-value)	S / NS
1	AUD	0.4090	NS	0.000	S
2	CNY	0.9534	NS	0.000	S
3	EUR	0.8853	NS	0.000	S
4	USD	0.8967	NS	0.000	S

S: Stationary NS: Non-Stationary

Based on the result of stationary test in Table 1, it is said that each variable is non-stationary at level, because the probability value is bigger that the absolute standard which is 5% (or 0.05). New variable will be stationary at 1st difference level due to the probability value of each variable less than the absolute standard of 5% (or 0.05). Hence, it can be concluded that each variable is stationary at 1st difference level.

4.2. Cointegration Test (Johansen's Cointegration Test)

This method is used to test whether there is cointegration between variables. The results of data processing using Johansen's Cointegration data processing are presented in Table 2 below.

Table 2 The Result of Johansen's Cointegration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.443418	246.2671	40.17493	0.0001
At most 1 *	0.393942	163.0636	24.27596	0.0001
At most 2 *	0.289649	91.95281	12.32090	0.0001
At most 3 *	0.263289	43.38947	4.129906	0.0001

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.443418	83.20353	24.15921	0.0000
At most 1 *	0.393942	71.11076	17.79730	0.0000
At most 2 *	0.289649	48.56335	11.22480	0.0000
At most 3 *	0.263289	43.38947	4.129906	0.0001

Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The cointegration relationship in this study can be seen from the value of trace-statistic. The cointegration relationship exists, if the trace-statistic value is higher than the critical value 5% (or 0.05). There is cointegration or long-term relationship between variables based on Table 2, because the values in Trace Statistics and Maximum Eigenvalue are greater than the Critical Value. Hence, the probability value is smaller than the standard absolute probability value of 5% (or 0.05).

4.3. Lag-Length Determination, Estimation, and Check Model

At this stage, the VECM estimation model and optimal lag selection on VECM model will be carried-out using the information criteria of Akaike Information Criteria (AIC) and Schwarz Criteria (SC). The following table summarizes AIC and SC for the VECM model.

Table 3 Optimum Lag-Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2968.427	NA	1.13e+14*	43.71216*	43.79783*	43.74697*
1	-2956.266	23.42823	1.20e+14	43.76861	44.19694	43.94268
2	-2950.997	9.840498	1.40e+14	43.92642	44.69742	44.23974
3	-2937.312	24.75265	1.46e+14	43.96047	45.07414	44.41304
4	-2933.786	6.170237	1.75e+14	44.14392	45.60025	44.73573
5	-2919.382	24.36085	1.80e+14	44.16738	45.96637	44.89844
6	-2901.382	29.38273*	1.76e+14	44.13796	46.27962	45.00828
7	-2893.082	13.05982	1.99e+14	44.25120	46.73553	45.26077
8	-2876.894	24.51981	2.01e+14	44.24844	47.07543	45.39726

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

From VAR table, the Lag Order Selection Criteria on non-intristic VAR model is lag 0. Meanwhile, for Final Prediction Error (FPE) category, the Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), and Hannan-Quin Criterion (HQ), is lag 6 in the Likelihood Ratio (LR) category. After several experiments, the researcher determined the optimal lag-length was 5, whereas the lag was neither too short nor too long.

The final stage of model analysis is performing the diagnostic test of VECM model using the Portmanteau test. The following table is the output of Portmanteau test in the VECM model:

Table 4 The Result of Stability Test Model – Portmanteau Autocorrelation Test

Lags	Q-Stat	Prob.	Adj. Q-Stat	Prob.	df
1	2.155609	NA*	2.171229	NA*	NA*
2	3.716025	NA*	3.754425	NA*	NA*
3	6.703219	NA*	6.807513	NA*	NA*
4	9.103846	NA*	9.279270	NA*	NA*
5	15.27908	NA*	15.68492	NA*	NA*
6	28.45965	0.0990	29.46011	0.0791	20
7	44.61561	0.1536	46.47282	0.1134	36
8	61.39463	0.1748	64.27651	0.1181	52
9	73.84287	0.2932	77.58656	0.1997	68
10	93.34296	0.2276	98.59828	0.1318	84
11	117.0587	0.1170	124.3520	0.0499	100
12	139.9266	0.0646	149.3808	0.0200	116
13	151.2330	0.1208	161.8537	0.0396	132
14	166.2063	0.1455	178.5040	0.0444	148
15	183.8887	0.1372	198.3254	0.0349	164
16	197.2287	0.1800	213.4006	0.0449	180
17	211.1655	0.2175	229.2795	0.0518	196
18	232.3819	0.1606	253.6520	0.0265	212
19	237.3510	0.3216	259.4079	0.0751	228
20	245.8742	0.4543	269.3635	0.1270	244
21	260.9458	0.4718	287.1174	0.1192	260
22	280.7483	0.4093	310.6434	0.0742	276
23	298.9183	0.3777	332.4162	0.0517	292
24	323.4036	0.2620	362.0115	0.0184	308
25	336.5913	0.3035	378.0912	0.0205	324
26	358.9896	0.2295	405.6431	0.0083	340
27	370.1261	0.2920	419.4643	0.0115	356
28	379.2885	0.3860	430.9378	0.0187	372
29	388.5279	0.4829	442.6131	0.0288	388
30	402.6778	0.5092	460.6575	0.0268	404

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Table 4 is the result of stability-test to detect whether the model still contains autocorrelation. The test results reveal that from 1st to 30th lag, the model does not contain autocorrelation, because the probability of Q-Statistic shows a value more than the absolute standard, which is 5% (or 0.05). In short, the model does not contain good autocorrelation.

Table 5 The Result of Stability Test Model – Root of Characteristic Polynomial

Root	Modulus
-0.251291 + 0.758600i	0.799138
-0.251291 - 0.758600i	0.799138
-0.583231 - 0.501100i	0.768934
-0.583231 + 0.501100i	0.768934
0.594396 + 0.421928i	0.728924
0.594396 - 0.421928i	0.728924
-0.075092 + 0.711484i	0.715436
-0.075092 - 0.711484i	0.715436
0.707783	0.707783
0.173791 - 0.683769i	0.705510
0.173791 + 0.683769i	0.705510
-0.686822	0.686822
0.632270 - 0.074037i	0.636590
0.632270 + 0.074037i	0.636590
0.375695 - 0.485175i	0.613630
0.375695 + 0.485175i	0.613630
-0.442080 - 0.409294i	0.602459
-0.442080 + 0.409294i	0.602459
-0.600261	0.600261
-0.355657	0.355657

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table 5 shows that the model does not contain unit roots (roots), because the value in the modulus is less than 1. The stability-test results can also be seen in the diagram, whereas the dots in the circle do not come out of the circle. Thus, it can be stated that the model no longer contains unit roots (roots).

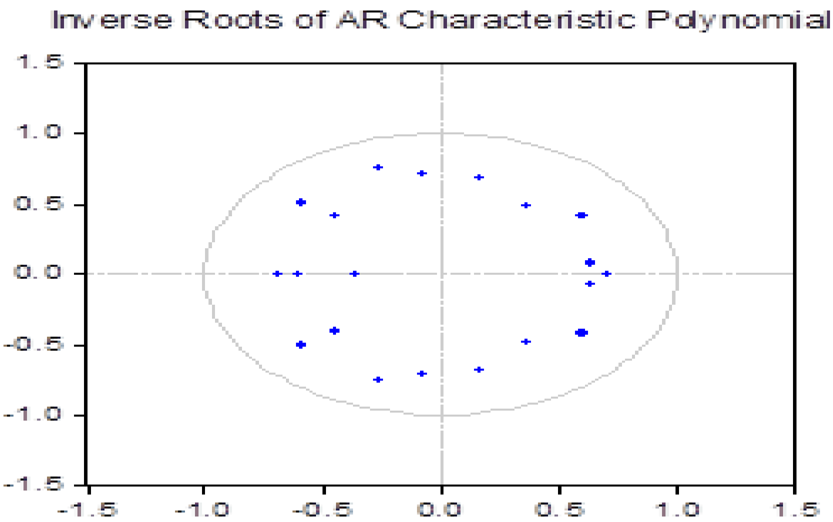

Figure 1 The Result of Stability-Test using VECM Model

4.4. Causality Analysis

Granger Causality Test is used to measure the causality between variables in short-term. Below are the results of Granger Causality Test, which were tested until the sixth period.

Table 6 The Result of Granger Causality Test Lag 1- Lag 6

No.	Variable	Nilai Probabilitas					
		Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 6
1.	USD does not Granger Cause CNY	0.4105	0.1596	0.0726	0.0995	**0.0115**	**0.0192**
	CNY does not Granger Cause USD	0.4349	0.4105	0.3860	0.5530	0.6129	0.6417
2.	EUR does not Granger Cause CNY	0.6934	0.7088	0.9297	0.9621	0.7372	0.5691
	CNY does not Granger Cause EUR	0.5491	0.6345	0.8330	0.8784	0.9326	0.8411
3.	AUD does not Granger Cause CNY	0.4788	0.5006	0.6310	0.7313	0.4605	0.3291
	CNY does not Granger Cause AUD	0.7081	0.6236	0.7805	0.8561	0.9334	0.9543
4.	EUR does not Granger Cause USD	0.5340	0.1147	0.2591	0.3775	0.5557	0.6863
	USD does not Granger Cause EUR	0.0673	0.1674	0.2763	0.3405	0.2993	0.0915
5.	AUD does not Granger Cause USD	0.1084	0.1870	0.2820	0.4188	0.3638	0.4509
	USD dose not Granger Cause AUD	0.2364	0.2862	0.4331	0.5773	0.7131	0.8521
6.	AUD does not Granger Cause EUR	0.1013	0.1889	0.3273	0.4713	0.2205	**0.0451**
	EUR does not Granger Cause AUD	0.8868	0.6514	0.0991	0.1126	0.0867	0.0944

Table 6 is the result of Granger Causality test from the 1st lag to 6th lag. From the test results, it can be concluded that:

a. Changes in the USD exchange-rate only have a significant effect on changes in CNY exchange rate, while this occurs after the fourth lag. In addition, changes in USD exchange-rate do not affect changes in AUD and EUR exchange-rates, because the probability value generated is more than the absolute standard of 5% (or 0.05).
b. Changes in EUR exchange-rate have no effect on changes in CNY, USD, and AUD exchange-rates, because the resulted probability value is more than the absolute standard of 5% (or 0.05).
c. Changes in CNY exchange-rate have no effect on changes in USD, EUR, and AUD exchange-rates, because the resulted probability value is more than the absolute standard of 5% (or 0.05).
d. Changes in AUD exchange-rate only have an effect on changes in EUR exchange-rate. This only occurs after the fifth period, while changes in USD and CNY exchange-rates do not happen.

4.5. Forecasting Analysis and Structural Analysis

In this section, forecasting and structural analysis of the VECM model are discussed. However, structural analysis will be discussed at first including the Impulse Response Function Analysis and Forecast Error Variance Decomposition.

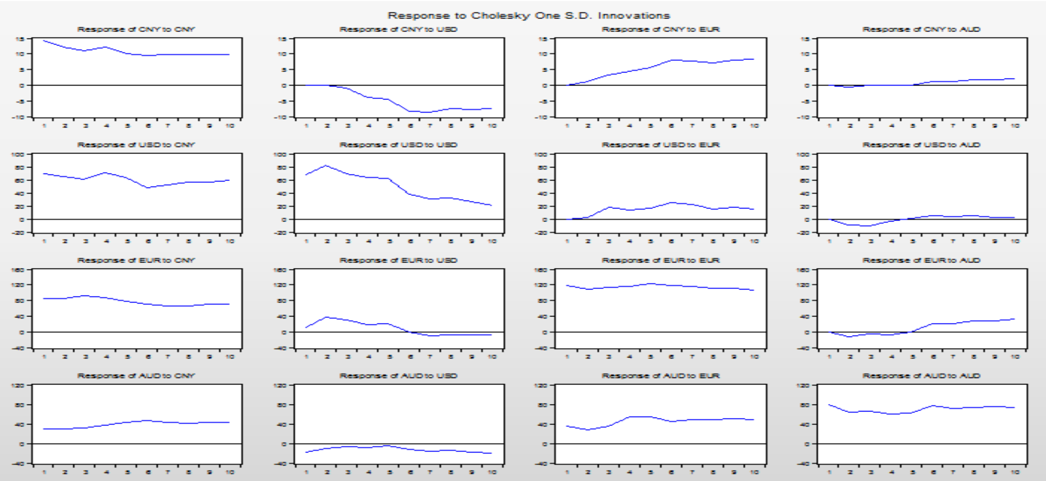

Figure 2 Graph of Impulse Response Function Analysis Result

4.5.1. CNY Exchange-Rate Response (REPUBLIC OF CHINA)

The response of CNY exchange-rate when there was a shock on EUR, USD and AUD rates, was only given in the second period. However, the shock that affected more was that against USD and EUR, because it was able to make the percentage value against USD decreased to minus 7.40% and increased against EUR to 8.18% until the end of the period.

4.5.2. USD Exchange-Rate Response (USA)

The response of USD exchange-rate to the shock occurred in the CNY, EUR and AUD exchange-rates, was shown in the first period of shock. This happened because the Republic of China, Spain, and Australia were trading partners of United States of America.

4.5.3. EUR Exchange-Rate Response (SPAIN)

The first response given by EUR exchange-rate to the shock occurred in CNY exchange-rate, was at the first period with a percentage rate of 84.73% and continued to increase until the third period, while the other variables did not.

4.5.4. AUD Exchange-Rate Response (AUSTRALIA)

AUD exchange-rate response to the shock in CNY exchange-rate, happened in the first period with a percentage level of 30.11%, while other variables gave response at the second period.

4.5.5. Analysis of Forecast Error Correction Model

The Forecast Error Variance Decomposition (FEVD) could be analyzed, after the analysis of Impulse Response Function (IRF). FEVD is better known as Variance Decomposition, which is the next analytical-step after Impulse Response Function (IRF) analysis, to find out how much the impact gives influence after the shock from the variable itself and from other variables.

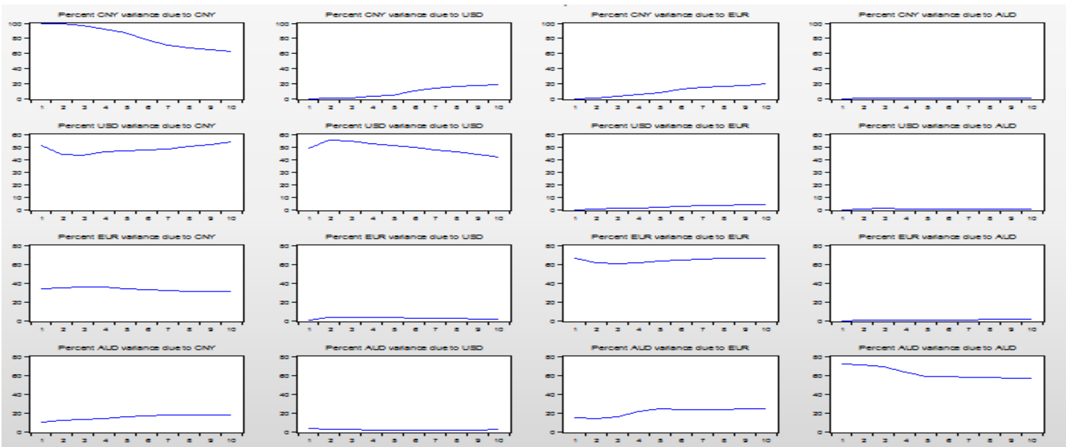

Figure 3 Graph of Forecast Error Variance Decomposition Analysis Result

Analysis of Variance Decomposition measures the percentage of shocks for each variable as shown in the graph above with the following explanation:

4.5.6. The Impact of the Shock on CNY Exchange-Rate (REPUBLIC OF CHINA)

The Variance-Decomposition Analysis shows that the forecast error variance of CNY exchange-rate in the first period was determined by CNY itself by 100%, while USD, EUR, and AUD exchange-rate only gave an effect in the second period by around 0.004%, 0.45% and 0.14%.

4.5.7. The Impact of the Shock on USD Exchange-Rate (USA)

The Variance Decomposition Analysis shows that forecast error variance of USD exchange-rate variable in the first period, was determined by USD by 48.96% and by CNY exchange-rate at 51.04%. EUR and AUD exchange-rates show a contribution in the second period with percentage rates of 0.01% and 0.46%. At last, it can be concluded that the movement of USD exchange-rate is more influenced by the movement of the CNY exchange-rate than the USD itself.

4.5.8. The Impact of the Shock on EUR Exchange-Rate (SPAIN)

The Variance-Decomposition Analysis shows that the forecast error variance of EUR exchange-rate in the first period is determined by EUR at 65.92%, by CNY exchange-rate at 33.45%, and by USD exchange-rate variable at 0.62%, while the AUD exchange-rate variable shows its contribution in the second period.

4.5.9. The Impact of the Shock on AUD Exchange-Rate (AUSTRALIA)

The Variance-Decomposition Analysis reveals that AUD exchange-rate is influenced by AUD at 71.68%, by CNY exchange-rate at 10.27%, by USD exchange-rate at 3.46% and by EUR-rate at 14.59% in the first period. In addition, the contribution percentage of AUD exchange-rate, starting from the second period to the end of the period, decreased regularly, but its percentage was the most influencing one.

4.5.10. Forecasting Model

In general, the VAR method can be used as a forecasting tool in the future based on the data in the past period and can be determined manually or systemically. In this study, the researchers used Microsoft Office Excel to calculate the MAPE value.

For forecasting purpose, we used this research data during and after the research period (January 2020). The average forecasting results is that the MAPE percentage is less than 5%, both during the research period and after the research period. From Table 7, it can be concluded that the results of the percentage of forecasting errors have good accuracy, because the MAPE value is almost close to 0%.

Table 7 The Result of MAPE Value

No	Variable	MAPE value (%)	
		Period	
		Jan 2017 – Dec 2019	Jan 2017 – Jan 2020
1	CNY	3.58	3.74
2	USD	2.53	2.59
3	EUR	1.75	1.76
4	AUD	2.96	3.04

5. DISCUSSIONS

This section discusses about each result of the test based on each analysis model used.

a. The resulted model based on the Vector Error Correction Model shows that each variable is non-stationary at level but it is stationary at First Difference level. However, after going through the cointegration test, it was found that each variable has a long-term and short-term relationship, so the resulted model is the Vector Error Correction Model (VECM) type.
b. Basically, each variable of AUD, CNY, EUR, and USD exchange-rate, has a relationship in the short-term and long-term. This is confirmed that when one of the variables experiences a shock, the other exchange-rates will receive the impact. Some of the perceived impacts are significant and some are insignificant. The effect of this impact does not directly make the situation return to normal in a short period against other exchange-rates. As an independent variable, CNY exchange-rate gives an insignificant response to the shock occurred in other exchange-rate variables. Differently, when there is a shock on CNY exchange-rate variable, the average other exchange-rate variable gives a significant response.
c. The variables of AUD, CNY, EUR, and USD exchange rate have a relationship with each exchange-rate movement, both in long-term and short-term in certain periods.
d. The variables of AUD, CNY, EUR, and USD exchange-rate have a cointegration relationship between each variable. This conclusion is also supported with the results of the Granger Causality test, whereas in certain periods, several variables have one-way relationship.
e. The analysis of Impulse Response Function (IRF) summarizes that each variable is related to another by demonstrating a response when one of the variables experience a shock. The response given is also quite significant and it takes a long time to return to normal condition.
f. Based on the analysis of Forecasting Error Variance Decomposition, it can be concluded that each variable influences the exchange-rate movements on other variables. The average exchange-rate movement is more influenced by internal factors excluding USD exchange-rate, which is more influenced by the movement of the CNY exchange-rate (external) than the USD itself (internal). The forecasting results using Microsoft Excel shows that the average forecasting accuracy value is below 5%, both during the research period and after the research period. So, it can be said that the forecast results have almost perfect accuracy.

6. CONCLUSIONS

The results of this study indicate that the movements of the AUD, CNY, EUR, and USD exchange-rate. are interrelated with each other. Although it is not significant, it can have a causal effect. In the future, researchers must ensure that the studied variables have impacts on the Indonesian economy, especially when a country's exchange rate greatly contributes to Indonesia. Therefore, the research results can be used and developed as a reference for new methods, especially if the result has a positive effect on the importance of international trade. Research on the interrelation of exchange rate can also describe the condition of economy between countries and can be used as material for further research.

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