Analysis of the Factors Affecting the Money Supply in Indonesia Using the Multiple Linear Regression Model

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Abstract
The money supply in Indonesia is a problem in the long-term economy and is influenced by many factors. This research was conducted with the aim of analyzing the effect of inflation, interest rates, and foreign exchange reserves on the money supply in Indonesia. This research uses multiple linear regression analysis method, and parameter estimation is done by using Ordinary Least Square (OLS) method. The analysis was carried out using secondary data, in the form of time series data from the Indonesian money supply, inflation rates, interest rates, and foreign exchange reserves. The data is obtained from Bank Indonesia (BI), the Central Bureau of Statistics (BPS) and other relevant sources. The results showed that the foreign exchange reserve, interest rate, and exchange rate variables simultaneously had a positive and significant effect on the money supply with probability values of 0.0048 and 0.0000. Meanwhile, the inflation rate variable does not have a significant effect on the money supply in Indonesia with a probability value of 0.0645.

Keywords
Money supply, inflation rate, foreign exchange reserves, interest rate, multiple linear regression, OLS method.

1. Introduction
In general, the money supply is considered to be directly determinable by the monetary authority without questioning the relationship with core money, which consists of currency plus reserves held by commercial banks. This behavior is based on the analysis of determining the money supply mechanically, where the money supply is linked to the core money via a multiplier. The amount of the multiplier is determined by banking reserves and the ratio between currency and demand deposits (Januaviani et al., 2019; 2020). The circulation of money in society can be influenced by several factors, including (1) high demand for money causes the flow of money to society to flow rapidly; (2) if the economy urgently needs more money in circulation to carry out trade transactions, the Central Bank will increase the amount of money circulating in the community by providing loans or credits; (3) government policies that regulate the rate of growth and circulation of money in a country. The main macroeconomic variables that are regulated by the monetary policy are inflation and unemployment (Shirvani & Bayram, 2013). The methods

that characterize monetary policy are setting interest rates, buying and selling government securities, and changing the amount of cash circulating in the market. The circulation of money is also influenced by factors of foreign exchange reserves, interest rates, and inflation rates. The behavior of the last three factors in influencing the circulation of money in Indonesia can be analyzed using multiple linear regression models (Chung & Ariff, 2016).

Research that discusses the factors that influence the circulation of money, was conducted by Martawijaya (2016), who examined various factors including net foreign assets, net claims on the central government, claims on institutions and state-owned enterprises, claims on private companies. and individuals who influence the money supply; trends in the factors affecting the money supply and their projections; and the correlation between the money supply, the interest rate, and the rate of inflation. The study analyzed secondary data from 1990-2000 from the Indonesian Financial Economic Statistics. The methods used are tabulation, trend, and regular linear regression. The results show that there is a positive correlation between the money supply, the interest rate, and the exchange rate. Meanwhile, the development of the factors affecting the money supply was relatively parallel, especially before mid-1997.

Saputra (2016) analyzes the effect of inflation, interest rates, and foreign exchange reserves on the money supply in Indonesia, which is analyzed is time-series data from January 2012 to July 2015, namely data on Indonesia's money supply, inflation rate, interest rate, and foreign exchange reserves. Data were obtained from Bank Indonesia (BI), the Central Bureau of Statistics/*Badan Pusat Statistik* (BPS), and other relevant sources. The method used is multiple linear regression analysis with the Ordinary Least Square (OLS) model. The results show that the foreign exchange reserves and interest rate variables together have a positive and significant effect on the money supply. Meanwhile, the inflation rate variable does not have a significant effect on the money supply in Indonesia.

Thus, this study intends to analyze the factors affecting the money supply in Indonesia. The factors analyzed include public money demand, loan amount, and the level of money circulation, and the analysis is carried out using multiple linear regression models. The aim is to determine the correlation between these factors and the amount of money circulating in Indonesia.

2. Materials and Methods

2.1 Materials

The data analyzed in this study include data on foreign exchange reserves, interest rates, and inflation rates as independent variables, as well as data on the money supply as dependent variables, where data is collected within a certain period from a sample. In this research, the data used are data from 1999 to 2019. The analysis was carried out using multiple linear regression models.

2.2 Methods

The discussion of methods in this section includes regression models, parameter estimation methods, and the goodness of fit test.

2.2.1 Regression Model

In this section the discussion of regression models includes simple linear regression and multiple linear regression in general.

Simple linear regression model

The simple linear regression model can actually be expressed as

$$Y = b_0 + b_1 X + e, \tag{1}$$

where Y is the dependent variable (regression), X is the independent variable (regressor), b_0 is the intercept parameter (constant), b_1 is the coefficient parameter (slope), and e is the residual. Equation (1) can be estimated as form

$$\hat{Y} = b_0 + b_1 X.$$

This equation is referred to as a simple regression estimator (Efron et al., 2004).

Multiple linear regression models in general
Multiple linear regression models can generally be expressed as

$$Y = b_0 + b_1X_1 + b_2X_2 + \cdots + b_kX_k + e, \tag{2}$$

where Y is the dependent variable (regression), $X_1, X_2, \dots, X_k$ is the independent variable (regressor), b_0 is the intercept parameter (constant), $b_1, b_2, \dots, b_k$ is the coefficient parameter (slope), and e is the residual. The multiple linear regression equation (2), has a stated estimator

$$\hat{Y} = b_0 + b_1X_1 + b_2X_2 + \cdots + b_kX_k. \tag{3}$$

Parameter estimation method
This section discusses the method of estimating the parameters of multiple linear regression in general using a matrix equation. The multiple linear regression equation (3) in a matrix can be expressed as

$$\mathbf{Y} = \mathbf{XB} + \mathbf{e}, \tag{4}$$

with

$$\mathbf{Y} = \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix}; \mathbf{X} = \begin{bmatrix} 1 & X_{12} & X_{13} & \cdots & X_{1k} \\ 1 & X_{22} & X_{23} & \cdots & X_{2k} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & X_{n2} & X_{n3} & \cdots & X_{nk} \end{bmatrix}; \mathbf{B} = \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{bmatrix}; \mathbf{e} = \begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_n \end{bmatrix},$$

where $\mathbf{Y}$ is a matrix $(n \times 1)$, $\mathbf{X}$ is a matrix $(n \times k)$, $\mathbf{B}$ is a matrix $(n \times 1)$, and $\mathbf{e}$ is a matrix $(n \times 1)$.

To determine the estimator value of the matrix $\mathbf{B}$ parameter, it is done by minimizing the number of squares of the residual, namely

$$\min \sum e_i^2 = \mathbf{e}^T\mathbf{e} = (\mathbf{Y} - \mathbf{XB})^T(\mathbf{Y} - \mathbf{XB}), \tag{5}$$

where $\mathbf{e}^T = (\mathbf{Y} - \mathbf{XB})^T$ is the transpose matrix of $\mathbf{e}$. Since $\mathbf{B}^T\mathbf{X}^T\mathbf{Y}$ is scalar, it equals the transpose, which is $\mathbf{Y}^T\mathbf{XB}$. For the minimization process, equation (5) is obtained as

$$\frac{\partial \sum e_i^2}{\partial \mathbf{B}} = -2\mathbf{X}^T\mathbf{Y} + 2\mathbf{X}^T\mathbf{XB} = 0. \tag{6}$$

From equation (6) the parameter estimator can be determined by

$$\mathbf{B} = (\mathbf{X}^T\mathbf{X})^{-1}\mathbf{X}^T\mathbf{Y}, \tag{7}$$

where $(\mathbf{X}^T\mathbf{X})^{-1}$ is inverse of $(\mathbf{X}^T\mathbf{X})$ (Lorchirachoonkul & Jitthavech, 2012; Vu et al., 2015).

The approach is used when $(\mathbf{X}^T\mathbf{X})$ has an inverse, but if there is multicollinearity, the inverse matrix calculation is incorrect.

Goodness of fit test
The goodness of fit test is used to ensure that the model is able to represent the actual appropriate data. The goodness of fit test of the parameter estimator is carried out using the individual significance test, simultaneous significance test, residual normality assumption test, and the coefficient of determination test.

Individual significance tests are used to test each $\beta_i (i = 0,1,2, \dots, k)$ parameter, where $\beta_i \in \{b_0, b_1, b_2, \dots, b_k\}$ is from equation (4), in influencing the dependent variable. To test the β_i parameter, the hypotheses were assigned as $H_0: \beta_i = 0$ and $H_1: \beta_i \neq 0$. Tests are carried out using t-statistic (t_{stat}), by equation

$$t_{stat} = \frac{\beta_i}{SE(\beta_i)}, \tag{8}$$

where $SE(\beta_i)$ is the standard error of parameter β_i.

Decision criteria: reject the hypothesis H_0 if $|t_{stat}| > \left|t_{\left(n-2,\frac{1}{2}\alpha\right)}\right|$ or $\Pr[t_{stat}] < \alpha$, where $t_{\left(n-2,\frac{1}{2}\alpha\right)}$ is the critical value of the t-distribution at the level of significance $100(1-\alpha)\%$ and n is the amount of data (Sukono et al., 2014; 2016; 2017).

Simultaneous significance test was used to test the $\beta_i (i = 0,1,2,\dots,k)$ parameter together, where $\beta_i \in \{b_0, b_1, b_2, \dots, b_k\}$ is from equation (4), in influencing the dependent variable. To test the β_i parameter, the hypotheses were assigned as $H_0: b_0 = b_1 = b_2 = \cdots = b_k = 0$ and $H_1: \exists b_0 \neq b_1 \neq b_2 \neq \cdots \neq b_k \neq 0$. Tests are carried out using F statistic (F_{stat}), by equation

$$F_{stat} = \frac{MS_{reg}}{MS_{error}}, \tag{9}$$

where MS_{reg} is mean square due to regression and MS_{error} is mean square due to residual variation.

Decision criteria: reject the hypothesis H_0 if $F_{stat} > F_{(1,n-2,1-\alpha)}$ or $\Pr[F_{stat}] < \alpha$, where $F_{(1,n-2,1-\alpha)}$ is the critical value of the F-distribution at the level of significance $100(1-\alpha)\%$ and n is the amount of data (Metropolis et al., 1953; Sukono et al., 2016).

The residual normality test was used to determine that the residual data spread normally. The normality test can be performed using the Kolmogorov-Smirnov (KS) statistic. The hypothesis is defined as H_0: data are normally distributed and H_1: data are not normally distributed. The test is carried out by determining the residual standard deviation based on the equation

$$S_{e_i} = \sqrt{\frac{\sum_{i=1}^{n}(e_i - \bar{e})^2}{n-1}}. \tag{10}$$

Transform the value of e_i into z_i by the equation $z_i = \frac{(e_i - \bar{e})}{S_{e_i}}$. The determination of the probability value $P(z_i)$ is carried out based on the standard normal distribution table. Meanwhile, the probability $S(z_i)$ is determined using the equation $S(z_i) = \frac{rand(z_i)}{n}$. Next, the absolute difference $|S(z_i) - P(z_i)|$ is calculated. Kolmogorov-Smirnov statistics (KS_{stat}) are determined using equations

$$KS_{stat} = \max\{|S(z_i) - P(z_i)|\}, \tag{11}$$

where $KS_{(\alpha,n-1)}$ is the critical value of the Kolmogorov-Smirnov statistics at the level of significance $\alpha = 0.05$. The test criteria are rejecting H_0 if $KS_{stat} > KS_{(\alpha,n-1)}$ (Alauddin & Nghiemb, 2019; Sukono et al., 2019.a; 2019.b).

The coefficient of determination (R^2) is used to measure how much diversity the independent variable has on the dependent variable, based on the level of strength of the relationship (Siniksaran, 2008). Therefore, the coefficient of determination is used to measure the ability or influence of the independent variable $X_i (i = 1,2,\dots,k)$ in influencing the dependent variable Y. The coefficient of determination (R^2) is determined using the equation

$$R^2 = \frac{\sum_{i=1}^{n}\left(\hat{Y}_i - \bar{Y}\right)^2}{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}. \tag{12}$$

The value of the coefficient of determination is between 0 and 1. A small determination value close to 0 means that the variation of the independent variable is very weak, and a value close to 1 means that the variation of the independent variable provides all the information needed to predict the dependent variable (Sidi et al., 2017).

3. Results and Discussion

3.1 Estimating the Regression Model

The approach used to analyze the relationship between variables in this study is in the form of economic theory, statistical theory, and econometric theory with more emphasis on the time series analysis model approach, the main variable to be used in this study is the amount of money in circulation (Y) as an independent variable, while the independent variables include foreign exchange reserves (X_1), Bank Indonesia certificate interest rates (X_2), inflation (X_3), and exchange rates (X_4).

The estimation of the coefficient parameters of the multiple linear regression model is carried out by referring to equation (7) and is carried out with the help of Minitab 19 software. The estimation results of the coefficient parameters, standard errors, t-statistics, and probability are presented in Table 1.

Table 1. Estimation Results of Multiple Linear Regression Model Parameters

Variables	Coefficient	Std. Error	t-Statistic	Probability
Constant (C)	-249308.69	2047301.69	-0.12177428	0.1217
Foreign exchange reserves (X_1)	25.534012	2.3627221	10.80703143	0.0048
Interest rates (X_2)	-8567.7971	987.87511	-8.672955734	0.0000
Inflation (X_3)	80139.162	189.76923	0.422297975	0.0645
Foreign exchange rates (X_4)	107.96988	42.57968	2.535713749	0.0000

3.2 Testing Significance of Regression Model

3.2.1 Individual significance testing

Tests were conducted to determine the relationship between the effects of each of the independent variables individually or separately on the related variables by referring to equation (8). Tests were carried out with the help of Minitab 19 software, and the results are presented in Table 1. Tests were carried out by taking the significance level $\alpha = 0.05$ and the degrees of freedom $df = 10 - 2 = 8$ so that from the standard Student (t) distribution table, t-statistic equal to -2.306004135. Taking into account the calculation results presented in Table 1, it can be explained as follows.

a. For Constant (C) is obtained $|-0.12177428| < |-2.306004135|$ with a probability of $0.1217 > 0.05$, so that the hypothesis H_0 is accepted. This means that the variable constant (C) does not significantly affect the money supply variable.
b. For the variable of foreign exchange reserve (X_1) is obtained $|10.80703143| > |-2.306004135|$ with a probability of $0.0048 < 0.05$, so that the hypothesis H_0 is rejected. This means that the variable of foreign exchange reserve (X_1) significantly affects the money supply variable.
c. For the variable of interest rate (X_2) is obtained $|-8.672955734| > |-2.306004135|$ with a probability of $0.0000 < 0.05$, so that the hypothesis H_0 is rejected. This means that the variable of interest rate (X_2) affects the money supply variable significantly.
d. For the variable of inflation rate (X_3) is obtained $|0.422297975| < |-2.306004135|$ with a probability of $0.0645 > 0.05$, so that the hypothesis H_0 is accepted. This means that the variable of inflation rate (X_3) does not significantly affect the money supply variable.
e. For the variable of foreign exchange rate (X_4) is obtained $|2.535713749| > |-2.306004135|$ with a probability of $0.0000 < 0.05$, so that the hypothesis H_0 is rejected. This means that the variable of foreign exchange rate (X_4) significantly affects the money supply variable.

3.2.2 Simultaneous significance testing

Simultaneous significance testing to test the effect of foreign exchange reserves (X_1), Bank Indonesia certificate interest rates (X_2), inflation (X_3), and exchange rates (X_4) against the money supply (Y). Testing was carried out by referring to equation (9) and carried out with the help of Minitab 19 software. The results obtained were the F-count equal to 84.70511, meanwhile for the significance level $\alpha = 0.05$ and the degrees of freedom $v_1 = 10 - 2 = 8$ and $v_2 = 4 - 1 = 3$, from the F-distribution table, the F-statistic value is obtained equal to 3.2001. It is clear that $84.705110 > 3.2001$, so the hypothesis H_0 is rejected. This means that the variable of foreign exchange reserves

(X_1), Bank Indonesia certificate interest rates (X_2), inflation (X_3), and exchange rates (X_4) simultaneously affect the money supply (Y).

3.2.3 Testing the residual normality assumption

The normality assumption test is used to test the validity that the residual data spreads normally. Normality test was carried out by referring to equations (10) and (11) and was carried out with the help of Minitab 19 software. The test results showed that the residuals spread normally or $\varepsilon \sim N(0.00032, 6.0725)$.

3.2.4 Coefficient of determination

Next is to measure the strength of the correlation between the predictor variable and the response variable, based on the magnitude of the statistical value R^2. The calculation R^2 is carried out by referring to equation (12), with the help of Minitab 19 software. The calculation results yield from $R^2 = 0.9081623$. This shows that the predictor variables: foreign exchange reserves (X_1), Bank Indonesia certificate interest rates (X_2), inflation (X_3), and exchange rates (X_4), have very strong correlations with the response variable to the money supply (Y). It also means that the predictor variables are 0.8987691 which can explain the response variable, and 0.1012309 is explained by other variables.

3.3 Discussion

Taking into account the results of the parameter estimation of the multiple linear regression model presented in Table 1, and also based on the results of the significance testing, several discussions can be carried out as follows.

The Effect of Foreign Exchange Reserve (X_1) on the Money Supply. In the Money Supply (Y), the first variable explains that the Foreign Exchange Reserve (X_1) is 25.534012. This means that the parameter sign for the Foreign Exchange Reserve (X_1) is positive and significant with a probability of 0.0048 and affects the Money Supply (Y). This means that if the Foreign Exchange Reserve ($X1$) appreciates by 1 rupiah, it will result in an increase in the volume of the Money Supply (Y) by 25.534012 billion rupiahs. This indicates that if the Foreign Exchange Reserve ($X1$) increases, it will affect imported goods and with an increase in the price of imported goods it will cause the money supply to increase to carry out these import transactions (Shirvani & Bayram, 2013).

The Effect of Interest Rate (X_2) on the Money Supply. In the Money Supply (Y), the second variable explains that the Interest Rate (X_2) is -8567.7971. This means that the parameter sign for Interest Rate (X_2) is negative and insignificant with a probability of 0.0000, and has no effect on the Money Supply (Y). This means that if the Interest Rate (X_2) increases by 1%, the Money Supply (Y) will decrease by -8567.7971 billion rupiahs. Thus, the Interest Rate (X_2) harms the Money Supply (Y), this effect is by the existing theory where the higher the Interest Rate (X_2) will reduce the level of money demand. Thus, one of the keys to the success of the bank in the future is to keep the Interest Rate (X_2) for credit low so that it can stimulate growth in the real sector, especially investment credit and working capital, which means that the demand for money in the community increases. This means that when Bank Indonesia raises the BI rate, banks must try not to increase their credit interest rate (X_2). It would be better if banks continue to lower credit interest rates so that people can have more money to make transactions or invest (Chung & Ariff, 2016).

The Effect of the Foreign Exchange Rate (X_4) on the Money Supply. In the Money Supply (Y), the fourth variable explains that the Foreign Exchange Rate (X_4) is 107.96988. This means that the parameter sign for the Foreign Exchange Rate (X_4) is positive and significant with a probability of 0.000 and affects the Money Supply (Y). This means that if the Foreign Exchange Rate (X_4), for example, the dollar appreciates by 1 rupiah, it will result in an increase in the volume of the Money Supply (Y) by 107.96988 billion rupiahs. This indicates that if the Foreign Exchange Rate (X_4), for example, the dollar increases, it will affect imported goods and with an increase in the price of imported goods, the money supply will increase to carry out these import transactions. The exchange rate of a currency is defined as the relative price of one currency against another. Although the ultimate goal of monetary policy is to focus more on controlling the inflation rate, Bank Indonesia will not allow developments in the rupiah exchange rate on the market to fluctuate. Bank Indonesia took steps to stabilize the rupiah exchange rate with two main considerations, namely (1) the stability of the rupiah exchange rate is needed to provide certainty in the economy, and (2) the fluctuating rupiah exchange rate and a drastic decline will make it difficult for Bank Indonesia to achieve its target. set inflation (Martawijaya, 2016).

4. Conclusion

This study is intended to examine the influence of the foreign exchange reserves (X_1), Bank Indonesia certificate interest rates (X_2), inflation (X_3), and exchange rates (X_4), which have a very strong correlation with the money supply response variable (Y), that occurred in Indonesia in the period 1999 to 2019, using multiple linear regression models, and parameter estimation was carried out using the Ordinary Least Squares (OLS) method. Based on the results of the data analysis that has been carried out, the following conclusions can be drawn. First, the foreign exchange reserves (X_1) has a positive and significant effect on the money supply in Indonesia with a coefficient value of 25.534012, which means that if GDP increases by 1 rupiah, the money supply increases by 25.534012 rupiahs. Second, the interest rate (X_2) by Bank Indonesia Certificates/*Sertifikat Bank Indonesia* (SBI) has a negative and significant effect on the money supply in Indonesia. The SBI elasticity coefficient of -8567.7971 shows that if the SBI is increased by 1%, the money supply will decrease by -8567.7971 rupiah. Third, the foreign exchange rate (X_4) has a positive impact on the money supply in Indonesia. The value of the foreign exchange rate (X_4) elasticity coefficient is 107.96988, which means that if the rupiah exchange rate increases it will increase the circulating amount of 107.96988 rupiahs.

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