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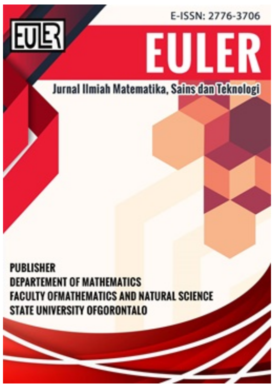

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Research Article

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Modeling of Gross Domestic Product Growth in Indonesia by Using Multi-Input Intervention Model

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ABSTRACT. *The Gross Domestic Product (GDP) Growth of Indonesia has fluctuated over time due to established policies, economic crises, changes in political direction, and natural disasters. In 1998, due to the fall of the New Order regime, the Indonesian economy contracted by -13.13 percent, leading to hyperinflation. In 2020 the COVID-19 pandemic occurred which caused Indonesia's GDP Growth to contract again. Accurate forecasting of GDP Growth is crucial for government to formulate effective future policy strategies to maintain the stability of Indonesia's economy. There are several outliers in Indonesia's GDP Growth data, so the proper analysis is a multi-input intervention. The best model analysis is ARIMA (1,0,0) with non-zero mean using the first order intervention* $b = 0,\ r = 0,\ s = 0$ *and the second order intervention* $b = 0,\ r = 0$, *and* $s = 0$ *which resulted in a Mean Absolute Percentage Error (MAPE) of 23.47 percent. The outlier effect on Indonesia's GDP Growth data is both direct and temporary.*

1. Introduction

Gross Domestic Product (GDP) Growth is an indicator that reflects the government's success in managing, developing, and running the country [1]. GDP represents one aspect of the national balance sheet, reflecting the market value of all goods and services produced in a region within a specific period [2]. GDP is important because it provides information about the size of the economy and its performance. GDP Growth in the era before the Reformation (1947-1967) consisted of three periods: post-independence economic reforms, the strengthening of economic pillars, and a crisis period that led to inflation [3]. At the beginning of independence, Indonesia's Gross Domestic Product (GDP) per capita was only around IDR 5,523,863. Until 1962, GDP Growth was always positive at an average rate of around 5 percent [4]. However, in 1963, GDP Growth contracted by 2.24 percent due to the high proportion of political costs in the State Revenue and Expenditure Budget (APBN). The state budget recorded a deficit of IDR 1,565.6 billion, and hyperinflation soared 600 percent [3]. The data demonstrates that Indonesia's economic growth in the pre-Reformation era was heavily influenced by political conditions and the fiscal policies adopted by the government. The relatively stable GDP growth up to the early 1960s indicates significant potential for Indonesia's economic development post-independence. However, the crisis in 1963 illustrates how imbalanced budget allocations, with excessive focus on political interests, could significantly undermine economic stability.

Indonesia's highest GDP Growth occurred during the reign of President Soeharto (1967-1998), reaching 6 percent-8 percent [5]. President Soeharto's government made various financial breakthroughs, including passing Law (UU) Number 1 of 1967 concerning Foreign Investment (PMA), allowing foreign investors to openly invest in Indonesia and accelerate the rate of GDP Growth [6]. The program that significantly boosted Indonesia's GDP Growth at this time was self-sufficiency, as stipulated in the five-year development plan, which focused on improving the welfare of agriculture and industry [7]. However, in 1998, a crisis caused Indonesia's inflation to rise to 80 percent, while GDP Growth fell to -13.13 percent, marking the lowest point in Indonesia's economic history. The high economic growth achieved during President Soeharto's era, while impressive, requires deeper analysis from the perspectives of sustainability and equity. The GDP growth of 6-8 percent during this period was largely supported by foreign investment and the exploitation of natural resources. The policy of opening the economy to foreign investment through Law (UU) No. 1 of 1967 on Foreign Investment (PMA) indeed provided a significant initial boost to the economy, but did not directly create domestic economic independence. Dependence on foreign investment made Indonesia vulnerable to global economic fluctuations, as evidenced by the 1998 monetary crisis.

The reformation era (1998-1999) was a transition period for the Indonesian economy. The government of President BJ Habibie implemented various financial and monetary policies, bringing Indonesia's GDP Growth to 0.79 percent in 1999, while the rupiah exchange rate also strengthened [8]. During the administration of President Gusdur, fiscal decentralization and regional autonomy policies were introduced. The Indonesian economy slowly recovered after the 1998 crisis, with GDP Growth reaching 4.8 percent. The issuance of debentures or bonds directly in 2000 supported this growth. Under President Megawati's administration (2001-2004), the economy stabilized with the strength-

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ening of the banking sector, especially through the issuance of debt securities or bonds [9]. GDP Growth was stable at around 5 to 6 percent during the reign of President SBY (2004-2014) [10]. However, in 2008, a global financial crisis caused a temporary decline in growth. Indonesia managed this crisis relatively well, ranking among the top three countries in the world for crisis management. Policies during this period focused on accelerating Indonesia's long-term economic development plans.

During President Jokowi's era, Indonesia experienced a weakening of the rupiah exchange rate against the US Dollar, while GDP Growth for four consecutive years was remained below the growth of President SBY's era [3]. During this period, imports increased while exports declined. The reshuffle of the APBN (State Budget) structure was implemented, focusing on increasing investment, infrastructure development, and efficiency. GDP Growth remained stable at around 5.2 percent until 2019 [11], but contracted in 2020 due to the COVID-19 pandemic [12].

The movement of GDP Growth over time is an important economic indicator for the government in formulating fiscal and monetary policies for the future. Therefore, forecasting GDP Growth in the future is needed to maintain domestic economic stability. GDP Growth is time-series data with an annual reference period. The statistical method used to analyze time series data is time series analysis, which establishes a forecasting model based on past variable trends [12].

Indonesia's GDP growth pattern from 1961 to 2021 shows fluctuations and the occurrence of two outliers [13]. The first outlier is the sharp decline that occurred in 1998 due to the economic crisis and the decline of the old order. The second outlier occurred during the Covid-19 pandemic in 2020. The intervention model is time series analysis which can overcome the existence of outliers [14]. In this study, a multi-input intervention model was used, because Indonesia's GDP growth data from 1961 to 2021 contains two outliers.

Several previous studies discuss multi-input intervention models. Miftahuddin, et al. [15] compared two models: the ARFIMA-GPH model and the multi-input intervention model in modeling IHPBI data. They found the best model to be the multi-input intervention model during the second intervention, with an MAE of 0.0119 and a MAPE of 0.9079. Similarly, Lee et al. [16] studied the impact of the Asian financial crisis and the Bali terrorist attacks on tourist arrivals using a multi-input intervention model.

Previous research has primarily focused on modeling to determine the impact of the variables used, leaving limited literature analyzing multi-input interventions to predict data, particularly Indonesia's GDP growth data. GDP statistics serve as a crucial indicator, signaling an approaching recession or reassuring businesses about consumer spending patterns [17]. Policymakers also rely on GDP as one of the key references for crafting monetary and fiscal policies based on the country's economic conditions. Therefore, accurate and timely predictions of GDP growth, especially before official data is published, are crucial, particularly during a crisis. This study models Indonesia's GDP growth for the period 1961-2021, characterized by a fluctuating pattern, using a multi-input intervention model. The best model obtained is then used to predict Indonesia's GDP growth for the years, namely 2022-2024.

2. Methods

2.1. Flowchart

This flowchart contains the research framework, starting from data selection to the determination of the methods used. This framework is used to present the concepts of the research. In general, the thinking framework in this study is illustrated through the flowchart in Figure 1.

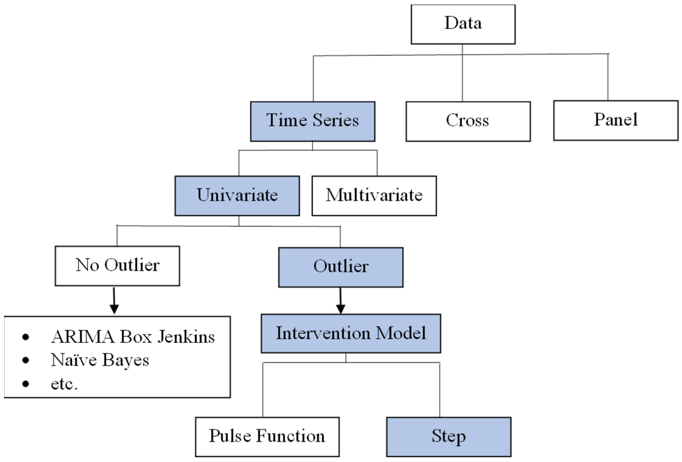

Figure 1. Flowchart of methodology analysis

2.2. Data Sources and Data Structures

The data used in this study consists of Gross Domestic Product (GDP) data from 1961 to 2006, which was obtained from the Harvard Dataverse publication [13], while data from 2006 to 2021 is obtained from the official website of the Central Agency of Statistics (BPS) Indonesia, consisting of 61 research objects [18]. The data structure in this study is based on ratio-scale time series data.

2.3. Intervention Models

Time series data often contains observations affected by unexpected and unforeseen extraordinary events, such as strikes, wars, and political or economic crises, which cause these observations to be inconsistent with the rest of the time series data. These observations are referred to as outliers [12]. If the timing and cause of these disturbances are known, their effects can be analyzed using intervention analysis.

Time series intervention analysis is used to explore the impact of unexpected events on the variables being observed. According to Wei [12], there are two types of intervention variables, as follows.

1. Step Function, forms of intervention that occur over a long period, such as government policies, the monetary crisis experienced by Indonesia in 1997, and the travel ban.

$$S_t = \begin{cases} 0, & t < T \\ 1, & t \geq T \end{cases} \tag{1}$$

where T is the start time of the intervention.

2. Pulse Function, forms of intervention that occur at a particular time, such as demonstrations and price discounts.

$$P_t = \begin{cases} 0, & t = T \\ 1, & t \neq T \end{cases} \tag{2}$$

The general model of intervention with the step function is written in the following equation.

$$Y_t = \frac{\omega_s(B)\, B^b}{\delta(B)} S_t + d_t \tag{3}$$

where,

Y_t	:	Response variable at time t,
$\omega_s(B)$	:	Operators of the orders, which indicate the abundance of past observations from S_t influencing Y_t,
$\delta(B)$	:	An operator of the order, which shows how many past observations of the output series itself have influenced Y_t,
b, s, r	:	Permanent,
d_t	:	Noise series following ARIMA $(p, d, q)(P, D, Q)_S$.

Variable $\omega_s(B)$ and $\delta(B)$ can be defined as follows:

$$\omega_s(B) = (\omega_0 - \omega_1 B - \cdots - \omega_s B^s), \tag{4}$$

$$\delta_r(B) = (\delta_0 - \delta_1 B - \cdots - \delta_r B^r). \tag{5}$$

The equation for obtaining MAPE is as follows [24]:

$$MAPE = \frac{1}{n} \sum_{t-1}^{n} \frac{|Ft - At|}{At} \tag{6}$$

where,

Ft	:	the result of forecasting in period t
At	:	the value *actual* period t
n	:	the total number of periods

A smaller MAPE indicates that the model has better accuracy, as outlined in the criteria in Table 1.

Table 1. Evaluation criteria model time series analysis based on MAPE

MAPE	Model Forecasting Capability
<10%	Very Good
10-20%	Good
20-50%	Quite Good
>50%	Bad

2.4. Step Function Intervention Modelling Steps

1. Data grouping into two based on the time of the intervention.
   (a) Data before intervention, starting from 1961–1997.
   (b) Data at the time of intervention, starting in 1998 and 2020.
2. Make time series plots to see intervention response patterns and predict possible intervention variables.
3. ARIMA model for pre-intervention data uses the Box-Jenkins method, which is preceded by checking the stationarity of mean and variance for initial data based on time series plots made previously.
4. Perform differencing if the data, before the occurrence of the intervention, does not meet the assumption of stationarity in mean, and transform the data if it does not meet the assumption of stationarity in variance for data before the intervention occurs.
5. Identify all possible models resulting from ACF and PACF plots of pre-intervention data.
6. Estimate the parameters of all possible ARIMA models from data before the intervention.
7. Test the significance of the parameters of the ARIMA model and choose a model with all significant parameters from the data before the intervention.
8. Examine the assumptions of independence and residual normality of the formed ARIMA model. A good model meets the assumptions of independence and residual normality.
9. Evaluate the forecasting model that has been obtained by calculating the MAPE value.
10. Select the best intervention model based on the smallest MAPE criteria.
11. Perform forecasting for data before the intervention occurs and extend to the data after the intervention, based on the model generated by the Box-Jenkins ARIMA method.
12. Calculate the residual response between the data after the intervention and the forecasting results from the data before the intervention.
13. Identify intervention response patterns and construct intervention models through residual plots. The ARIMA residual plot determines the order of intervention responses b, s, and r.
14. Estimate the parameters of the intervention model.
15. Test the significance of the parameters of the intervention model and choose a model that produces all significant parameters.
16. Perform diagnostic testing of the residual model to determine whether it is independent (white noise) and normally distributed.
17. Select the best forecasting model by considering the smallest MAPE value.
18. Forecast GDP Growth using the best step function intervention model that has been formed from the three datasets.

3. Results and Discussion

3.1. Descriptive Statistics

Before modeling the GDP growth data, the first step is to identify the characteristics of the data using descriptive statistics and a time series plot, as presented in Table 2.

Table 2. Descriptive statistics

Variable	Mean	Stat. Dev	Min.	Median	Max.
GDP Growth (%)	5.097	3.429	-13.127	5.618	10.915

Based on the results of descriptive statistical analysis in Table 2, it was found that the average percentage of GDP growth was 5.097% and the median value was 5.618%. The highest percentage of GDP growth occurred in 1968, which was 10.915%. This was due to the inflation rate, which was originally 650% was successfully suppressed to 120% in 1967 and 80% in 1968, respectively. This was also caused by the demographic transition that occurred in ASEAN in 1968, which is believed to have influenced GDP Growth [19]. Meanwhile, the lowest percentage of GDP growth occurred in 1998, which was about -13.127%. This was due to the monetary economic crisis in the New Order era [20]. Then the standard deviation value is less than the average value, it shows that the percentage data for GDP Growth is around the target set by the government. The time series plot of GDP growth data for the period 1961-2021 is presented in Figure 2.

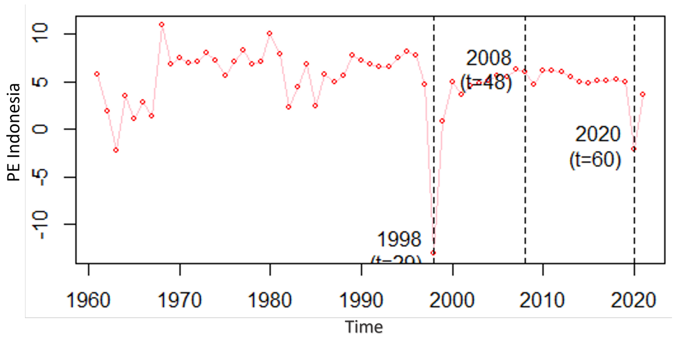

Figure 2. Time series plot of GDP growth

Based on the plot in Figure 2, the percentage of Indonesia's GDP growth in 1961-2021 experienced fluctuations. In 1998, the percentage of GDP growth significantly decreased compared to previous years. However, in 1999, the percentage of Indonesia's GDP growth began to recover. This is due to the reform era, during which Indonesia's GDP growth gradually improved [21]. Then, the percentage of GDP growth declined again in 2008. This was due to the global financial crisis, which also impacted the Indonesian economy [22]. Furthermore, GDP Growth dropped again in 2020. This is due to Covid-19.

3.2. Modeling of Indonesia's GDP Growth Intervention 1961 to 2021

The first step of modeling the step function is to create an ARIMA model for the data before the intervention $(t < T)$. In this study, modeling was carried out on data from 1961 to 2021, specially for $t < 38$ (1998) and $t < 60$ (2020). Figure 3 shows that the data before the intervention (N_t) needs to be checked for stationarity at the mean using the ACF plot and the ADF test.

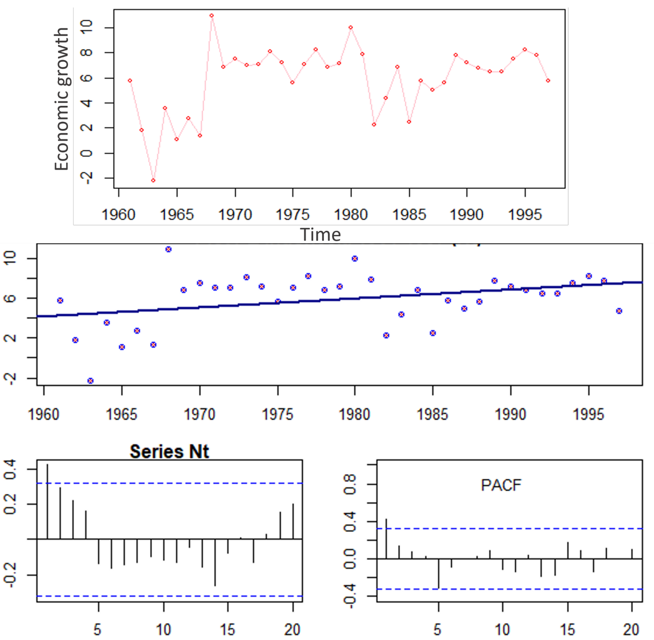

Figure 3. Time series plot of GDP growth of Indonesia 1961-1997 (N_t), ACF, and PACF

The ACF plot decreases slowly, indicating that Indonesia's GDP Growth data before the intervention was not stationary at the mean. The test results using the ADF also show *a p-value* of 0.4945 so at a significance level of $\alpha = 5\%$, there is not enough evidence to state that the data is stationary at the mean. Differencing is performed to make the data stationary at the mean. The results of the ADF test in the second differencing stage show a p-value < 0.01, indicating that the data is stationary after the second differencing. Figure 4 shows the visualization of ACF and PACF plots from the second differencing data (W_{t_1}).

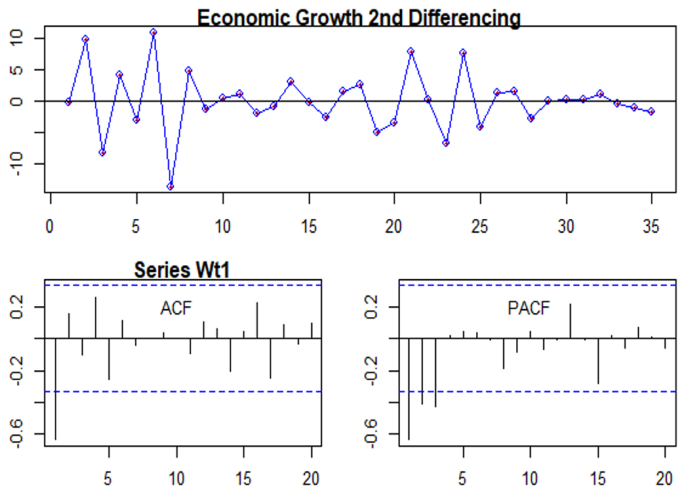

Figure 4. Plot ACF dan PACF 2^{nd} differencing of GDP growth (W_{t_1})

The second step is to identify the appropriate ARIMA model for the pre-intervention data that has been made stationary, following the guidelines in Figure 4. The ARIMA models formed include ARIMA (2,0,2) with non-zero mean, ARIMA (0,0,0) with non-zero mean, ARIMA (1,0,0) with non-zero mean, ARIMA (0,0,1) with non-zero mean, ARIMA (0,0,0) with zero mean, ARIMA (2,0,0) with non-zero mean, ARIMA (1,0,1) with non-zero mean, ARIMA (2,0,1) with non-zero mean, and ARIMA (1,0,0) with zero mean. Based on the parameter significance test and the diagnostic test on the residual, only the ARIMA model (1,0,0) with a non-zero mean can be used to build an intervention model.

From the ARIMA model before the intervention, values can be obtained forecast for the year after the intervention until 2019. The residual results of forecasting with ARIMA (1,0,0) with a non-zero mean are used to construct the residual plot to obtain order $b = 0,\ s = 0$, and $r = 0$ from the first input intervention function. Figure 5 illustrates the residual pattern of the intervention response function.

The best model in the first input intervention model based on Eq. (6) has parameters $\omega_0 = -2.82429$. The function of the impact of the intervention of the economic crisis and the collapse of the New Order on Indonesia's GDP Growth can be written as $f\left(S_{1t}\right) = -2.82429 S_{1t}$. Eq. (7) is the first intervention model for Indonesia's GDP Growth data from 1961 to 2021 based on Eq. (3),

$$Y_t = -2.82429 S_{1t} + \frac{5.88868}{(1 + 0.042188B)} d_t \tag{7}$$

with $S_{1t} = \{0; t > 38 \quad 1; t \geq 38\}$.

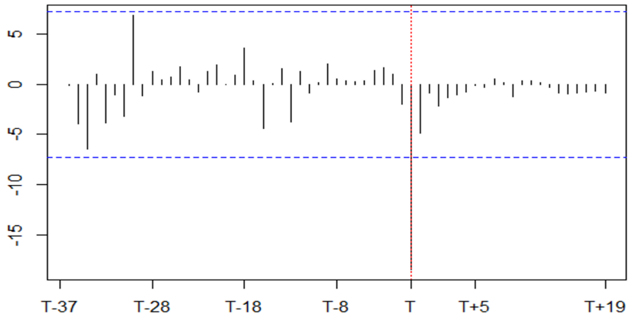

Figure 5. Residual plot as first input intervention response function

The coefficient -2.82429 indicates the magnitude and direction of the impact of the economic crisis and the collapse of the New Order on Indonesia's GDP Growth. The negative value signifies that these events caused a significant decline in GDP Growth. S_{1t} represents the intervention variable, reflecting the timing and occurrence of these historical events. When S_{1t} is active, the GDP Growth decreases by approximately 2.82 units due to the intervention. The coefficient $\frac{5.88868}{(1+0.042188B)}$ d_t is the ARIMA component that models the basic dynamics of GDP Growth after accounting for the intervention. It includes the autoregressive component (B) with a coefficient of 0.042188, which indicates the level of persistence or memory of previous observations. The coefficient 5.88868 represents the baseline level of GDP Growth after considering the effect of the intervention.

The forecasting results of the first input intervention model are shown in Figure 6. The first input intervention model has been able to follow the pattern of actual GDP Growth data.

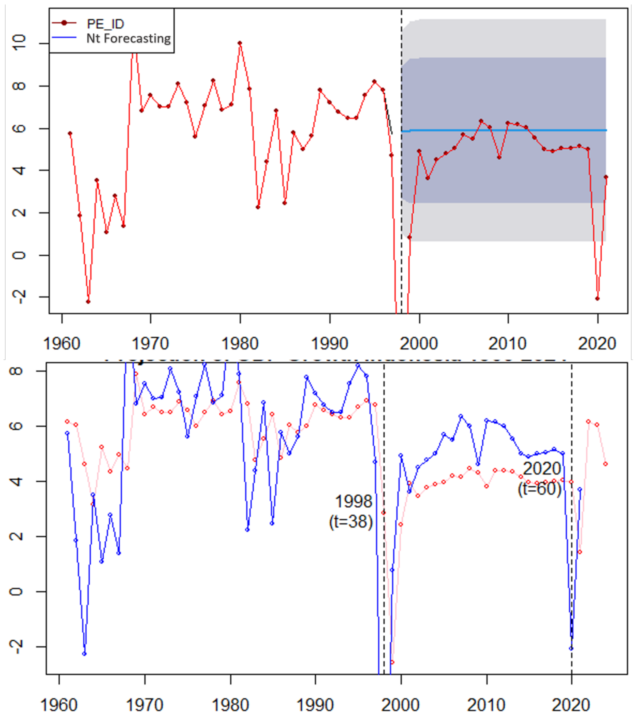

Figure 6. Comparison of forecasting pre-intervention ARIMA model with first input intervention model

The result of fitting the first intervention model is used as a variable output for the analysis of the second input intervention, namely during the 2020 COVID-19 pandemic. The Residual plot of the second input intervention model is shown in Figure 7.

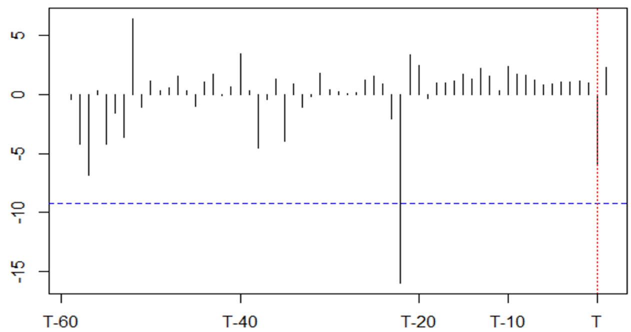

Figure 7. Residual plot as a function of second input intervention response

The best model of the second Intervention model based on Eq. (6) has a parameter $\omega_0 = -4.62694$. The function of the impact of the COVID-19 pandemic intervention on Indonesia's GDP Growth can be written as $f(S_{2t}) = -4.62694S_{2t}$. Eq. (8) is the second intervention model for Indonesia's GDP Growth data from 1961 to 2021 based on Eq. (3).

$$Y_t = -4.62694S_{2t} - 2.82429S_{1t} + \frac{5.88868}{(1+0.042188B)} d_t \quad (8)$$

with $S_{1t} = \{0; t < 38 \quad 1; t \geq 38\}$ and $S_{2t} = \{0; t < 60 \quad 1; t \geq 60\}$.

The coefficient -4.62694 represents the impact of the COVID-19 pandemic on Indonesia's GDP growth. A negative value indicates that the pandemic caused a significant decline in GDP growth. Specifically, for every unit change in the intervention variable S_{2t}, GDP growth is reduced by 4.62694 units. The model suggests that both the economic crisis (1997-1998) and the COVID-19 pandemic (2020) had a significant negative impact on Indonesia's GDP growth, with the latter being especially severe. The autoregressive term indicates that past values of GDP growth continue to influence the current GDP growth, showing the persistence of economic trends even after these interventions.

3.3. *Forecasting Indonesia's GDP Growth 2022 to 2024*

The model used for forecasting is an equation. Forecasting is done to determine the value of GDP Growth from 2022 to 2024 as presented in Table 3.

Table 3. Forecasting results for Indonesia's GDP growth from 2021 to 2024

Year	Forecasting of GDP Growth	95% Confidence Interval	
		Lower	Upper
2022	5.787	-0.439	12.013
2023	5.453	-1.096	12.002
2024	5.236	-1.346	11.827

Figure 8 shows the forecasting results of the second input intervention model of Indonesia's GDP Growth from 1961-2024.

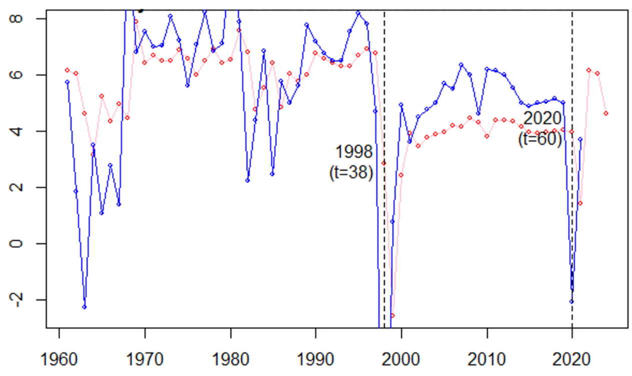

Figure 8. The forecasting results of the second input intervention model for Indonesia's GDP growth from 1961 to 2024

From Figure 8, it can be seen visually that the forecast data pattern is sufficient to follow the actual data pattern. GDP Growth in 2021 will only reach 3.69 percent. In 2023, it is predicted that the world will experience an economic recession, so countries that do not make mature anticipation will be vulnerable to experiencing an economic crisis in their country. The forecasting results of the two-input intervention model show that in 2023, Indonesia's GDP Growth will be able to return to its initial point of around 5.787 percent, this can be targeted by the competent government, so it be able to make policies to support the forecasting results. That means that preparing appropriate policies can boost Indonesia's domestic economy. However, in 2023 and 2024, the government must implement economic policies more strictly so that Indonesia's growth continues to grow, not the other way around. Data evaluation out sample based on Eq. (6), resulting in a MAPE calculation of 23.47%. MAPE values between $20\%-50\%$ indicate that the model's power in forecasting is quite good.

4. Conclusion

Between 1961-2021, GDP Growth in Indonesia showed fluctuating trends, and there were extreme declines and increases which became outlier data. The best ARIMA model before the intervention is ARIMA (1,0,0) with a nonzero mean with the following equation. The first intervention step function model formed with the order $b = 0$, $s = 0$, and $r = 0$ in Indonesia's GDP Growth data from 1961 to 2021 has a MAPE of 22.49 percent and is good enough to forecast the data. The second intervention step function model formed with the order $b = 0$, $s = 0$, and $r = 0$ in Indonesia's GDP Growth data from 1961 to 2021 has a MAPE of 23.47 percent, which is sufficiently accurate for data forecasting. The second outlier, resulting from the economic crisis of the New Order and the existence of the COVID-19 pandemic, had a direct and temporary effect on Indonesia's GDP Growth.

Author Contributions. **Chandrawati:** Conceptualization, methodology, software, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision, project administration, funding acquisition. **Kertanah:** Validation, writing—review and editing, supervision, funding acquisition. **Tri Juliantin Ramli:** Software, formal analysis, investigation, resources. **Alissa Chintyana:** Validation, writing—review and editing, funding acquisition. **Ristu Haiban Hirzi:** Validation, writing—review and editing, funding acquisition. All authors discussed the results and contributed to the final manuscript.

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