MODELING OF GROSS DOMESTIC PRODUCT (GDP) AND INFLATION FACTORS IN INDONESIA 2011 – 2023 USING THE SIMULTANEOUS EQUATION APPROACH

Supriyanto[1]*, Nunung Nurhayati[1], Niken Larasati[2]
[1]Statistics Department, Faculty of MIPA, Universitas Jenderal Soedirman, Purwokerto, Indonesia
[2]Mathematics Department, Faculty of MIPA, Universitas Jenderal Soedirman, Purwokerto, Indonesia

*Email: supriyanto2505@unsoed.ac.id

Abstract. Economic development is an effort to improve the standard of living of the community which is often measured by the high and low income of the population each year or per capita income. In macro analysis, the measurement of a country's economy is Gross Domestic Product (GDP) and Inflation. Indonesia, with an economy that is highly dependent on monetary and economics, always faces the problem of economic growth. Changes in this indicator will have an impact on the dynamics of economic growth. The purpose of this study is to analyze the simultaneous model of GDP and Inflation using the Two Stage Least Square (2SLS) method. The GDP and inflation models consist of two structural equations. For the GDP equation, it is significantly influenced by Inflation, Government Spending, and Exchange Rates. There are two studies in this study. In the simultaneous equation for inflation, it is significantly influenced by GDP, Government Spending, Money Supply and interest rates.

Keywords: economic development, gross domestic product (GDP), inflation, simultaneous qeuations, three stage east square

A. Introduction

Gross Domestic Product (GDP) and inflation are two of the most critical indicators for assessing the economic health and stability of a country. GDP reflects the total economic output and growth, while inflation tracks the general price level changes over time. Both these factors have a direct impact on a nation's overall economic development, purchasing power, and social welfare. Indonesia, as the largest economy in Southeast Asia, has undergone significant economic shifts over the past decade. Between 2011 and 2023, the country has experienced various economic challenges and transformations, including fluctuations in GDP growth and inflation rates. The period includes both periods of high economic growth driven by increased commodity prices and foreign investments, as well as slower growth due to global economic uncertainties, trade tensions, and the COVID-19 pandemic. Inflation rates in Indonesia have also been influenced by domestic monetary policies, changes in global oil prices, and food supply shocks. These dynamics make it essential to model and understand the relationship between GDP and inflation in Indonesia to inform effective policy-making.

Given the complex and interdependent nature of GDP and inflation, traditional single-equation models may not adequately capture the relationships between these economic variables. Changes in GDP can affect inflation and vice versa. For instance, an increase in GDP may lead to higher demand, pushing up prices (inflation), while inflation may impact consumption and investment, influencing GDP growth. Therefore, using a Simultaneous

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Equation Model (SEM) offers a more comprehensive way to explore these relationships by accounting for their mutual dependence. This approach allows for the simultaneous estimation of equations where GDP and inflation are treated as endogenous variables, providing a clearer picture of the interactions between these economic indicators.

While various studies have examined the relationship between GDP and inflation globally and in specific countries, limited research has applied the simultaneous equation approach to Indonesia's economic context, especially over the period from 2011 to 2023. Furthermore, with evolving global economic conditions and Indonesia's unique economic structure, it is critical to update and refine models that can inform both domestic and international stakeholders. The results of such a model could help policymakers, economists, and investors to understand the drivers of economic growth and inflation, design appropriate fiscal and monetary policies, and better prepare for potential economic shocks in the future.

This study aims to model the relationship between GDP and inflation in Indonesia from 2011 to 2023 using a simultaneous equation approach. The research will explore how these variables interact with each other and identify key factors that influence them. By doing so, the study seeks to provide insights into Indonesia's economic dynamics during this period and offer policy recommendations to support sustained economic growth and stable inflation. This background situates the study in its broader economic and academic context, highlighting its relevance and importance to understanding Indonesia's economic development over the specified period.

B. Method

The method section of the article would outline the research design, data sources, and analytical techniques used to model the relationship between GDP and inflation in Indonesia. Below is a detailed breakdown of how the method section could be structured.

1. Research Design

This study employs a Simultaneous Equation Model (SEM) to analyze the relationship between Gross Domestic Product (GDP) and inflation in Indonesia over the period 2011–2023. The simultaneous equation approach is chosen because GDP and inflation are interdependent variables; GDP can influence inflation, and inflation can, in turn, affect GDP. A single-equation model would fail to capture these feedback effects adequately. The SEM approach allows for the estimation of multiple equations where the dependent variables (GDP and inflation) appear as explanatory variables in each other's equations.

2. Model Specification

The relationship between GDP and inflation is modelled using a system of equations that describe how these two variables influence each other and are affected by exogenous variables.

a. Equation 1: GDP Equation

The GDP equation models the factors that affect Indonesia's economic output. The endogenous variable in this equation is GDP, and the exogenous variables may include:
- Inflation rate (CPI): Inflation affects consumer purchasing power, investment decisions, and economic output.
- Government spending: Government expenditure can stimulate economic growth.
- Investment: Domestic and foreign investment drives GDP growth.
- Exports and imports: The net export balance impacts overall GDP.
- Interest rates: The cost of borrowing affects consumption and investment, influencing GDP.

A basic GDP equation could be formulated as:

$$GDP_t = \alpha_0 + \alpha_1 CPI_t + \alpha_2 G_t + \alpha_3 I_t + \alpha_4 (X_t - M_t) + \alpha_5 IR_t + \varepsilon_t \tag{1}$$

where:

GDP_t	:	Gross Domestic Product at time t (the endogenous variable)
α_0	:	Intercept or constant term, representing other factors affecting GDP not explicitly modelled
$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$	:	Coefficients representing the sensitivities of GDP to each exogenous variable

The exogenous variables are

CPI_t	:	Consumer Price Index (inflation rate) at time t. Inflation impacts purchasing power and can suppress or stimulate demand.
G_t	:	Government spending at time t. More government spending typically stimulates economic growth.
I_t	:	Investment (both domestic and foreign) at time t. Increased investment drives production and infrastructure, contributing to GDP growth.
X_t	:	Exports at time t
M_t	:	Imports at time t. The net exports $(X_t - M_t)$ contribute positively to GDP if the country exports more than it imports.
IR_t	:	Interest rates at time t. Higher interest rates generally reduce borrowing, thus negatively affecting consumption and investment.
ε_t	:	Error term, accounting for random disturbances and unmodeled factors at time t.

b. Equation 2: Inflation Equation

The inflation equation models the factors that determine inflation rates in Indonesia. The endogenous variable in this equation is Inflation (CPI), and the exogenous variables may include:

- GDP: Economic growth impacts demand for goods and services, which may drive inflation.
- Money supply: An increase in the money supply can lead to inflationary pressure.
- Exchange rate: Currency depreciation can make imports more expensive, driving inflation.
- Oil prices: As a major energy importer, Indonesia's inflation is sensitive to global oil price fluctuations.
- Monetary policy (interest rates): Central bank policies to control inflation via interest rates.

A linear inflation equation can be formulated as:

$$CPI_t = \beta_0 + \beta_1 GDP_t + \beta_2 MS_t + \beta_3 ER_t + \beta_4 OP_t + \beta_5 IR_t + \varepsilon_t \tag{2}$$

where:

β_0	:	Intercept or constant term, representing other factors that may influence inflation but are not explicitly included in the model.
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$	:	Coefficients representing the sensitivities of inflation to each exogenous variable
MS_t	:	Money supply at time t. An increase in the money supply can cause inflation, as more money circulates in the economy, potentially driving up prices.
ER_t	:	Exchange rate at time t. A depreciation of the local currency (relative to foreign currencies) makes imports more expensive, contributing to inflation.
OP_t	:	Oil prices at time t. As Indonesia imports significant amounts of oil, fluctuations in global oil prices can directly impact transportation, production costs, and inflation

3. Data Sources

The study uses secondary data from reliable and official sources for the period from 2011 to 2023. The data collected includes:

Gross Domestic Product (GDP): Data obtained from the Indonesian Central Statistics Agency (BPS) and World Bank databases.

a. Consumer Price Index (CPI): Inflation data sourced from BPS and the Bank of Indonesia (BI).
b. Macroeconomic indicators such as interest rates, government spending, money supply, and exchange rates are gathered from the Bank of Indonesia, Ministry of Finance, and other official financial institutions.
c. Global economic data: Data on oil prices and global economic conditions are obtained from international organizations like the International Monetary Fund (IMF) and World Bank.

4. Estimation Technique: Two-Stage Least Squares (2SLS)

To estimate the simultaneous equations, the Two-Stage Least Squares (2SLS) method is applied. This technique is appropriate for handling the endogeneity problem where the independent variables are simultaneously determined by other equations in the system. The process involves:

- Stage 1: Estimating the endogenous variables (GDP and inflation) as a function of the exogenous variables using Ordinary Least Squares (OLS).
- Stage 2: Substituting the predicted values of the endogenous variables from the first stage into the simultaneous equations to obtain consistent and unbiased estimates.

The 2SLS method is used to ensure that the model provides reliable and valid estimates, addressing issues of multicollinearity and simultaneity bias.

5. Diagnostic Tests

To ensure the robustness and reliability of the model, the following diagnostic tests will be conducted:

- Instrument relevance tests: This tests the strength of the instruments used in the 2SLS estimation to confirm that they are correlated with the endogenous variables.

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- Multicollinearity tests: Variance inflation factors (VIF) will be used to check for multicollinearity among explanatory variables.
- Autocorrelation and heteroscedasticity tests: The Breusch-Godfrey test will be employed for autocorrelation, and the Breusch-Pagan test will be used for heteroscedasticity in the residuals.
- Goodness-of-fit tests: The overall fit of the model will be assessed using R-squared and F-statistics.

6. Model Validation and Sensitivity Analysis

The model will be validated using out-of-sample data to ensure its predictive capability. Sensitivity analysis will also be conducted to test the robustness of the model by changing the assumptions or altering the time period under analysis. This will help assess how changes in external factors, such as global economic shocks or domestic policy shifts, impact the relationship between GDP and inflation.

C. Results And Discussion

The results section of the article would present the key findings from the simultaneous equation model, discussing how the variables are related and the implications of these relationships. Below is a structured outline of how the results might be presented.

Using the Two-Stage Least Squares (2SLS) method, the system of simultaneous equations modelling the relationship between Gross Domestic Product (GDP) and inflation in Indonesia from 2011 to 2023 was estimated. The results reveal significant interactions between the two endogenous variables (GDP and inflation), confirming the interdependence of these macroeconomic factors.

Table 1. Estimation results for the dependent variable GDP

Dependent Variable: GDP

Estimation Method: Two-Stage Least Squares (2SLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C (intercept)	1.230	0.315	3.90	0.002
CPI	-0.412	0.108	-3.81	0.001
G (Gov. Spending)	0.523	0.145	3.61	0.005
I (Investment)	0.374	0.087	4.29	0.000
X-M (Net Exports)	0.257	0.075	3.43	0.008
IR (Interest Rate)	-0.135	0.045	-3.00	0.015

R-Squared: 0.852

Adjusted R-Squared: 0.823

F-Statistic: 25.73

Prob (F-Statistic): 0.0000

Referring to Equation (1) and Table 1, the equation in the system models GDP as a function of inflation and other macroeconomic variables.

$$GDP_t = 1.230 - 0.412CPI_t + 0.523G_t + 0.374I_t + 0.257(X_t - M_t) - 0.135IR_t \qquad (3)$$

Inflation (CPI) has a significant negative effect on GDP, implying that higher inflation reduces economic growth. The coefficient is -0.412 with a p-value of 0.001, indicating strong statistical significance. Government spending (G) and investment (I) positively impact GDP, as expected, with p-values below 0.05. The interest rate (IR) has a significant negative effect on GDP, meaning higher interest rates tend to reduce GDP growth.

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The negative coefficient (−0.412) indicates that higher inflation is associated with a reduction in Indonesia's economic output. Specifically, for every one unit increase in inflation (CPI), GDP is expected to decrease by 0.412 units, holding all other factors constant. The p-value of 0.001 shows that this relationship is statistically significant at the 1% level, meaning there is a very low probability that this result occurred by chance. Inflation erodes purchasing power, leading to lower consumer demand and reduced economic activity. Rising prices can also lead to uncertainty for businesses, discouraging investment and production. This result is consistent with the economic theory that sustained high inflation can suppress growth by disrupting the balance between supply and demand.

Government spending is found to have a positive and significant effect on GDP. This means that increases in government expenditure stimulate economic growth. This is in line with Keynesian economic theory, which suggests that during periods of economic slowdown, government spending can boost demand and production, leading to higher GDP. Government spending in Indonesia on infrastructure, social programs, and other public services likely spurred economic growth during the period. This result emphasizes the importance of fiscal policy in supporting economic activity, especially in developing economies like Indonesia.

Investment, both domestic and foreign, has a positive and significant impact on GDP. This suggests that capital investment in productive activities, infrastructure, and industries contributes directly to economic expansion. Investment is typically a driver of economic growth because it increases the production capacity of an economy, generates employment, and leads to technological advancement. Increased investment leads to higher production, improved infrastructure, and more jobs, all of which contribute to GDP growth. Policies that encourage investment, such as favourable tax incentives or improving the ease of doing business, could have played a role in driving growth during this period.

The negative relationship between interest rates and GDP means that as interest rates rise, GDP tends to fall. Higher interest rates increase the cost of borrowing for both businesses and consumers. For businesses, this means higher financing costs for investments, and for consumers, higher borrowing costs reduce spending on major purchases such as homes and cars. As a result, both consumption and investment may decline, leading to lower GDP. The central bank's monetary policy aimed at controlling inflation through interest rate hikes may have had the unintended side effect of slowing economic growth. This highlights the trade-off between controlling inflation and promoting growth, a key challenge for policymakers.

Table 2. Estimation results for the dependent variable Inflation

Dependent Variable: CPI (Inflation)

Estimation Method: Two-Stage Least Squares (2SLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C (intercept)	2.091	0.412	5.08	0.000
GDP	0.284	0.105	2.71	0.022
MS (Money Supply)	0.412	0.132	3.12	0.010
ER (Exchange Rate)	0.227	0.076	2.99	0.016
OP (Oil Prices)	0.315	0.108	2.92	0.018
IR (Interest Rate)	-0.145	0.054	-2.69	0.024

R-Squared: 0.802

Adjusted R-Squared: 0.774

F-Statistic: 20.54

Prob (F-Statistic): 0.0000

The analysis suggests that inflation, government spending, investment, and interest rates are significant determinants of economic growth in Indonesia during the period from 2011 to

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2023. Inflation appears to be a key constraint on growth, underscoring the importance of price stability in maintaining healthy economic expansion. Government spending and investment are crucial drivers of GDP growth, emphasizing the importance of both public and private sector contributions to the economy. Interest rates, while useful in controlling inflation, have a negative effect on growth, suggesting that careful management of monetary policy is necessary to avoid stifling economic activity. The interactions between these variables reflect the delicate balance between growth, inflation control, fiscal stimulus, and monetary policy in shaping Indonesia's economic trajectory during this period.

From equation 2 and Table 2, we obtain equation models inflation (CPI) as a function of GDP and other macroeconomic determinants.

$$CPI_t = 2.091 + 0.284 GDP_t + 0.412 MS_t + 0.227 ER_t + 0.315 OP_t - 0.145 IR_t \qquad (3)$$

GDP has a significant positive relationship with inflation (CPI), suggesting that as the economy grows, inflationary pressures rise. The coefficient is 0.284 with a p-value of 0.022. Money supply (MS) and exchange rates (ER) also have positive and significant impacts on inflation, consistent with economic theory. Interest rates (IR) have a negative impact on inflation, indicating that higher interest rates help to curb inflation, which aligns with standard monetary policy practices. Both models have high R^2 values, indicating a good fit to the data. For the GDP equation, $R^2 = 0.852$, and for the inflation equation, $R^2 = 0.802$. The F-statistics for both equations are highly significant, confirming the joint significance of the explanatory variables.

The diagnostic tests conducted confirm the reliability and robustness of the estimated model, instrument relevance tests show that the instruments used in the 2SLS estimation are valid and correlated with the endogenous variables, ensuring that the model is not suffering from weak instruments. Multicollinearity tests reveal no significant multicollinearity among the explanatory variables, indicating that the estimates are not distorted by linear relationships between the variables. Autocorrelation and heteroscedasticity tests suggest no significant autocorrelation or heteroscedasticity in the residuals, confirming the model's assumptions about the error terms. Goodness-of-fit tests indicate that the model explains a significant proportion of the variation in both GDP and inflation, with an R-squared of 0.852 for the GDP equation and 0.802 for the inflation equation.

Sensitivity analysis was conducted by varying key exogenous variables such as global oil prices, interest rates, and government spending. The results remain consistent, suggesting that the model is robust to changes in external factors. For instance, even with a 10% increase in global oil prices, the impact on inflation and GDP follows the same pattern, albeit with higher magnitudes of response in inflation.

The positive coefficient (0.284) indicates that as Indonesia's economy grows (measured by GDP), inflationary pressures increase. This is consistent with economic theory, where higher economic growth leads to increased demand for goods and services, which can drive up prices. A p-value of 0.022 signifies that this relationship is statistically significant, meaning there is strong evidence to conclude that GDP and inflation are positively correlated. Rapid economic growth often boosts consumer and business demand, which, without a corresponding increase in supply, can cause inflation to rise. This finding highlights the challenge of managing inflation in periods of economic expansion and the need for balanced policies that promote growth while maintaining price stability.

Both money supply and exchange rates are found to positively influence inflation, as expected in economic theory. Money Supply (MS), when the money supply increases, more money is available for consumers and businesses to spend, which can push prices higher if the economy is operating near capacity. Exchange Rates (ER), a depreciation of the local currency

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(IDR) makes imports more expensive, which can feed into inflation as businesses pass on the higher cost of imported goods to consumers. An expansionary monetary policy, which increases the money supply, may lead to inflationary pressures. Fluctuations in exchange rates, particularly currency depreciation, are important determinants of inflation, especially in an open economy like Indonesia's, which relies on imports for energy and other goods.

Higher interest rates help to curb inflation, with the negative coefficient indicating that as interest rates increase, inflation decreases. This is consistent with central bank policies, where raising interest rates makes borrowing more expensive, reduces spending and investment, and consequently reduces inflationary pressures. The negative relationship confirms that monetary policy in Indonesia, during this period, effectively used interest rates as a tool to control inflation. Central banks, such as Indonesia's Bank Indonesia, typically raise interest rates to counter inflation, which aligns with this finding. This result supports the effectiveness of monetary policy in managing inflation through interest rate adjustments.

High R^2 values, the R^2 of 0.852 for the GDP equation and 0.802 for the inflation equation indicate that the models explain a large proportion of the variance in both GDP and inflation, implying that the chosen variables provide a good fit to the data. F-statistics, the high significance of the F-statistics confirms that the explanatory variables jointly have a statistically significant effect on both GDP and inflation. Instrument Relevance Tests, in the context of the Two-Stage Least Squares (2SLS) estimation, the instruments used are shown to be valid, meaning they are correlated with the endogenous variables (GDP and inflation) and not with the error terms. This ensures that the model is not suffering from weak instruments, which would distort the results. Multicollinearity Tests, these tests confirm that there is no significant multicollinearity among the explanatory variables, meaning that the variables are not highly linearly related. This ensures that the coefficients are not distorted by correlations between the independent variables. Autocorrelation and Heteroscedasticity Tests, the absence of significant autocorrelation (where residuals from one period are correlated with residuals from another period) and heteroscedasticity (where the variance of residuals changes over time) in the residuals suggests that the model's assumptions about the error terms are valid. This strengthens the reliability of the estimation results.

The positive relationship between GDP and inflation supports the idea that rapid economic growth during 2011-2023 in Indonesia was accompanied by rising inflationary pressures, as demand increased without equivalent increases in supply. The money supply and exchange rates also significantly contributed to inflation, indicating the need for careful management of monetary policy and foreign exchange stability. Interest rates effectively controlled inflation, showing the role of central bank interventions in maintaining price stability during periods of high growth. The robustness of the model, confirmed by diagnostic tests, means that the results are reliable, and the estimates provide a good understanding of the dynamics between GDP, inflation, and other macroeconomic variables during this period.

In summary, the analysis for Indonesia's economic growth from 2011 to 2023 indicates that while economic expansion contributed to inflationary pressures, careful management of monetary policy, including interest rates and money supply, played a key role in mitigating inflation. The model's strong fit and diagnostic checks further confirm the reliability of these findings.

D. Conclusion

The simultaneous equation modelling of GDP and inflation for Indonesia from 2011 to 2023 reveals a complex and interdependent relationship between these key macroeconomic variables. Inflation has a negative impact on GDP, while GDP growth exerts upward pressure on inflation. Other factors such as government spending, investment, money supply, exchange rates, and global oil prices also play significant roles in shaping Indonesia's economic landscape

during the period under study. The results suggest that careful management of inflation and strategic fiscal and monetary policies are necessary for achieving balanced and sustained economic growth.

Key Findings:

1. Inflation's Negative Impact on GDP: The results show that inflation has a negative and significant impact on GDP growth in Indonesia. Higher inflation erodes purchasing power and investment, leading to a reduction in economic output. This underscores the importance of inflation control in promoting sustainable economic growth.

2. GDP's Positive Influence on Inflation: Economic growth exerts moderate upward pressure on inflation. As GDP expands, increased demand for goods and services can drive prices higher, highlighting the need for balanced growth policies that also monitor inflationary pressures.

3. Government Spending and Investment: Government spending and investment are identified as key drivers of GDP growth. Continued fiscal stimulus and increased capital formation, especially in infrastructure and human resources, are essential to support Indonesia's economic development.

4. External Factors and Inflation Vulnerability: The study highlights the vulnerability of Indonesia's inflation rate to external factors, particularly exchange rate fluctuations and global oil prices. Managing these external shocks, through exchange rate stabilization and energy diversification, is critical to maintaining price stability.

5. Monetary Policy and Inflation Control: The findings suggest that interest rates have a significant role in controlling inflation. Effective monetary policy is essential for keeping inflation within target levels, while minimizing adverse effects on GDP growth.

Policy Implications:

1. Monetary and Fiscal Coordination: The interdependence between GDP and inflation calls for better coordination between fiscal and monetary policies. While fiscal spending can drive growth, it must be balanced with monetary measures to ensure inflation remains under control.

2. Inflation Management: Policymakers should prioritize inflation management to ensure that price stability supports long-term economic growth. Targeted policies to address supply-side constraints, improve productivity, and maintain stable exchange rates are crucial.

3. Investment in Infrastructure and Human Capital**: The positive impact of government spending and investment on GDP suggests the need for continued investment in infrastructure and human capital development to sustain growth.

Final Thoughts:

This study contributes to the understanding of Indonesia's macroeconomic dynamics by providing an empirical model that captures the complex relationship between GDP and inflation. The findings emphasize the importance of maintaining a stable macroeconomic environment, where inflation is controlled, and growth is supported through strategic fiscal and monetary policies. As Indonesia continues its development journey, these insights will be crucial for shaping policies that foster both economic stability and sustainable growth.

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