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An empirical analysis of the effects of macroeconomic variables on exchange rate: A time series analysis using ECM

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ABSTRACT

There are increasing on debate about how the macroeconomic variables causes exchange rate. There are evidence that macroeconomic variables has a little evidence on exchange rate volatility and vice versa. This study aims to analyze the impact of macroeconomic variables, namely exports, imports, inflation, money supply, and interest rates, on the Rupiah exchange rate using the Error Correction Model approach. Using monthly data from 2010 to 2023 obtained from the Central Bureau of Statistics and Bank Indonesia. The finding shows in the long run, exports have a negative effect on the exchange rate, while money supply and interest rates have a positive effect and indicates that an increase in these variables will strengthen the exchange rate. In the long run, imports and inflation do not show a significant effect in the long run. In the short run, only money supply and interest rates significantly affect the exchange rate, while exports, imports, and inflation do not. This study highlights the importance of understanding these macroeconomic dynamics for more effective economic policy making in Indonesia. The dominant role of monetary policy over trade and price variables in stabilizing the exchange rate. Policymakers should focus on managing money supply and interest rates while promoting exports to maintain Rupiah stability amid global uncertainty.

1. Introduction

The interaction of macroeconomic variables causes affects on exchange rate stability. Exchange rate fluctuations can create uncertainty in international trade and increase investment risks. Currency appreciation reduces the competitiveness of domestic products, while depreciation increases import costs (Carissa & Khoirudin, 2020). This study analyzes the impact of the macroeconomic variables on the exchange rate over the short and long run estimation. Exchange rate instability have negative impacts on a domestics economy. Changes in exchange rates significantly affect the prices of imported and exported goods, which ultimately disrupt the balance of trade (Hoffmann & MacDonald, 2009). The fluctuations of exchange rate led to uncertainty and has risks on investment and international trade (Wilya et al., 2015). There are increasing on debate about how the macroeconomic variables causes exchange rate. Early study from Flood & Rose (1995) founds that macroeconomic volatility is not important source of exchange rate fluctuations for G-7 countries. Contrast to Grubacic (2000) there are evidence that macroeconomic variables has the effect on exchange rate in eastern Europe.

In 2018, the world witnessed a trade conflict between the United States and China, triggered by protectionist policies under President Donald Trump's leadership that raised import tariffs on Chinese products. China responded by raising import tariffs on American products. This policy triggered uncertainty in the global market and increased volatility in various international financial markets

(Felinda, 2020). This trade tension caused global economic instability which impacted the economic growth of the countries involved, including Indonesia. In addition, this trade war has the impact on monetary policy in many countries as the respond to stabilize their currency exchange rates amidst global economic uncertainty (Wijaya, 2020). The impact of this trade war is felt throughout the world, including Indonesia, where the rupiah depreciated sharply against the US dollar exceeding IDR 15.000 per USD causes higher import costs, increased inflationary pressures, and challenges for external debt repayments (Bank Indonesia, 2019). These exchange rate fluctuations, driven by global uncertainty, have significantly strained Indonesia's economic stability (Nugroho & Nasrudin, 2022).

Although earlier studies have highlighted the significance of exchange rates in the global economy, several important aspects have yet to be explored in depth. The exchange rate is one of macroeconomic indicators (Salim & Soelistyo, 2024). One significant gap is the lack of research that integrates the simultaneous effect of various macroeconomic variables namely exports, imports, inflation, money supply, and interest rates on exchange rates as macroeconomic variables. These variables are used in the study and has assumption of these variables has direct effect on a country's external trade performance, domestic price stability, monetary conditions, and the cost of capital, and led to exchange rate movements. The focus of this study to analyze the effect of macroeconomic variables on exchange rate that led to economic instability (Buncic & Müller, 2017). Exchange rates affect various aspects of the economy, such as international trade, inflation, and global competitiveness. Krugman et al (2018) stated the exchange rate refers to an important factor in determining the competitiveness of a country in the global economy. Mishkin (2015) emphasizes a stable of exchange rate helps reduce economic uncertainty and encourages foreign investment.

To address this gap, this study used the Error Correction Model (ECM), which allows for simultaneous analysis of long-term and short-term estimations. This approach provides a deeper understanding of the complex dynamics between macroeconomic variables with the exchange rate. The aims of the study to analyze the macroeconomic variable on the exchange rate and how macroeconomic variables interact in the long-run and short-run estimations. Previous research has adopted similar ECM approaches, for example Dornbusch (1976) analyze how trade balances adjust to exchange rate changes over time. The ECM framework is theoretically grounded in the notion of purchasing power parity (PPP) and the monetary approach to the exchange rate, where deviations from long-run equilibrium are gradually corrected through short-run adjustments. Morana (2009) argued little evidence on affect of macroeconomic variables on exchange rate in the country that has system of flexible exchange rate. This study contribute to the literature in two ways. Firstly, it provides evidence on the linkage of macroeconomic variables on exchange rate and secondly analyze the estimation of the long-run and short-run estimation on macroeconomic variables on exchange rate in Indonesia.

2. Literature Review

Krugman et al (2018) emphasizes that exchange rates function depend on supply and demand in the international market. Exchange rate fluctuations can be influenced by various macroeconomic variables, including exports, imports, inflation, money supply, and interest rates, which interact with each other to affect economic stability (Salvatore, 2013). The flexible exchange rate offers several vulnerabilities and the higher vulnerabilities lies on high volatility. In a flexible or floating exchange rate system the value of currency depend on supply and demand. While high volatility of exchange rate due to speculative flow from investors seeking quick return on foreign exchange market and all depend on how macroeconomic variables interact in both domestic and global to exchange rate. Investors are sensitive to changes in interest rates, which affects their decisions in foreign exchange market. Higher domestic interest rate led to attract foreign capital and increasing demand for the currency (appreciation) and vice versa.

Ahmed & Mazlan (2021) found the changes in interest rates have short-run symmetric effects on the exchange rates, which also hold in the long run for five ASEAN countries, namely, Cambodia, Malaysia, Thailand, Vietnam, and Singapore. On the other hand, changes in interest rates have asymmetric (negative) effects on the exchange rates, which also hold in the long run for seven ASEAN countries, namely, Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. The volatility of interest rate policies led to investor uncertainty and may have volatility on exchange rate. Sarpong et al (2021) found that interest rate has the effect on exchange rate in both short and long run estimation in Ghana. Musa & Sanusi (2020) states increase in interest rate will

depreciate the exchange in the long run (either in an open or a closed capital account setting) and also in the short run if the capital account is open. Moreover, Suryavanshi (2022) highlighted that interest rate play important role on exchange rate volatility in India.

Kano (2024) argued trend inflation helps explain the empirical puzzles of the exchange rate dynamics. High inflation reduce purchasing power and impact on lowers currency attractiveness. Inflation is an important macroeconomic variable that affects the exchange rate through changes in domestic currency's purchasing power. Purchasing power parity (PPP) theory indicates that domestic currency's purchasing power will be reduced by high inflation and cause exchange rate depreciation (Mankiw, 2008). Muzzaky (2015) argued that high inflation can result in a decline of the exchange rate, because the price of domestic goods and services becomes costly compared to goods and services from other countries. Conversely, effective inflation control can help maintain exchange rate stability and increase the attractiveness of foreign investment (Parkin, 2008). Boubaker & Mouna (2024) found the response of exchange rates to inflation induced shocks was neither immediate nor as pronounced as the corresponding reaction of inflation to sudden shifts in exchange rates.

Melati & Kurniawan (2023) argued that money has a pivotal role on economy. Incrasing in money supply means more domestic currency in circulation and often to lower interest rate and led to reduce return on domestic assets and less attractive to foreign investor. Money supply has indirect effect on exchange rate and still have effect on exchange rate. the quantity theory of money, increased money supply can lead to inflation if it is not balanced by real output growth, which in turn can weaken the exchange rate (Sitorus, 2018). Increasing of money supply without proper control can result in inflation and a depreciation of the exchange rate, while a prudent monetary policy can help maintain exchange rate stability and support economic growth (Oktarina et al., 2009). Wahab & Adelowotan (2025) states control the supplies of money in the circulation and that government should put on policy implementation that will ensure the stability of naira value. In the context of the Indonesian economy, macroeconomic policies such as inflation control, money supply regulation, and interest rate adjustments have played a crucial role in maintaining exchange rate stability. For example, during the period of 2018–2019, Bank Indonesia raised its policy interest rate from 4.25% to 6% to counter excessive rupiah depreciation amid global shocks, which helped stabilize the exchange rate around IDR 14.000–14.500 per USD (Bank Indonesia, 2019). Fordatkosu et al (2021) reveals that consistent monetary policy and effective inflation control can help maintain exchange rate stability and support sustainable economic growth. In addition, efficient management of exports and imports can also affect exchange rate dynamics, by ensuring a balance of trade that supports the strength of the domestic currency.

3. Method

This study used secondary data and obtained from Bank Indonesia. Data used in the study is monthly data from 2010-2023. To examine the effect of macroeconomic variables on exchange rate in Indonesia, the model based on Morana (2009) was adapted as follows:

$$ER = f(EXP, IMP, INF, MS, r) \quad (1)$$

Where ER is the exchange rate, EXP is the value of export, IMP is the value of import, INF is the inflation, MS is the money supply and r is the domestic interest rate. Error Correction Model (ECM) is used to evaluate long-term equilibrium and short-term adjustment in the model. This model helps overcome the problem of inaccurate and fluctuating time series data. By using the Error Correction Term (ECT), ECM shows how quickly adjustments occur due to deviations from long-term equilibrium. The ECM equation used in this study includes the research variables as well as ECT, which indicates the short-term adjustments needed to return to long-term equilibrium (Widarjono, 2013). The equation of ECM as follows:

$$lnER_t = \alpha_0 + \beta_1 lnEXP_t + \beta_2 lnIMP_t + \beta_3 INF_t + \beta_4 lnMS_t + \beta_5 r_t + ECT(-1) + \varepsilon_t \quad (2)$$

Where $ECT(-1)$ Components that indicate long-term adjustments in the ECM model, $\beta_1 - \beta_5$ is the coefficient of independent variables, ε_t is the disturbance error and ln is notation for transforming to logarithm form. Following Odusanya et al (2018) the estimation of ECM including the stationery of variables, cointegration test, classical assumption and estimation of short and long-run of ECM. The advantages using ECM as Engle & Granger (1987) explained that corrects for disequilibrium to

measures how far the system is from its long-run equilibrium and captures for short and long-run estimation.

4. Results and Discussion

Before analyzing the examining of macroeconomic variables on exchange rate, a test was first conducted on the macroeconomic data. The unit root test is important to make sure that the data used is stationary, preventing biased estimations in the analysis. Table 1 shows for each macroeconomic variables used in the study and exchange rate has a stationary state after the unit root test was done on the first difference. The degree of integration test results show that these variables are stationary on the first difference, with significant test statistic values at the 5% significance level.

Table 1. Result of Stationery

Variable	Augmented Dickey-Fuller					
	Level			1st Difference		
	ADF	Prob	Conclusion	ADF	Prob	Conclusion
ER	-1.097996	0.7162	No Stationary	-13.71435	0.0000	Stationary
EXP	-1.708249	0.4253	No Stationary	-13.14059	0.0000	Stationary
IMP	-2.375593	0.1504	No Stationary	-3.606140	0.0067	Stationary
INF	-10.58384	0.0000	Stationary	-12.48981	0.0000	Stationary
MS	-1.885960	0.3383	No Stationary	-17.41801	0.0000	Stationary
r	-1.851709	0.3545	No Stationary	-7.723869	0.0000	Stationary

Source: data processed

The cointegration test is carried out to evaluate whether a long-term correlation is found between variables. This test helps determine if the variables exhibit a simultaneous movement over time even with short-term fluctuations. Identifying such a relationship is crucial for understanding the long-term dynamics of the variables. Table 2 shows ADF probability value is 0.000, smaller than the 5% significance level, indicating cointegration between the observed variables, namely ECT (-1) and constant (C). This indicates a long-term correlation between these variables. The Error Correction Term (ECT) coefficient of -0.330 indicates that around 33 months of short-term imbalances will be corrected towards long-term equilibrium in the same period (lag -1). The t-statistic value of -5.802 with a probability of 0.000 confirms the statistical significance of the ECT coefficient. The negative ECT coefficient indicates a long-term adjustment mechanism in the Error Correction Model (ECM), where deviations from long-term equilibrium will return to equilibrium at a certain time. The use of the ECM model is proven to be relevant to capture the dynamics of adjustment between variables from short-term imbalances to long-term equilibrium.

Table 2. Cointegration Result

Variable	Coef	Std. Error	t-stat	Prob.
ECT(-1)	-0.330	0.057	-5.802	0.000

Source: data processed

The dynamic Error Correction Model (ECM) estimation method is to analyze export, import, inflation, money supply, and interest rate variables on exchange rate in both the short as well as the long term estimation. Table 2 shows the results of the cointegration test where the study used the ECM method and several criteria have been met. The ECM estimation method can also provide information on the correlation between changes in independent variables as well as dependent variables over the long run. The short-term regression results show that the export (EXP) as well as import (IMP) variables do not significantly affect the exchange rate, with t-statistics of -0.748 and 0.669 respectively and probabilities of 0.455 and 0.504. These findings align with the view of Mishkin (2015) argued the effects of trade variables such as imports may not be immediately reflected in the short run due to adjustment lags and international market rigidity. Likewise, Kurniawan & A'yun, (2022) also suggested that while exports can affect currency appreciation over time, the transmission may not be

evident in the short term due to delays in foreign exchange settlements or external shocks. Notwithstanding that both were observed to be persistent in the model and the result is insignificant for both short-run estimation. Nuhu & Bukari (2021) states the lower exchange rate make a country's export more competitive abroad led to increased the higher export volumes. For the IMP this may be due to external factors such as international commodity prices and global trade policies that affect the correlation between imports with the exchange rate.

Table 3. The Result of ECM Estimation

Variable	Coef	Variable	Coef
Long-run Estimation		Short-run Estimation	
lnEXP	-0.226	ΔlnEXP	-0.022
	(-6.753)***		(-0.748)
lnIMP	-0.005	ΔlnIMP	0.013
	(-0.140)		(0.669)
INF	-0.012	ΔINF	-0.006
	(-1.568)		(-1.910)*
lnMS	0.548	ΔlnMS	0.283
	(51.911)***		(3.464)***
r	0.021	Δr	0.021
	(6.512)***		(2.124)**
		ECT(-1)	-0.174
			(-3.791)***
C	3.123	C	0.0006
	(14.897)***		(0.355)

Source: data processed

Table 3 shows the INF does not significant in both short and long-run estimation. Indicates that the affect of inflation on exchange rate can be minimized by other economic policies. The insignificant impact of inflation contradicts theoretical expectations but may result from stabilizing factors like trade regulations or reserve management (Nasir et al., 2021). Likewise, although PPP theory suggests inflation should affect the exchange rate (Mankiw, 2008), effective monetary policy may have mitigated its influence (Muzzaky, 2015). Sayifullah & Arifin (2024) argued central banks typically adjust interest rates in respond to inflation, this leads, where inflation doesn't add explanatory power. Salim & Soelistyo (2024) argued prices and wages adjust slowly, even if domestic inflation rises, the exchange rate doesn't adjust immediately.

Meanwhile, the money supply and interest rate variables shows a significant effect on exchange rate. The money supply has a coefficient of -0.548 over the long run and 0.283 for the short run, with probabilities of 0.000 and 0.000 respectively, indicating a significant positive impact on exchange rate depreciation. Interest rates also show a significant positive effect with coefficients of 0.021 and 0.021 and a probability of 0.000 in the long and short run, indicates that increased interest rates weaken the exchange rate. These findings suggest that both money supply and interest rates play a very important role in influencing the exchange rate, with consistent effects in both the short and long run. In the context of the Indonesian economy, this implies that prudent monetary policy particularly in controlling money supply growth and adjusting interest rates can serve as an effective tool for maintaining exchange rate stability. Increasing in money supply means more domestic currency in circulation and often to lower interest rate and led to reduce return on domestic assets and less attractive to foreign investor. The volatility of interest rate policies led to investor uncertainty and may have volatility on exchange rate. Sarpong et al (2021) found that interest rate has the effect on exchange rate in both short and long run estimation and Musa & Sanusi (2020) states increase in interest rate will depreciate the exchange in the long run.

5. Conclusion

The interaction of macroeconomic variables causes affects on exchange rate stability. Exchange rate fluctuations can create uncertainty in international trade and increase investment risks. Currency appreciation reduces the competitiveness of domestic products, while depreciation increases import costs. There are increasing on debate about how the macroeconomic variables causes exchange rate. In 2018, the world witnessed a trade conflict between the United States and China, triggered by

protectionist policies under President Donald Trump's leadership that raised import tariffs on Chinese products. China responded by raising import tariffs on American products. This policy triggered uncertainty in the global market and increased volatility in various international financial markets. The aims of the study to analyze the macroeconomic variable on the exchange rate and how macroeconomic variables interact in the long-run and short-run estimations. This study contribute to the literature in two ways. Firstly, it provides evidence on the linkage of macroeconomic variables on exchange rate and secondly analyze the estimation of the long-run and short-run estimation on macroeconomic variables on exchange rate in Indonesia.

The findings of this study shows in the long run, exports have a negative effect on the exchange rate, while money supply and interest rates have a positive effect and indicates that an increase in these variables will strengthen the exchange rate. In the long run, imports and inflation do not show a significant effect in the long run. In the short run, only money supply and interest rates significantly affect the exchange rate, while exports, imports, and inflation do not. The dominant role of monetary policy over trade and price variables in stabilizing the exchange rate. Policymakers should focus on managing money supply and interest rates while promoting exports to maintain Rupiah stability amid global uncertainty.

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