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The Effect of Exchange Rate Volatility on Foreign Tourist Visits in Indonesia: GARCH Analysis

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Abstract
In this era of globalization, currency exchange rates are one of the crucial factors affecting a country's economy. The exchange rate of a country's currency plays an important role in economic stability and international trade, especially in the tourism sector. This study aims to conduct an in-depth analysis to identify patterns of rupiah exchange rate volatility using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model, and then examine whether these patterns have a significant correlation with the number of foreign tourist arrivals in Indonesia. In analyzing the data, researchers conducted several classical assumption tests, namely the normality test and the heteroscedasticity test. The test results show that the data used, namely the rupiah exchange rate data and the number of foreign tourist visits, are not normally distributed and heteroscedastic. In this case, it resulted in researchers not use the Pearson correlation test so they used the Kendall-Tau correlation test and Granger Causality test which resulted in the two variables being correlated. Furthermore, GARCH modeling is carried out which provides forecasting on both data to increase in 2024. The results of this study are expected to provide a basis consideration for stakeholders to determine policies, especially in the financial and tourism sectors.

***Keyword** : exchange rate, foreign tourists, GARCH, Granger Causality, Kendall Tau test*.

1. INTRODUCTION

In this era of globalization, currency exchange rates are one of the crucial factors affecting a country's economy. A country's currency exchange rate plays an important role in economic stability and international trade (Kartiasih, 2019; Laura et al., 2023; Pertiwi et al., 2023; Setiawan & Kartiasih, 2021). Exchange rates play an important role in macroeconomic adjustment, serving as a monetary policy transmission mechanism and accommodating shocks through changes in the real exchange rate (RER), especially in open economies with inflation-targeting regimes, thus becoming an important component in the adjustment process (Adwendi & Kartiasih, 2016; Edwards & Cabezas, 2022; Hawari & Kartiasih, 2017;

Ningsih & Kartiasih, 2019). Volatile exchange rates can have a significant impact on certain economic sectors, one of which is the tourism industry. In global market dynamics, Rupiah as Indonesia's currency has experienced significant changes in value. Tourism plays an important role in international trade by facilitating business deals, contributing to the economic growth of domestic and local markets through spending, and attracting tourists and travelers who also contribute to the economy (Dincer et al., 2015). Therefore, it is important to understand and analyze the volatility of the Rupiah exchange rate and its relationship with the number of foreign tourist arrivals.

This research includes several new characteristics and two contributions to the Indonesian regional literature regarding the correlation and volatility analysis of the rupiah exchange rate and the number of foreign tourist arrivals. In the economic literature, the study of correlation and volatility analysis of the Rupiah exchange rate and number of foreign tourist arrivals using the ARCH/GARCH model has been an interesting topic. However, some research gaps need to be addressed to improve our understanding of the correlation between tourism and exchange rates. First, research on the impact of exchange rate volatility on the number of foreign tourist arrivals is limited. The study conducted by Chang et al. (2013) examined the side effects of spillover volatility on firm performance and exchange rate asymmetry in Taiwan's tourism industry. Further studies could explore the impact of exchange rate volatility on foreign tourists' decisions about their destinations. While some studies may have examined the volatility of the Rupiah exchange rate or its impact on the tourism industry separately, the lack of integrated research investigating both aspects simultaneously may be a gap from previous studies, such as those conducted by Irandoust (2019) and Meo et al. (2018). Second, this study has novelty in the method used. The literature study that researchers found used the nonlinear autoregressive distributed lag (NARDL) method (Meo et al., 2018). This research used the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) method. Therefore, further research can help understand the complex dynamics between tourism and exchange rates. Tourism is also strongly related to the exchange rate because tourism will increase when the exchange rate falls, especially when the number of foreign tourists increases (Fairuuz et al., 2022).

The correlation and volatility between the Rupiah exchange rate and the number of tourist arrivals have significant implications for economic and business planning. First, the correlation can provide insight into how fluctuations in the Rupiah exchange rate affect the manufacturing industry, which is critical to understanding the impact of economic health on the manufacturing sector. Second, understanding correlations and volatility can help develop more responsible business strategies. Third, correlation can serve as an indicator of economic health, indicating potential economic instability and aiding the decision-making process. This analysis not only helps in predicting the success of the manufacturing sector but also provides a more comprehensive view of the country's economic health.

This study aims to identify patterns of volatility in the rupiah exchange rate perform forecasting using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model, and then examine whether these patterns have a significant correlation with the number of foreign tourist arrivals in Indonesia. Thus, it is hoped that this paper can provide a more detailed view for policymakers, business people, economists, researchers, and stakeholders in the tourism industry, such as local governments and tourism businesses to make informed decisions and formulate effective strategies in risk management and more effective economic policies in the future.

In the following sections, this paper will discuss the methodology, data analysis, and findings of this study, to provide a comprehensive understanding of Rupiah exchange rate volatility and its correlation with foreign tourist arrivals in Indonesia. Implications of the findings will be discussed, as well as recommendations for future research and policy considerations will be presented.

This study has several limitations designed to provide a clear focus and framework in analyzing the correlation and volatility of the Rupiah exchange rate and the number of foreign tourist arrivals using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. First, this study will limit itself to a specific period chosen based on the availability of relevant data, thus ensuring a focus on significant market dynamics. This study uses data with monthly periods ranging from January 2008 to September 2023 to test the correlation of the two data, while seeing the volatility of the exchange rate data using daily data.

In addition, this research will consider certain limitations in modeling volatility with the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model, which may include certain assumptions or limitations in the interpretation of causation. This research may consider limitations in the methodology used, such as certain assumptions in the GARCH model and conducting correlation tests. All these limitations will be geared towards ensuring that the research makes a significant and reliable contribution to the relationship under study.

2. LITERATURE REVIEW

2.1 Exchange rate

There is at least one significant coefficient in a measure of exchange rate volatility (Bahmani-oskooee & Aftab, 2017). The value of the rupiah relative to the currency of another nation is known as the exchange rate (Ginting & Kartiasih, 2019; Kartiasih et al., 2022; Maulana & Kartiasih, 2017; Rachma Safitri & Kartiasih, 2019). An appreciating exchange rate (positive value) lowers inflation, according to the definition of the exchange rate, e. The effect of the percentage change in prices resulting from an exchange rate change on inflation is captured by the parameter v. The residual term is assigned to all other aspects that have been overlooked (Ábel & Siklos, 2023). The way that monetary policy is implemented is significantly influenced by the exchange rate. Macroeconomic risks are significant factors that influence the economic climate in which businesses make financial decisions, even when they have no direct bearing on a company's finances or projects. Similar to specific commercial risks that impact a company's finances, macro-financial risks, such as fluctuations in interest rates, inflation, and exchange rates, must be examined and managed (Yescombe 2014, p. 257).

2.2 Foreign tourist

The Central Bureau of Statistics defines international tourists as travelers who travel to a nation other than their own country for one or more reasons, with no plan to make money while there, and for a maximum of twelve (twelve) months at a time.

Because tourism plays a significant role in the balance of payments, its contribution to national economic growth has been extensively researched (Sokhanvar, 2019). As one of the main economic drivers in emerging nations, tourism plays a significant role. Because of the size of tourism and the movement of millions of people on indirect tourism journeys, the government and management of tourist sites must continuously enhance the quality of tourism in terms of destination, industry, institutions, and marketing. As of the now, international visitors are aware of Bali and Lombok as tourism attractions (Simandjorang et al., 2023).

2.3 Correlation between exchange rate and foreign tourists

A decline in the value of the Rupiah relative to the US dollar usually results in losses for certain domestic economic sectors, but it also helps the travel and tourist industry. The nominal value will differ from the previous value if the rupiah exchange rate changes. Foreign visitors to Indonesia using US dollars would profit from the decline of the rupiah exchange rate since the dollar is now more costly than it was previously. Foreign exchange flows to a nation increase with the number of visitors that visit it.

The symbol τ represents the Kendall Tau correlation coefficient. Without assuming anything about the frequency distribution of the variables under study, the measurement of the Spearman correlation coefficient is used to evaluate how effectively the monotonic function—an orderly function—describes the connection between two variables. The correlation coefficient's value and the standards for determining how strongly two variables are related are the same as those applied in Pearson correlation analysis. In the meanwhile, the strength of the association between two variables is determined using the

Kendall-Tau correlation. This correlation belongs to the category of nonparametric statistics, much like the Sperman correlation does. It is not necessary for the data to be regularly distributed when using an ordinal scale (Yanti & Akhri, 2022).

3. METHODOLOGY

In processing this research, secondary data is used, such as daily and monthly data on the rupiah (IDR) exchange rate to the US dollar (USD) and monthly data on the number of international visitors from 2008 to 2023. The Central Statistics Agency (BPS) provides monthly statistics on foreign visitors visiting Indonesia, while the Investing website provides daily and monthly data on the rupiah currency rate.

We will utilize monthly data on the exchange rate between the rupiah and the number of foreign visitors for the inferential analysis, which will take the form of the Pearson Correlation Coefficient Test. Following inferential analysis, forecasting is done using monthly data on foreign visitor numbers and daily data on the rupiah currency rate. The frequency of the rupiah exchange rate data varies since there is a lack of information on the total number of visitors. Initially, researchers planned to use daily data on the rupiah exchange rate in the correlation test, but in reality, the existing data on the number of tourist visits was only available in a monthly frequency so the rupiah exchange rate data was adjusted to monthly data for the correlation test. Meanwhile, in forecasting, researchers use rupiah exchange rate data with a daily frequency because the volatility will be more visible compared to rupiah exchange rate data with a monthly frequency. The difference in daily and monthly frequencies in forecasting is of course not a problem because it is done after inferential analysis. This is also done due to limitations in the available dataset.

Granger Causality Tests

Granger causality is a concept in statistical analysis used to test whether a time variable can be considered as the cause of a change in another time variable. Suppose we have two time variables, X_t and Y_t. Granger causality checks whether past values of X can provide additional information in forecasting Y and vice versa. If the past values of X help predict Y better than just using the history of Y, then we can say that X Granger causes Y, and vice versa. Mathematically, Granger causality is tested using an autoregressive (AR) model. Suppose we have an AR model for Y as follows:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + \epsilon_t \quad (1)$$

and AR model for Y with the addition of variable X:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + \gamma_1 X_{t-1} + \gamma_2 X_{t-2} + \cdots + \gamma_q X_{t-q} + \epsilon_t \quad (2)$$

Granger causality is tested by testing the null hypothesis that all coefficients γ_i (which are related to variable X) are equally zero. If this hypothesis is rejected, then we can conclude that X Granger causes Y.

Augmented Dickey-Fuller Test

The Dickey-Fuller test is a statistical test used to test the null hypothesis that a time series has a unit root, which indicates that the time series is non-stationary. The Augmented Dickey-Fuller (ADF) test is an extended version of the Dickey-Fuller test that incorporates an additional autoregressive component into the equation to overcome possible autoregressive deficiencies in modeling time series processes.

The Augmented Dickey-Fuller (ADF) equation is as follows.

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + u_t \quad (3)$$

The ADF test tests the null hypothesis that there is a unit root in the time series, which indicates that the time series is non-stationary. The alternative hypothesis is that the time series is stationary after differentiation.

$H_0: \delta = 0$ (non-stasionary)

$H_\alpha: \delta < 0$ (stasionary) (4)

The test statistic used is the τ statistic developed by McKinnon.

$$\tau = \frac{\hat{\rho}}{SE(\hat{\rho})} \quad (5)$$

where $\hat{\rho} - 1 = \delta$. The decision is to reject H_0 if τ exceeds the McKinnon critical value.

ARCH Effect Test

The ARCH effect test is generally performed with the Ljung-Box Test on the squared residuals of the model. This test helps to check whether there is autocorrelation in the squared residuals which may indicate the presence of Autoregressive Conditional Heteroskedasticity (ARCH) effect or conditional volatility fluctuations. In this test, the hypothesis proposed is as follows.

H_0: There is no ARCH effect on the model residuals

H_α: There is an ARCH effect on the model residuals (6)

The test statistic used has a chi-squared distribution with m degrees of freedom.

$$LB = n(n+2)\sum_{k=1}^{m}\left(\frac{\hat{\rho}_k^2}{n-1}\right) \sim \chi_m^2 \quad (7)$$

where m and n are the lag length and sample size, respectively. The decision is to reject H_0 if LB exceeds the corresponding chi-squared table value.

GARCH (p, q) Modeling

GARCH is a statistical model developed to address the problem of heteroscedasticity in data, i.e. volatility variations that are not constant over time. GARCH takes into account the dependence between the variance of the data at the previous time and the variance at the current time. In general, the model of GARCH(p, q) can be seen in the following formula.

$$\sigma_t^2 = \omega + \sum_{i=1}^{p}\alpha_i\epsilon_{t-i}^2 + \sum_{j=1}^{q}\beta_j\sigma_{t-j}^2 \quad (8)$$

where $\sigma_t^2, \omega, \alpha_i, \epsilon_{t-i}^2, \beta_j$, and σ_{t-j}^2 are the conditional variance at time t, constant, i-th autoregressive coefficient, squared residual at *t-i*, moving average coefficient, and conditional variance at time *t-j*, respectively.

Each parameter in the GARCH model is simply estimated by maximum likelihood using the following likelihood function.

$$log\ log\ (L) = \sum_{i=1}^{T}\left(-\ log\ log\ (\sigma_t^2) - \frac{\epsilon_t^2}{\sigma_t^2}\right) (9)$$

where we will choose the parameter that produces the maximum likelihood.

4. RESULTS AND DISCUSSION

Volatility Modeling of the Number of Foreign Tourists

Plotting the quantity of international visitor visits as well as variations in their values over time is essential for recognizing data trends. Figures 1 and 2 show the state of the data on the value of the number of foreign visitors.

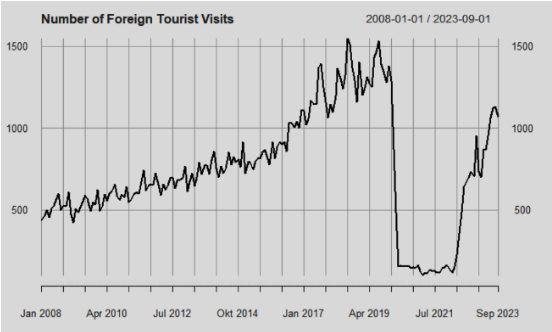

Figure 1. Number of Foreign Tourist Visits
Source: BPS, processed

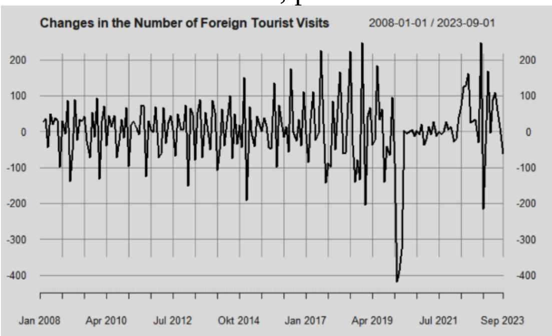

Figure 2. Changes in the Number of Foreign Tourists
Source: BPS, processed

The number of visitors from overseas varies a lot. The number of visits from international tourists comes into the volatile data category since numerical changes also have a tendency to vary. As expected from the rupiah exchange rate data, GARCH is a time series model that would be appropriate given the significant volatility in the number of international tourist visits.

Many tests are required to make sure that the GARCH model is an appropriate technique for modeling the volatility of the number of foreign tourist visits, much as with the prior procedure using rupiah exchange rate data. Therefore, in order to determine whether or not data on the number of foreign tourist visits is steady, the Augmented Dickey-Fuller (ADF) Test was conducted. The outcomes of the computed statistics and the determined p-value are as follows:

Table 1. ADF test at level

lag	*Type 1: no drift no trend*		*Type 2: with drift no trend*		*Type 3: with drift and trend*	
	ADF	*p-value*	ADF	*p-value*	ADF	*p-value*
0	1.22	0.942	1.79	0.99	1.8	0.99
1	1.16	0.933	1.74	0.99	1.74	0.99
2	1.11	0.927	1.73	0.99	1.72	0.99

3	1.03	0.918	1.56	0.99	1.56	0.99
4	1.05	0.919	1.66	0.99	1.66	0.99

Source: BPS, processed

Table 2. ADF test at first difference

lag	*Type 1: no drift no trend*		*Type 2: with drift no trend*		*Type 3: with drift and trend*	
	ADF	*p-value*	ADF	*p-value*	ADF	*p-value*
0	13.1	0.99	13.1	0.99	13	0.99
1	18.2	0.99	18.2	0.99	18.1	0.99
2	21.5	0.99	21.5	0.99	21.5	0.99
3	24.5	0.99	24.5	0.99	24.5	0.99
4	26.7	0.99	26.7	0.99	26.6	0.99

Source: BPS, processed

The test findings demonstrate that the p-value obtained is more than the significance level of 5%, indicating that there is non-stationarity in the number of visits from foreign tourists at either the first or second difference levels. The likelihood that GARCH is the best model increases with the data's non-stationarity.

Table 3. ADF test at second difference

lag	*Type 1: no drift no trend*		*Type 2: with drift no trend*		*Type 3: with drift and trend*	
	ADF	*p-value*	ADF	*p-value*	ADF	*p-value*
0	23.3	0.99	23.2	0.99	23.2	0.99
1	39.4	0.99	39.3	0.99	39.2	0.99
2	52.4	0.99	52.3	0.99	52.2	0.99
3	70.5	0.99	70.3	0.99	70.1	0.99
4	86	0.99	85.7	0.99	85.5	0.99

Source: BPS, processed

To determine whether or not there is an ARCH impact on the model residuals, the Box-Ljung Test must be performed next. The test findings showed a p-value of 5.1×10^{-14} and an X-squared of 61.215, both of which are significantly less than the significance level of 5%. We were able to derive a residual model from the test findings, which makes GARCH and ARCH appropriate for modeling data related to the number of visits by foreign tourists. GARCH is favored in modeling because it may represent more complicated volatility.

The mean GARCH model will make use of the following number of candidate ARIMA models:

Table 4. ARIMA Model Candidates

Model	AIC
ARIMA(2,1,2) with drift	2237.18
ARIMA(0,1,0) with drift	2228.45
ARIMA(1,1,0) with drift	2231.15
ARIMA(0,1,1) with drift	2230.23
ARIMA(0,1,0)	2226.66
ARIMA(1,1,1) with drift	2232.53

Source: BPS, processed

The ARIMA (0,1,0) model has the lowest AIC value, making it the best model. Real significant regression coefficients, however, could be disregarded by this model. Because the average GARCH modeling in this study yielded a significant regression coefficient with a similar AIC to ARIMA (0,1,0), the ARIMA (1,1,0) model was selected as the average model. Of the models other than ARIMA (0,1,0), the simplest is also the ARIMA (1,1,0) model. Based on the test results, the ARIMA (1, 1, 0) model indicates that the z value is -9.3878, the p-value is 2.2×10^{-16}, the estimated value is -0.14433, and the standard error is 0.015374. Here are a few things to think about while choosing GARCH candidates for modeling.

Table 5. GARCH Candidates

Model	AIC	SBC
GARCH(1,1)	11.728	11.797
GARCH(1,2)	11.717	11.803
GARCH(2,1)	11.743	11.829

Source: BPS, processed

The best models are GARCH (1,2) and GARCH (1,1), respectively, based on AIC and SBC. On closer inspection, though, it becomes clear that there is very little difference in AIC and SBC between GARCH (1,1) and GARCH (1,2). Because it is simpler, GARCH (1,1) is favored as a model in research.

The coefficient estimate for the constructed GARCH (1,1) model up to the p-value is as follows:

Table 6. GARCH (1,1) Model

Coefficient	*Estimate*	*Std. Error*	*z value*	Pr(>|z|)
ar1	-0.18457	0.091597	-2.015	0.043906
omega	925.86704	699.182507	1.3242	0.185432
alpha1	0.37572	0.145897	2.5753	0.010017
beta1	0.58731	0.108823	5.3969	0

Source: BPS, processed

Certain coefficients do not meet the threshold for statistical significance. However, GARCH (1,1) was still selected as the study model despite the fact that negligible coefficients were also discovered in other GARCH candidates. The resulting GARCH (1,1) equation is as follows:

$$\sigma_t^2 = 925.86704 + 0.37572\epsilon_{t-1}^2 + 0.58731\sigma_{t-1}^2$$

Plotting the conditional variance as a square root versus the time series may be done using equation (9).

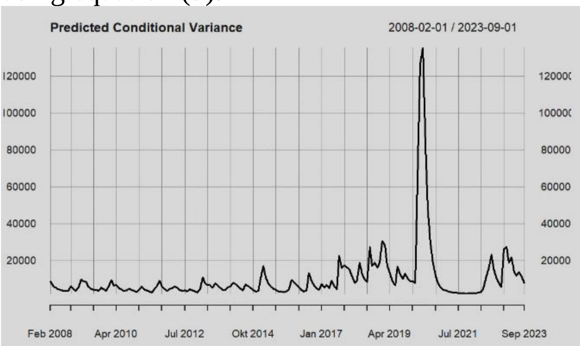

Figure 3. Conditional Variance Plot

Source: BPS, processed

Based on past data, predicted conditional variance estimates the volatility of the number of foreign visitor visits over a given time period.

The volatility of the number of foreign visitor visits until December 2024 is predicted in the following, where T stands for September 2023.

Table 7. GARCH (1,1) Forecasting

Periode	Series (%)	Sigma (%)
T+1	1.15E+01	82.93
T+2	-2.13E+00	86.88
T+3	3.92E-01	90.53
T+4	-7.24E-02	93.91
T+5	1.34E-02	97.05
T+6	-2.47E-03	99.98
T+7	4.55E-04	102.72
T+8	-8.40E-05	105.3
T+9	1.55E-05	107.72
T+10	-2.86E-06	110
T+11	5.28E-07	112.16
T+12	-9.75E-08	114.19
T+13	1.80E-08	116.12
T+14	-3.32E-09	117.95
T+15	6.13E-10	119.68

Source: BPS, processed

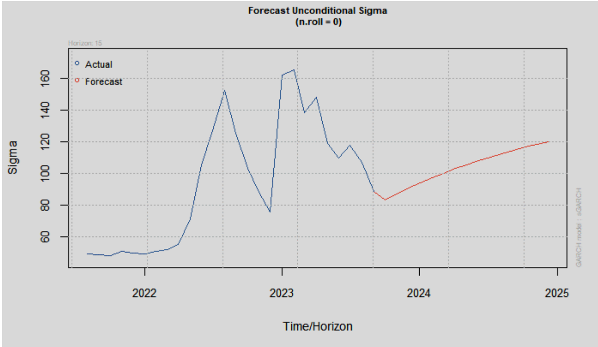

Figure 4. Plot of Forecasting Results of the Number of Foreign Tourist Visits to the End December 2024

Source: BPS, processed

It is evident from the predicting findings that Sigma, or the square root of conditional variance, keeps rising with time. This suggests that, until the end of December 2024, there will be an anticipated rise in volatility in the number of international visitor visits. Naturally, this is consistent with the anticipated rise in volatility in the value of the rupiah relative to the US dollar. An increase in the Sigma value indicates a rise in the number of international visitor visits. The growth was 4.76% in the first and second projections, 4.20% in the next forecast, and still declining in the last forecast. Numerous variables, including the Consumer Price Index (CPI), political stability and security, and income per capita, are to blame for this. This suggests that in order to meet the growing number of international visitors, the regional government, tourism industry players, and other stakeholders must keep raising the standard of travel to Indonesia. In addition, the study's scope is constrained by the other factors that affect the quantity of foreign tourist visits. As a result, future research must look into additional factors like the Consumer Price Index (CPI), income per capita, political stability and security, and so forth. One can locate the ideal model.

Correlation testing just shows how closely these two variables are related; more research is required to determine the precise link between the rupiah exchange rate relative to the US dollar and the number of international visitors. The relationship and fluctuations between the number of tourist visits and the Rupiah exchange rate have important ramifications for business and economic planning. First, the connection can shed light on how changes in the Rupiah exchange rate effect the manufacturing sector, which is important information to know when assessing how the state of the economy affects the manufacturing sector. Secondly, developing more conscientious commercial plans may be aided by comprehending correlation and volatility. Third, correlation may help with decision-making by pointing to possible economic instability and acting as an indication of the state of the economy. This research offers a more complete picture of the nation's economic situation in addition to aiding in the prediction of the manufacturing sector's performance. It is envisaged that by understanding a more definite link between these two factors, Indonesia would be able to use the global travel industry as one of its primary sources of foreign money in the future, hence optimizing control over the value of the rupiah.

Modeling of the Rupiah Exchange Rate Volatility

Plotting the rupiah exchange rate against the US dollar and its changes in value (the difference from the previous value) over time is required to determine the state of the data. Figures 5 and 6 below show the state of the rupiah exchange rate data relative to the US dollar.

Figure 5. Rupiah exchange rate against US dollars over time (daily)
Source: Investing Website, processed

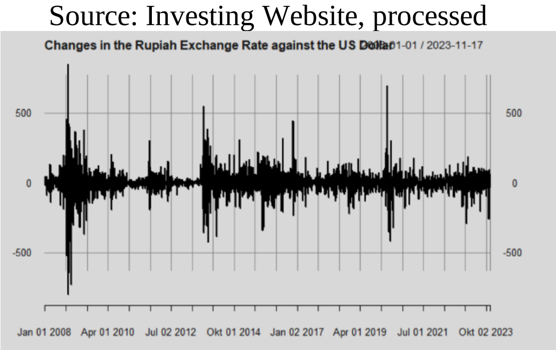

Figure 6. Changes in the rupiah exchange rate over time (daily)
Source: Investing Website, processed

This graph illustrates how unstable the rupiah exchange rate is and how it has been trending upward in recent years. The data on the rupiah exchange rate is variable due to fluctuations in the value of the currency relative to the US dollar. GARCH is a time series model that could be appropriate given the high volatility of the rupiah exchange rate.

To ascertain if GARCH is an appropriate technique for simulating the volatility of the rupiah exchange rate versus the US dollar, a number of conditions must be satisfied before beginning GARCH modeling. Because of this, the ADF (Augmented Dickey-Fuller) Test was used to determine whether or not the data on the rupiah's exchange rate versus the US dollar was stationary. The p-value and the outcomes of the computed statistics are shown below.

Table 8. ADF test at level

lag	*Type 1: no drift no trend*		*Type 2: with drift no trend*		*Type 3: with drift and trend*	
	ADF	*p-value*	ADF	*p-value*	ADF	*p-value*
0	1.46	0.963	1.13	0.99	2.5	0.99
1	1.68	0.977	1.27	0.99	2.78	0.99
2	1.68	0.977	1.27	0.99	2.79	0.99
3	1.62	0.975	1.24	0.99	2.71	0.99
4	1.58	0.972	1.24	0.99	2.66	0.99
5	1.46	0.963	1.14	0.99	2.47	0.99
6	1.49	0.965	1.16	0.99	2.51	0.99
7	1.42	0.96	1.1	0.99	2.4	0.99
8	1.35	0.955	1.03	0.99	2.27	0.99
9	1.33	0.954	1.02	0.99	2.24	0.99

Source: Investing Website, processed

Table 9. ADF test on first difference

lag	*Type 1: no drift no trend*		*Type 2: with drift no trend*		*Type 3: with drift and trend*	
	ADF	*p-value*	ADF	*p-value*	ADF	*p-value*
0	74.4	0.99	74.4	0.99	74.4	0.99
1	104.5	0.99	104.6	0.99	104.5	0.99
2	126.2	0.99	126.3	0.99	126.3	0.99
3	144.1	0.99	144.3	0.99	144.3	0.99
4	157.3	0.99	157.5	0.99	157.5	0.99
5	170.5	0.99	170.7	0.99	170.7	0.99
6	181.4	0.99	181.7	0.99	181.7	0.99
7	190.6	0.99	191	0.99	190.9	0.99
8	199.4	0.99	199.8	0.99	199.8	0.99

9	208	0.99	208.5	0.99	208.5	0.99

Source: Investing Website, processed

Table 10. ADF test on second difference

lag	*Type 1: no drift no trend*		*Type 2: with drift no trend*		*Type 3: with drift and trend*	
	ADF	*p-value*	ADF	*p-value*	ADF	*p-value*
0	74.4	0.99	123	0.99	123	0.99
1	104.5	0.99	206	0.99	206	0.99
2	126.2	0.99	288	0.99	288	0.99
3	144.1	0.99	387	0.99	387	0.99
4	157.3	0.99	470	0.99	470	0.99
5	170.5	0.99	573	0.99	573	0.99
6	181.4	0.99	684	0.99	684	0.99
7	190.6	0.99	790	0.99	790	0.99
8	199.4	0.99	893	0.99	893	0.99
9	208	0.99	1010	0.99	1009	0.99

Source: Investing Website, processed

The test findings demonstrate that the p-value obtained is greaterter than the significance level of 5%, indicating that the US dollar to rupiah exchange rate is not stationary at the first or second difference levels. The idea that GARCH is a viable model is further reinforced by the non-stationary data on the exchange rate of the rupiah against the US dollar.

To determine whether or not there is an ARCH impact on the model residuals, the Ljung-Box Test must be performed next. Based on the test findings, the p-value was $2,2 \times 10^{-16}$ much less than the significance level of 5%. This indicates that the residual model has an ARCH effect, indicating that either GARCH or ARCH is appropriate for modeling the study data. The X-squared value was 1913.2. However, because GARCH can mimic more complicated volatility, it is chosen in the modeling process.

The following are several candidate ARIMA models that will be used in GARCH average modeling.

Table 11. ARIMA Model Candidates

Model	AIC	Model	AIC
ARIMA(2,1,2) with drift	47391.58	ARIMA(3,1,2) with drift	47387.91
ARIMA(0,1,0) with drift	47494.67	ARIMA(3,1,4) with drift	47376.43
ARIMA(1,1,0) with drift	47409.88	ARIMA(4,1,4) with drift	47369.48
ARIMA(0,1,1) with drift	47411.05	ARIMA(4,1,3) with drift	47389.58
ARIMA(0,1,0)	47494.29	ARIMA(5,1,4) with drift	47368.53
ARIMA(1,1,2) with drift	47390.63	ARIMA(5,1,3) with drift	47368.42
ARIMA(0,1,2) with drift	47409.89	ARIMA(5,1,2) with drift	47383.9
ARIMA(1,1,1) with drift	47411.86	ARIMA(4,1,2) with drift	47390.8
ARIMA(1,1,3) with drift	47391.03	ARIMA(5,1,3)	47367.68
ARIMA(0,1,3) with drift	47406.81	ARIMA(4,1,3)	47388.87
ARIMA(2,1,1) with drift	Inf	ARIMA(5,1,2)	47383.18
ARIMA(2,1,3) with drift	47385.19	ARIMA(5,1,4)	47367.78
ARIMA(3,1,3) with drift	47388.01	ARIMA(4,1,2)	47390.04
ARIMA(2,1,4) with drift	47387.19	ARIMA(4,1,4)	47368.8
ARIMA(1,1,4) with drift	47392.49		

Source: Investing Website, processed

The ARIMA (5, 1, 3) model has the lowest AIC value, making it the best model. Subsequent practice revealed that several of the regression coefficients obtained were not significant, necessitating the development of a more appropriate model that took into account factors other than AIC. The average GARCH modeling used in this study is the ARIMA (3, 1, 1) model, as the regression coefficient it produces is significant and its AIC is not significantly different from ARIMA (5, 1, 3).

Table 12. ARIMA Model (3,1,1)

Coefficient	*Estimate*	*Std. Error*	*z value*	Pr(>|z|)
ar1	0.671	0.052	12.952	2.20E-16
ar2	0.122	0.020	6.208	5.38E-10
ar3	0.046	0.016	2.802	0.005075
ma1	-0.821	0.050	-16.466	2.20E-16

Source: Investing Website, processed

The following are several considerations from GARCH candidates that can be applied to research:

Table 13. GARCH Candidates

Model	AIC	SBC
GARCH(1,1)	10.688	10.705
GARCH(1,2)	10.681	10.699
GARCH(2,1)	10.689	10.707

Source: Investing Website, processed

GARCH is the best model, according to AIC and SBC (1, 2). On closer inspection, though, it becomes clear that there is very little difference in AIC and SBC between GARCH (1, 1) and GARCH (1, 2). For parsimonious criteria, GARCH (1, 1) is therefore favored as a model in the study. The coefficient estimate for the constructed GARCH (1, 1) model up to the p-value is as follows:

Table 14. GARCH (1, 1) Model

Coefficient	*Estimate*	*Std. Error*	*z value*	Pr(>|z|)
ar1	0.9599	0.0027	3.51E+02	0
ar2	0.0311	0.0185	1.68E+00	0.092674
ar3	0.0089	0.0179	4.96E-01	0.619801
ma1	-0.9965	0.0000	-7.64E+04	0
omega	42.3252	9.7884	4.32E+00	0.000015
alpha1	0.1426	0.0122	1.17E+01	0
beta1	0.8564	0.0130	6.57E+01	0

Source: Investing Website, processed

It is evident that a non-significant coefficient exists. But negligible coefficients were also discovered in other contenders, leading to the continued use of GARCH (1, 1) as the study model. The resulting GARCH (1, 1) equation looks like this:

$$\sigma_t^2 = 42{,}325178 + 0{,}142579\epsilon_{t-1}^2 + 0{,}85642\sigma_{t-1}^2$$

Plotting the conditional variance as a square root versus the time series may be done using equation (8).

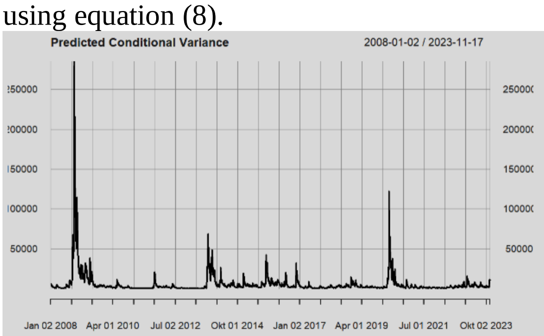

Figure 7. Conditional Variance Plot

Source: Investing Website, processed

The term "predicted conditional variance" describes how volatile the rupiah will be in relation to the US dollar during a certain time period, based on past data.

The exchange rate volatility of the rupiah vs. the US dollar through the end of December 2024 is predicted below, with T standing for November 17, 2023.

Table 15. GARCH (1, 1) Forecasting

Periode	Series (%)	Sigma (%)
T+1	2.624	98.04
T+2	1.945	98.21
T+3	1.62	98.38
T+4	1.639	98.54
T+5	1.641	98.71
⋮	⋮	⋮
T+410	1.557	143.52

Source: Investing Website, processed

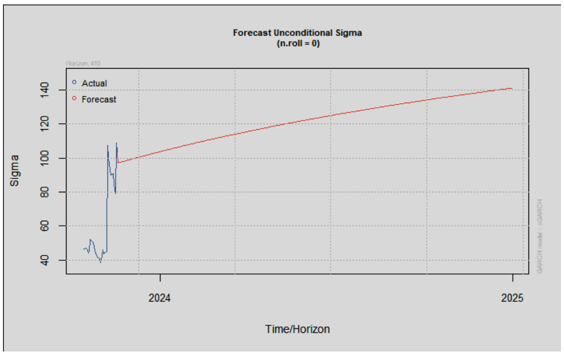

Figure 8. Plot of Rupiah Exchange Rate Forecasting Results until the end of December 2024

Source: Investing Website, processed

It is evident from the predicting findings that Sigma, or the square root of conditional variance, keeps rising with time. This suggests that there is more volatility in the rupiah exchange rate compared to the US dollar, which is to be expected until the end of December 2024. Given their strong positive link, it stands to reason that this will be correlated with the number of international visitors. In-depth topics about the quantity of foreign visitor visits will be covered in the next debate. In addition, in order to improve control over the volatility of the rupiah exchange rate in the future, more research must be done on the variables that influence its volatility and how they could evolve.

5. CONCLUSIONS

The study employed the Kendall Tau correlation test because, according to the results of the data normalcy test, the data on the exchange rate of the rupiah and the number of foreign tourist visits for the period January 2008 to September 2023, with a total of 189 observations and at a significance level of 0.05, were not normally distributed. The results of the Kolmogorov-Smirnov test also indicated that the data was heteroscedastic, meaning that heteroscedastic results were obtained in the model, which meant that the assumptions of the Pearson correlation test were not met. Drawing on the findings of the Granger Causality and Kendall Tau correlation tests, the findings demonstrated a correlation between the amount of international visitor visits and the rupiah exchange rate between January 2008 and September 2023.

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