Study of Exchange Rate Volatility and Its Effect on Indonesian Economic Indicators With Potential Exchange Rate Crisis

A Nugroho[1,2*], **Nasrudin**[1*]

[1]STIS Polytechnic of Statistics, Jakarta 13330, Indonesia
[2]BPS Statistics of West Kutai Regency, West Kutai, East Kalimantan 75777, Indonesia

*Corresponding author's e-mail: *adin0nugroho01@gmail.com, nasrudin@bps.go.id

Abstract. Exchange rate volatility occurred when exchange rate movement was wildly fluctuating which could depict uncertainty. Since Indonesia used an open economy, exchange rate fluctuation became important to be maintained due to crisis potential. This research was conducted to analyze the effect or impact of exchange rate volatility on the Indonesian economy in general and few related case using time series analysis. ARIMA (*Autoregressive Integrated Moving Average*) and EGARCH (*Exponential Generalized Autoregressive Conditional Heteroscedasticity*) were used for measuring the volatility in the period between 1997-2021. Then, regressions were applied to analyze the impact of exchange rate volatility on few macroeconomic indicators. The result shows that exchange rate volatility yielded a significant negative effect on GDP Growth rate, export, and import. Logistic regression was used to analyze the factors that were affecting the crisis potential. The result showed only a negative GDP growth rate and high volatility that gave more risk which could lead to crisis. Therefore, it is important to keep exchange rate volatility stable.

1. Introduction

The floating exchange rate system had been officially used as Indonesia's current system since 1997 in which the managed floating exchange rate system was used before. This system could drive the exchange rate to be freely floating based on an international market mechanism. As a result, nowadays Indonesia's exchange rate was more dynamically changing compared to the time before 1997. Due to that freely floating movements, any kind of disturbances including internal and external would affect the flow which could be indicated as shocks. In fact, there were many shocks and high fluctuations during the crisis period 1998 and 2008, 2018 and even the recent quarter of 2020 (Figure A1). This phenomenon was commonly called as exchange rate volatility which could be defined as uncertainty or flexibility that was caused by dynamic movements of exchange rate through time. In brief, higher volatility could lead to higher uncertainty. Nevertheless, there was no consensus about the measurement standard of volatility that could be used universally.

Volatility was one of the government's main concerns to maintain the stability of economic environment. In addition, the economy of Indonesia started to lead to openness towards the international market. This could be seen from Indonesia's trade flow which went faster, inflow investments that grew up, and trade balance that fluctuated in a wide range.

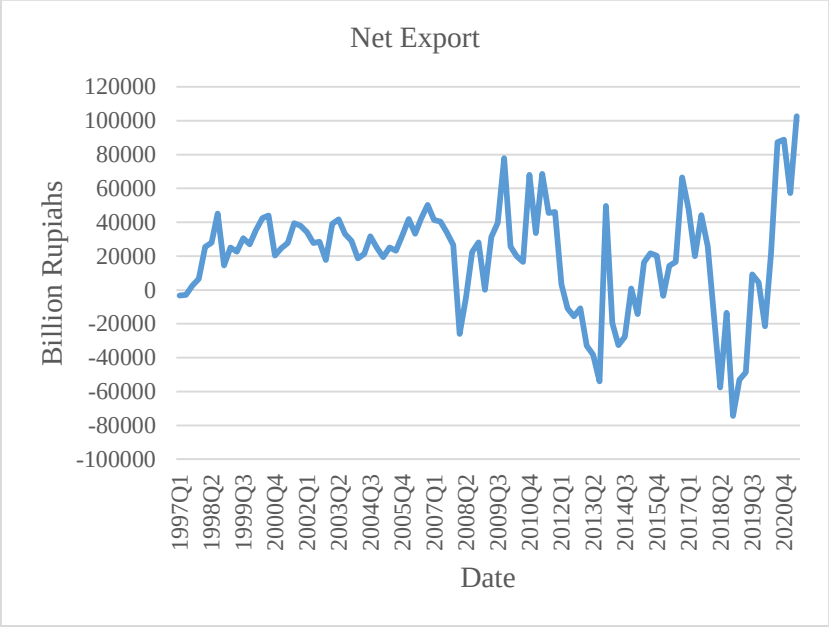

Figure 1. Net Export of Indonesia from 1997-2021 in Billion Rupiahs.

According to Figure 1 and Figure A1, it could be said that exchange rate volatility had a big role on Indonesia economy through net export as the fact that Indonesia's nominal exchange rate went fluctuatively uptrend since early 2008. If it was assumed that there was no difference in the quality of goods from each country, then the one that took place as a determinant of sales was the price. Simply said, if the price was stable then producers would easily determine how many goods should be sold exactly, thus they were able to gain maximum profit. Besides, consumers could also be able to approximate how many goods should be bought to gain maximum advantage. A stable exchange rate also affected investor's decision to invest such as increasing investment risk perception. Then, if investors found a high risk would happen, they would tend to do wait-and-see. This certainly disrupted the flow of trade and investment. Another impact could be seen from labor absorption. When uncertainty goes high, the price of import goods would be rising. Companies were likely to reduce labor absorption to avoid bankruptcy. Then, if production factors were reducing their capacity, output was going to be reduced as well. These would slow down economic growth.

The phenomenon of Indonesia's exchange rate depreciation in the second quarter of 2020 that reached the lowest point of above 15000 IDR per USD (Figure A1) might be related to the case of oil and gas net export deficit that reached 1.6 billion USD. In addition, reflecting from the historical exchange rate movements in 1998 and 2008 during the Asian and Global crises, high exchange rate volatility also contributed to the crises potential. So the existence of an Early Warning System and identification of any factors that influence the potential crisis is important to be analyzed further. Some of the objectives of this study are: (i) Studying the effect of exchange rate volatility on the Indonesian economy, (ii) identifying exchange rate pressures using the EMP *(Exchange rate Market Pressure)* index and analyze for current 2021, (iii) analyzing factors that influence the potential for a crisis.

2. Methodology

2.1. Theoretical base

2.1.1. Exchange rate volatility impact on the economy. Fluctuating exchange rates will certainly have the potential to be volatile if it is under pressure. High volatility represents a high exchange rate uncertainty. The uncertainty will certainly disrupt all economic activities because generally economic actors will tend to avoid high risks. Moreover, Indonesia is a country with an open economy, so economic activities that directly interact with exchange rates are international trade and foreign

investment. By definition, according to Munyama and Todani (2005) [12], it was explained that volatility is the tendency of level changes in the exchange rate. Therefore according to Supaat, et.al (2003) [13] that volatility has an important role in the flow of commercial trade. Barkoulas et.al (2002) [3] stated that exchange rate volatility has an important relationship with trade flows. High exchange rate volatility can cause a high-cost economy because economic actors will tend to reduce risk by placing prices relatively higher. This makes the competitiveness of domestic products lower. McKinnon and Ohno (1997)[10] stated that exchange rate volatility can depress trade flows, change the direction of investment policies, and inaccurate selection of locations for multinationals. High exchange rate volatility will tend to reduce the volume of international trade due to uncertainty and profit risk and also inhibit the flow of international capital in the form of both direct and portfolio investments.

The relative price theory illustrated that the depreciation of the domestic exchange rate could increase excess demand for exported goods, thereby giving the cause of increasing exports and reducing imports. Another impact that might occur was the exchange rate volatility would increase the price of imported raw materials. This caused the price of the product to be more expensive so it would not be competitive for export. In order not to lose, exporters would shift sales to domestic so that the nominal exports would tend to fall.

While in terms of investment, the effect of volatility could occur either directly or indirectly. The direct impact was the increase of investor risk perception of future investments as a a result of exchange rate uncertaity. Therefore, investors would tend to hold their investment flow by doing a wait-and-see until the situation was considered safe enough to continue investing. As a result, high volatility of exchange rate could indicate that country's economy was not in a healty condition so that investors would see this as unprofitable place to invest. This could cause massive investment withdrawals from a country which would certainly generate a serious impact. Besides, the indirect effect occurred when the exchange rate volatilty caused uncertainty of production factor price. To avoid losses, investors would tend to reduce their investment in less profitable production factors, then shift it to other investment instruments that were more profitable to maximize marginal profitability.

Based on Solow's growth theory, the variables that influence economic growth were Output, Capital, and Labor and those were accompanied by technological developments. So based on previous theories regarding factor prices, it was suspected that exchange rate volatility would affect a country's economic growth through increament and absorption of production factors so that it would affect production in aggregate. If the Solow and Cobb Douglas growth theory suggested the effect of exchange rate volatility on economic growth from the supply side, then the Mundell-Fleming model, Mundel (1961) [11] could explain the effect of the exchange rate on GDP *(Gross Domestic Product)* from the demand side also. According to the model, the components of GDP from the demand side were consumption, investment, government spending, and export-import. Based on previous theories, the changes and uncertainties in output prices would disrupt investment flows and hamper trade flows. Based on previous research, Zainal (2004) [14] showed that there was a relationship between Indonesia's export performance and exchange rate volatility. As well as Campa and Goldberg (1995) [6] that examined the relationship between changes in exchange rates and investment. So based on the theory above, it was suspected that there was an influence of exchange rate volatility on international trade, investment, and economic growth.

2.1.2. Exchange Market Pressure. Countries that adopt a free-floating exchange rate system would be vulnerable to shocks both from within and outside the country. The stable fluctuation of the exchange rate after being hit by shock and pressure showed a strong economy of a country. These pressures could be in the form of trade wars, crises, economic policies, inflations, and even the economic conditions of other countries. To measure this pressure, an EMP *(Exchange Rate Market Pressure)* indicator was used. A country with a fixed exchange rate system would reduce the pressure by using foreign exchange reserves. Whereas, countries with a free-floating exchange rate system would reduce the pressure by using exchange rate changes itself. This EMP was used as an Early Warning System by measuring how much pressure was happening. If the pressure exceeded a certain threshold or boundary then a potential crisis could be indicated. There were no standards regarding the limits, but

based on the world bank, model of 1.5 times standard deviations were used to identify potential crises in a country, Imansyah (2009) [8]. The causes of financial and exchange rate crises according to Berg and friends (1999) [4] were divided into two, namely the disruption of economic fundamentals (inflation, economic growth, and balance of payment) and the existence of speculative attacks that could accelerate the onset of the crisis (self-fulfilling crisis). In addition, the 1998 IMF study, Kaminsky G (1997) [9] showed the components which could drive into the crisis were the current account deficit, large external debt, the vulnerability of the financial sector, monetary policy that ran a fixed exchange rate system, and interest rate that were in a high level.

2.2. Method of collecting the data

This research was conducted with a focus on Indonesia in the period of 1997 to 2018. The data used in the analysis were secondary data with *Bank Indonesia* [2] and the *Federal Reserve Economic Data* (FRED) [7] as the source. The GDP Growth Rate variable was the percentage change of Indonesia's GDP at the constant 2010 prices. Besides, the FDI variable was a Indonesia;s foreign direct investment in million USD.Then, exports and imports were in billions rupiahs. Nominal exchange rate was in rupiah per USD

2.3. Method of analysis

The analytical methods used in this research were descriptive and inference. Descriptive analysis was used to give a clear picture of movements and characteristics of these variables visually by using graphs during the study period. Whereas inference analysis was used to estimate and test hypotheses using time series analysis. The time series methods that were used to analyze the effect of exchange rate volatility on the economy were ARIMA *(Autoregressive Integrated Moving Average)* and EGARCH *(Exponential Generalized Autoregressive Conditional Heteroscedasticity)*, Baltagi (2010) [1]. Meanwhile, the logistic time series regression method was used to analyze the factors that influenced the potential for crisis.

2.3.1. Estimate exchange rate volatility. Volatility could be measured through several approaches by utilizing data deviation. According to Bollerslev (1986) [5], the measurement of volatility can be done using conditional variance from ARCH / GARCH. Firstly, the ARIMA method was used on the nominal exchange rate variable to get a model. Then, a heteroscedasticity problem was found after diagnostic testing on the error series. After that, the estimation was continued by forming a conditional variance on the error. The best model was taken from several tentatives based on predetermined criteria. The general model was as follows:

The mean model of the exchange rate was the ARIMA model (p, d, q)

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=1}^{q} \beta_j e_{t-j} + \varepsilon_t \quad (1)$$

While the conditional variance model formed as GARCH (p, q)

$$\sigma_t^2 = \gamma_0 + \sum_{i=1}^{p} \gamma_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \varphi_i \sigma_{t-i}^2 + u_t \quad (2)$$

The series which was formed from the conditional variance model was then used as the exchange rate volatility variable. Furthermore, an analysis was conducted to study the effect of exchange rate volatility on several macroeconomic variables using time series regression which was involving lags of the dependent variable and lags of the independent variable. The general model was as follows:

$$GDPGR_t = \beta_0 + \sum_{i=1}^{p} \alpha_i GDPGR_{t-i} + \sum_{j=1}^{q} \beta_j EGARCH_{t-j} + \varepsilon_t \quad (3)$$

$$\Delta FDI_t = \beta_0 + \sum_{i=1}^{p} \alpha_i \Delta FDI_{t-i} + \sum_{j=1}^{q} \beta_j EGARCH_{t-j} + \varepsilon_t \quad (4)$$

$$\Delta EXPORT = \beta_0 + \sum_{i=1}^{p} \alpha_i \Delta EXPORT_{t-i} + \sum_{j=1}^{q} \beta_j EGARCH_{t-j} + \varepsilon_t \quad (5)$$

$$\Delta IMPORT = \beta_0 + \sum_{i=1}^{p} \alpha_i \Delta IMPORT_{t-i} + \sum_{j=1}^{q} \beta_j EGARCH_{t-j} + \varepsilon_t \quad (6)$$

$$for\ i = 1, 2, 3, \ldots\ and\ \ j = 0, 1, 2, \ldots\ldots$$

Properties:

$EGARCH_t$: Exchange Rate Volatility of Indonesia IDR/USD
$GDPGR_t$: GDP Growth Rate of Indonesia
ΔFDI_t : First differentiation of Foreign Direct Investment of Indonesia
$\Delta EXPORT_t$: First differentiation of Export of Indonesia
$\Delta IMPORT_t$: First differentiation of Import of Indonesia

The best model was chosen based on the specified criteria. Then, it was tested until all the required assumptions were met. The model interpretation was obtained based on estimation results after the final model was formed.

2.3.2. Exchange rate Market Pressure. The development of the EMP formula provided several modifications to the initial formula. In this study, the formula from Kaminsky, Lizondo, and Reinhart (1999) [9] was used:

$$EMP_t = \delta e_t + \left(\frac{\sigma_{\delta e}}{\sigma_{\delta r}}\right) \delta r_t \quad (7)$$

In which

$$\delta e_t = \frac{e_t - e_{t-1}}{e_{t-1}} \quad (8)$$

$$\delta r_t = \frac{r_t - r_{t-1}}{r_{t-1}} \quad (9)$$

Properties:
EMP_t : Exchange Rate Market Pressure
δe_t : Changes in Nominal Exchange Rates
δr_t : Changes in Foreign Exchange Reserves
$\sigma_{\delta e}$: Standard Deviation of Changes in Nominal Exchange Rates
$\sigma_{\delta r}$: Standard Deviation of Changes in Foreign Exchange Reserves

The formula was used because researchers indicated that although Indonesia applied a free-floating exchange rate system, government intervention was still existed to keep exchange rate fluctuations from being too high. This could be seen from the pattern of the country's foreign exchange reserve movement. The limit used as thresholds to identify potential crises were 1.5 standard deviations following world bank standards and 1 standard deviation based on previous research, Imansyah (2009) [8].

2.3.3. Some Factors that affect Crisis Potential. The previous EMP series was taken, then recoded into a binary-valued variable, therefore the value became 1 and 0. The recode was by classifying each of the EMP series. The value that exceeded the 1.5 standard deviations threshold would be coded as 1 which means it was identified as a potential crisis period, while others were 0. Binary logistic regression was used as the analysis tool to see the factors that influenced the potential for a crisis. Furthermore, the model was tested for feasibility assumptions. After that, an interpretation of each coefficient was taken from the final model. The general model was as follows:

$$Log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1\, GDPGR_t + \beta_2\, TRADE_t + \beta_3\, D(FDI)_t + \beta_4\, EGARCH_t + \varepsilon_t \qquad (10)$$

3. Result

3.1. Macroeconomic variable characteristics

Based on the movement pattern of Indonesia's nominal exchange rate from 1997 to 2021, there was a shift in 1998 compared to the time before 1998, especially when the system switched from a managed-floating to a free-floating. Moreover, Asian financial crisis in 1998 also contributed to the exchange rate volatility, therefore it was considered as the highest volatility. Besides, high volatility also occurred in 2008 during the global financial crisis and around 2021 during the pandemic. This indicated that high exchange rate volatility would reflect current Indonesia's economic state.

According to the research of Munyama and Todani (2005) [12] there was indicated that the exchange rate and the trade balance had a relation. The net export variability seemed to be increasing over time. Variability started to look even greater from the period 2007 to 2021. This indicated that the flow of foreign trade was getting bigger or getting more open to the international market. However, Indonesia's net export was seen unaffected by the crisis in 1998. It remained positive until before 2008 as the global crisis hit which then turned negative for the first time. During 2018 it seemed that Indonesia's foreign trade was not in good condition because the deficit value throughout the year was always relatively high. Several factors influenced were the depreciation of the exchange rate, the impact of the US-China trade war threat, the impact of the Argentina and Turkey crisis, and the infrastructure development program in Indonesia which needed capital goods from imports.

On the investment side, FDI *(Foreign Direct Investment)* variable, illustrated that in general, the development in Indonesia improved from the period 2000 to 2021. The flow of FDI had seen more volatile since 2009 after the global crisis. In addition, there was a very sharp decline from around 5,000 million USD to around -7000 million USD in 2016, which was approximately caused by speculation and diversion of investment to the United States due to the discourse about an increment of interest rates of the Central Bank of America, the Fed, and other external factors. The impact of the crisis period did not seem to have an impact on FDI but there was still a visible pattern of decline around the crisis period.

Meanwhile, GDP growth seemed to be more stable from around 2009 to 2019 even though the crisis period directly impacted in 1998 that almost touching -8% per quarter. Nevertheless, it could be said that Indonesia's economic fundamental was getting stronger in which during the 2008 global crisis, GDP growth per quarter was still positive instead of negative. In addition, Indonesia's GDP growth remained stable at around 1.2% per quarter even though the exchange rate depreciation reached 15,000 rupiahs per USD in 2020 and many other external-internal disturbances occurred. This could picture the success of the government in maintaining and increasing Indonesia's economic growth.

3.2. Effects of Exchange rate volatility on the Indonesian Economy

ARIMA model which was applied on the nominal exchange rate variable to obtain the exchange rate volatility variable provided several alternative models.

Table 1. Criteria comparison of several tentative models.

Model	Criteria				
	R^2	F significance	Number of t significant	AIC	SIC
ARIMA (3,1,3)	0.191082	0.007051	1/6	16.87771	17.09006
ARIMA (4,1,4)	0.271812	0.000738	3/8	16.85703	17.12247
ARIMA (3,1,4)	0.195820	0.011063	0/7	16.89473	17.13362
ARIMA (4,1,3)	0.209779	0.006146	3/7	16.85490	17.11380

Based on several criteria for selecting the best model included R-squared, independent variable test both simultaneously and partial, AIC *(Akaike Information Criterion)*, and SIC *(Schwarz Information Criterion)*, the researchers decided to use the ARIMA (4,1,3) model as the best model. Then, assumption testing which included white noise test, autocorrelation test, and heteroscedastic test gave a result that there were heteroscedastic problems. Therefore, it continued to the ARCH / GARCH method to model the variance error. However, during error exploration, the researchers indicated an asymmetrical pattern in the error fluctuations. Therefore, asymmetric testing was done by observing the correlation between the squared of residuals and the lag standardized residuals (Table B1). The test results showed that there was an asymmetrical effect on error fluctuations. Next, modeling continued by the EGARCH method.

Table 2. Criteria comparison of several tentative models.

Model	Criteria				
	R^2	Log likelihood	Number of t significant	AIC	SIC
EGARCH (1,0)	0.385917	-736.3199	2/7	16.09290	16.41969
EGARCH (0,1)	0.410956	-724.4061	5/7	15.83669	16.16348
EGARCH (1,1)	0.332399	-718.8299	6/7	15.73828	16.09230

Based on the criteria above, the EGARCH model (1,1) was chosen as the best model. The assumption test was conducted to test the feasibility of the model which the results were obtained that the model was feasible to use. After that, the series from the conditional variance was used as an exchange rate volatility variable which then was analyzed for its effect on several economic variables.

3.3. Effect of exchange rate volatility on GDP growth

The regression was involving GDP growth as the dependent variable, while the independent variables were GDP growth lag, exchange rate volatility, and exchange rate volatility lag. As a result, the best model was composed with 1 lag of GDP growth and 0 lags in exchange rate volatility. However, after went through the assumption testing, it was found that there was still a heteroscedasticity problem. Therefore, modeling continued with ARCH / GARCH to overcome the problem of heteroscedasticity. So, the final model was as follows:

$$\widehat{GDPGR}_t = 1{,}258 + 0{,}308\, GDPGR_{t-1} - 0{,}000332\, EGARCH_t \quad (11)$$

$$\sigma_t^2 = 0{,}01 + 3{,}94\, e_{t-1}^2 \quad (12)$$

Based on the feasibility test of the model, it could be said that the model was already feasible to be used because it had fulfilled all the required assumptions so that the estimator was also BLUE *(Best Linear Unbiased Estimator)*. Based on the estimation results, the movement of GDP growth would remain relatively stable because current growth was in line with growth in the previous period. Meanwhile, the exchange rate volatility variable at current time had a negative influence on GDP growth. So, It was estimated that an increase of exchange rate volatility by 1000 rupiahs per USD would hamper GDP growth by 0.3%. Based on the previous descriptive analysis, it was known that GDP growth in each quarter in 2018 was stable at around 1.2% while there was also a spike in exchange rate depreciation. This could mean that if exchange rate fluctuations were maintained in normal condition, then it could be expected that the 2018 GDP Growth should be higher than what was achieved.

3.4. Effect of exchange rate volatility on FDI

The regression was involving changes of FDI as the dependent variable, while independent variables were exchange rate volatility and lag of FDI-change. The best model was composed of 3 lags of FDI-change. The final model was as follows:

$$\widehat{D(FDI)}_t = 542{,}88 - 0{,}654\, D(FDI)_{t-1} - 0{,}494\, D(FDI)_{t-2} - 0{,}324\, D(FDI)_{t-3} - 0{,}472\, EGARCH_t \quad (13)$$

Based on the feasibility test of the model, it could be said that the model was already feasible to be used because it had fulfilled all the required assumptions so that the estimator was also BLUE. Based on the estimation results, the FDI movement would fluctuate over time because the current FDI-change was not in line with FDI-change in the previous period. In addition, the exchange rate volatility variable had a negative influence on FDI-change. Nevertheless, the effect was not significant based on alpha 5%. It was estimated that an increase of exchange rate volatility by 1000 rupiahs per USD would suppress FDI growth for about 472 million USD.

3.5. Effect of exchange rate volatility on export

The regression was involving changes of export as the dependent variable, while independent variables were lag of export-change, exchange rate volatility, and lag of exchange rate volatility. The best model was composed of 4 lag of export-change and 0 lag of exchange rate volatility. However, after the assumption testing, it was found that there was still a heteroscedasticity problem. Therefore, modeling continued with ARCH / GARCH to overcome the problem of heteroscedasticity. So, the final model was as follows:

$$\widehat{D(EXPORT)}_t = 16175{,}34 - 0{,}0673\, D(EXPORT)_{t-1} - 0{,}145\, D(EXPORT)_{t-2} - 0{,}124\, D(EXPORT)_{t-3} - 0{,}35\, D(EXPORT)_{t-4} - 8{,}796\, EGARCH_t \quad (14)$$

$$\sigma_t^2 = 829633 + 0{,}545\, e_{t-1}^2 - 0{,}122\, e_{t-1}^2 \quad (15)$$

Based on the feasibility test of the model, it could be said that the model was already feasible to be used because it had fulfilled all the required assumptions so that the estimator was also BLUE. Based on the estimation results, the export movement would fluctuate over time because the current export-change was not in line with the export-change in the previous period. The exchange rate volatility variable at lag 0 had a negativee influence on the export-change. The negative effect of exchange rate volatility on exports was caused by the high prices on imported raw materials which made the price of domestic goods relatively more expensive. Therefore, domestic goods would tend to lose competitiveness in the international market. Furthermore, exporters would shift the sales to the domestic market so that it would reduce the value of exports. It was estimated that an increase in exchange rate volatility by 1000 rupiahs per USD would decrease export-change by 8.7 trillion rupiahs.

3.6. Effect of exchange rate volatility on import

The regression was involving changes of import as the dependent variable, while independent variables were lag of import-change, exchange rate volatility, and lag of exchange rate volatility. The best model consisted of 1 lag of import-change and 0 lag of exchange rate volatility. The final model was as follows:

$$D(\widehat{IMPORT})_t = 17470 + 0{,}278\, D(IMPORT)_{t-1} - 31{,}055\, EGARCH_t \quad (16)$$

Based on the feasibility test of the model, it could be said that the model was already feasible to be used because it had fulfilled all the required assumptions so that the estimator was also BLUE. Based on the estimation results, the movement of imports would be relatively stable over time because the current import-change was in line with import-change in the previous period. The exchange rate volatility variable at lag 0 had a negative effect on the import-change. It was estimated that an increase of exchange rate volatility by 1000 rupiahs per USD would decrease import-change by 31 billion rupiahs. The positive effect was caused by the exchange rate initial shock resulting in the price of imported goods becoming more expensive than the previous. As a result, imports would increase due to the fulfillment of a country's needs. On the other hand, the negative effect was caused by an adjustment due to higher prices.

3.7. Exchange rate market pressure

This measurement of exchange rate market pressure used the formula (7). Together with the Thresholds, they produced a chart like the one below:

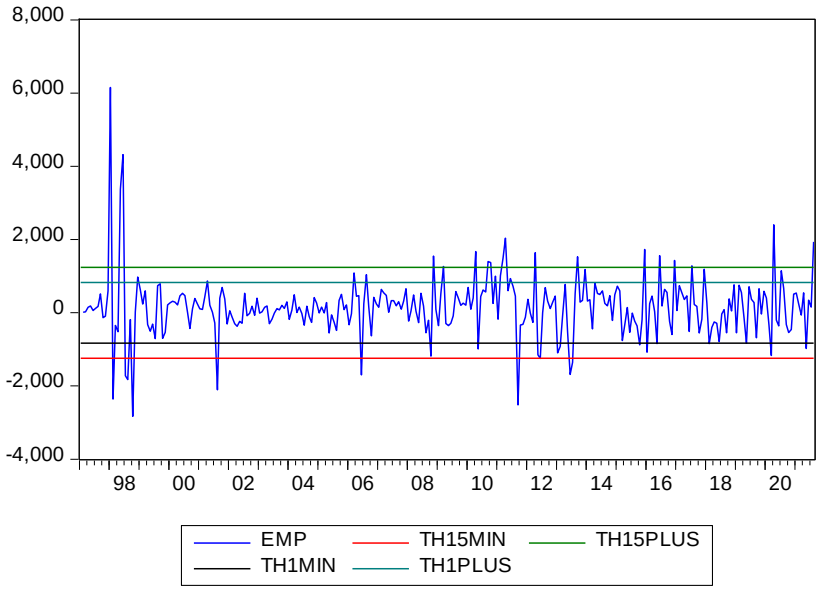

Figure 2. Measurement of Indonesia's EMP from 1997-2021

The graph above can provide a clear picture of the periods in which were indicated to have high exchange rate market pressures that had the potential for crisis. The upper and lower limits were the thresholds by world banks which were 1.5 and 1 standard deviation. The narrower thresholds were more sensitive. The exchange rate depreciation in 2018 gave pressure on the exchange rate market but it was still far from a potential crisis according to the 1.5 standard deviation threshold. However, the government needed to be more cautious in maintaining exchange rate volatility because the pressure that was generated in 2020 and 2021 had touched the 1.5 standard deviation threshold. It could be said that in early Indonesia is in the middle of a crisis.

The EMP variable was recoded to a binary variable which value was 1 and 0. Then, it was considered as a dependent variable in the binary logistic regression and used to analyze the factors that influenced potential crises. In this new variable, a value of 1 was identified as a potential crises period.

Besides, the independent variables were GDP growth, FDI-change, net exports, and exchange rate volatility. The model was formed as follows:

$$Log\left(\frac{p}{1-p}\right) = -1{,}598 - 1{,}669\ GDPGR_t - 1{,}41\ x\ 10^{-14}\ TRADE_t - 8{,}4\ x10^{-5}\ D(FDI)_t + 0{,}00782\ EGARCH_t \quad (17)$$

The model was tested through feasibility tests such as autocorrelation, multicollinearity, and goodness of fit test. The results showed that the model was feasible to use. Based on the partial significance, it could be said that with a significance level of 5%, only the GDP growth and exchange rate volatility variable had a significant effect on the potential crises at the 1.5 standard deviation threshold. Meanwhile, FDI-change and net exports had an effect but were not significant. Based on parameter estimation, a trend could be calculated using exponential rank coefficient calculation. As a result, it was estimated that a 1% increase in GDP growth would encourage a tendency of 0.1883 towards potential crises. In other words, a 1% increase in GDP growth resulted in a tendency of 5.3 to move away from potential crises. Besides, an 100 rupiahs increase in exchange rate volatility would increase the tendency of 2.18 for a crisis.

4. Conclusion And Discussion

Based on the research, it is concluded as follows:

1. Exchange rate volatility has an important role in the economy because it significantly influenced economic variables which were GDP growth and changes in exports and imports.
2. High exchange rate volatility will drag down economic growth, inhibit international trade flow, and suppress direct investment.
3. Volatility and depreciation of exchange rate that occurred in 2021 can be used as a signal to be more careful regarding the potential crises that went in line.
4. The factors that significantly influence the potential for crises at the 1.5 standard deviation threshold are negative GDP growth and high exchange rate volatility.

Few recommendations proposed based on the conclusion above are:

1. The government should pay more attention to keeping the exchange rate stable. External shocks cannot be avoided but their effects can be mitigated by maintaining macroeconomic assumptions and strengthening the economic foundations from the inside.
2. To maintain exchange rate volatility, the government should also focus on increasing Indonesia's GDP growth by creating attractive investment climates. The increased investment will trigger an increase in the production and output quality of domestic goods. It can also play a role in overcoming deeper trade deficits. So it is expected that rapid economic growth can avoid the risk of crises
3. Hopefully, further research will use more specific variables on commodities or other variables that have not been used in this study.
4. It is recommended for the next researcher to use a time series method that can also identify long-term relationship.

Acknowledgment

The Author would like to express his gratitude to those who have helped contribute to the preparation of this paper and those who have provided the opportunity to join the call for paper event. Beside getting more experience, the author hopes that this paper could be classified as a published journal so that it would be useful for those who need it.

Appendices

Appendix A

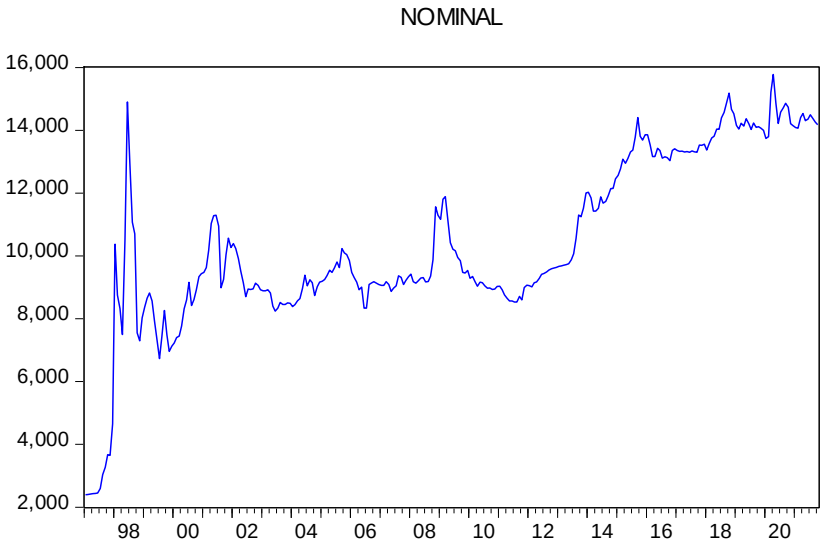

Figure A1. Nominal Exchange Rate Rupiah to USD

Appendix B

Table B1. Asymetric Test of residual

KW,LAG(-i)	KW,LAG(+i)	i	lag	lead
		0	0.2017	0.2017
		1	0.0002	0.4192
		2	-0.0103	-0.1344
		3	0.1879	0.0023
		4	0.3050	-0.0267
		5	0.0524	0.0903
		6	0.0300	0.2152
		7	-0.0668	-0.1155
		8	0.2312	-0.0859
		9	0.0546	-0.1374
		10	0.0039	-0.3028
		11	0.0196	-0.0565
		12	0.0119	0.0381
		13	0.0183	-0.0617
		14	0.0079	-0.0207
		15	0.0127	0.0342
		16	0.0306	-0.0096
		17	0.0071	-0.0795
		18	-0.0061	-0.0809
		19	0.0054	0.0406
		20	0.0099	0.0299
		21	0.0025	0.0529
		22	0.0047	-0.0752
		23	0.0027	0.0305
		24	-0.0049	-0.0065
		25	-0.0055	0.0623
		26	-0.0001	0.0116
		27	0.0135	0.0008
		28	-0.0069	0.0353
		29	-0.0172	0.0848
		30	-0.0017	0.0290

Reference

[1] Baltagi Badi H 2010 *Econometrics 2nd edition* (New York: Springer)
[2] Bank Indonesia 2018 (SEKI) *Financial Account: Direct Investment Laporan Tahunan* (Jakarta: Bank Indonesia)
[3] Barkoulas et al (2002) *Exchange rate effects on the volume and variability of trade flow Work. Pap.*1 *pp 1 – 27*
[4] Berg A and Pattillo C 1999 Predicting currency crises: The indicators approach and an alternative *J. of Int. Money and Finc.* 18 561 – 586
[5] Bollerslev T 1986 Generelized autoregressive conditional heteroscedastivity *J. of Eco.* 31 pp 307 – 327
[6] Campa J and Goldberg 1995 Investment, exchange rates and external exposure *J. of Int, Eco.* 38 pp 297 – 320
[7] Federal Reserve Bank of St. Louis, St. Louis: One Federal Reserve Bank Plaza, MO 63102
[8] Imansyah M Handry 2009 *Krisis keuangan di Indonesia* (Jakarta: PT Elex Media Komputindo)
[9] Kaminsky G, S Lizondo and C M Reinhart 1997 Leading indicators of currency crisis (Washington DC: IMF) July *IMF W. Pap.* pp 97-98
[10] McKinnon R and Ohno K 1997 *Dollar and Yen: Resolving Economic Connflict Between the United States and Japan* (London: The MIT Press)
[11] Mundell Robert A 1961 A theory of optimum currency areas *The American Economic Rev.* 51 pp 657 – 665
[12] Munyama T and Todani K 2005 Exchange rate volatility and export in South Africa *TIPS/DPRU Annual Forum.* 30 pp 1 – 24
[13] Supaat et al 2003 Investigating the relationship between exchange rate volatility and macroeconomic volatility in Singapore *MAS Staff Paper* 25
[14] Zainal Arindha Artasya 2004 Exchange rate Pass-Through, Exchange rate volatility, and their impact on export: evidence from Indonesian data *Disrt. Kansas University*