

Nonparametric Spline Regression in Inflation Analysis in Indonesia

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ABSTRACT

This study aims to form a nonparametric spline regression model to analyze the factors that influence inflation in Indonesia. The data used are secondary data used are secondary data for the period January 2020-December 2024 from BPS and Bank Indonesia, with inflation variables as responses and CPI, interest rates, exchange rates, and money supply as predictors. The spline model is built with optimal knot points based on minimum Generalized Cross Validation (GCV). The results show that the best model has three knot points with a minimum GCV value of 0.6560 and a coefficient of determination (R^2) of 64.13%. With significant predictor variables on the response variable is the Consumer Price Index variable (X_1), Interest Rate (X_2) and Money Supply (X_4). Thus, nonparametric spline regression is able to capture nonlinear relationships between variables and can be an effective analytical tool in planning inflation control policies.

KEYWORDS

Inflation, Nonparametric Spline Regression, Consumer Price Index, Interest Rate, Money Supply, GCV

1. INTRODUCTION

Inflation is an important macroeconomic indicator that reflects a general and sustained increase in the prices of goods and services [1]. In Indonesia, inflation is commonly affected by several macroeconomic variables, including the consumer price index, interest rates, exchange rates, and the money supply. The relationship between inflation and these variables is typically analyzed using parametric approaches; however, such methods often lack flexibility in capturing nonlinear relationships. According to Bank Indonesia data, Indonesia's year-on-year inflation rate in December 2023 reached 2.61%, which was considerably lower than the inflation rates recorded in December 2022 (5.51%) and December 2021 (1.87%). These fluctuations indicate that inflation in Indonesia is relatively unstable, highlighting the need for appropriate modeling techniques to better understand its behavior.

Several previous studies have examined inflation using various statistical approaches. Ramadhani et al.[2], for instance, applied kernel estimators and non-seasonal ARIMA models to analyze monthly inflation in Indonesia. Their findings showed that the triweight kernel regression was the best-performing kernel, with an optimal bandwidth of 1.124, an R^2 value of 99.990%, an MSE of 0.00016, and a MAPE of 0.34%. Moreover, predictions for the subsequent thirteen months indicated that the kernel estimator outperformed the non-seasonal ARIMA model, as evidenced by a lower MAPE value of 10.92%. These results demonstrate that nonparametric regression using the triweight kernel function is accurate for predicting Indonesia's monthly inflation.

In addition, Alwi et al.[3] investigated factors influencing the poverty rate in South Sulawesi in 2017 and found that unemployment, population growth, and literacy rates were the main determinants. Their analysis revealed that the optimal spline model employed three knot points. Further research by Susmiati et al.[4] examined the effects of money supply and the rupiah exchange rate on inflation in Indonesia during 2011–2018. The results indicated that, partially, the money supply had a

significant negative effect on inflation, while the exchange rate had a significant effect. Simultaneously, both variables jointly had a significant influence on inflation in Indonesia. These findings support the inclusion of money supply and exchange rates as predictors in inflation modeling using nonparametric regression.

Moreover, Alwi [5] reported that the best spline model, based on the minimum Generalized Cross Validation (GCV) criterion, employed three knot points at 0.2591359, with an R^2 value of 84.79%. Panjaitan et al.[6] also found that the SBI interest rate had a positive and significant relationship with inflation, while the money supply exhibited a positive but insignificant relationship. Meanwhile, the exchange rate showed a negative and insignificant relationship with inflation, and the inflation targeting framework policy had a positive relationship with Indonesia's inflation rate.

Based on these previous studies, nonparametric regression has proven effective in modeling fluctuating and irregular data, such as inflation and other economic phenomena. Among various nonparametric approaches, this study employs Nonparametric Spline Regression. Spline regression offers distinctive statistical and graphical interpretations and is well suited for modeling smooth data patterns. Nonparametric spline regression does not assume a specific functional form; instead, it only requires the function to be smooth and belong to a particular function space [7]. Splines are highly flexible and capable of capturing differing data behavior across various intervals [8]. This study uses the Consumer Price Index (CPI), interest rates, exchange rates, and the money supply as explanatory variables.

2. LITERATURE REVIEW

2.1 Regression Analysis

Regression analysis is a statistical technique used to examine the relationship between response variables and explanatory variables. In statistics, regression analysis aims to identify and explain the causal relationship between one variable and another [5]. The primary objective of regression is to estimate the value of a response variable based on one or more predictor variables and to understand the underlying pattern of the relationship between them [9]. Broadly, regression approaches can be classified into three main categories: parametric regression models, semiparametric regression models, and nonparametric regression models. In general, the regression analysis model with data pairs (x_i, y_i) can be written as follows:

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon \quad (1)$$

Where β_0 and β_1 are the parameters to be estimated. The estimate β_0 is a constant which is usually called the intercept, while β_1 is the regression coefficient (slope) for Y . The Y variable acts as the dependent variable while X is the independent variable. The pattern of the relationship between the dependent variable and the independent variable is known through a scatterplot in the form of a linear, quadratic, cubic pattern, even if it is not in the form of a pattern or random.

2.2 Nonparametric Spline Regression

Nonparametric regression is a statistical method used to identify the relationship between a response variable and a predictor variable [3]. Unlike parametric regression, which requires assumptions about data distribution and model form, nonparametric regression provides greater flexibility in capturing complex patterns in the data. This method is particularly useful when the data does not follow a linear pattern or when the relationship between variables cannot be determined in advance [10].

However, in reality there are models for a set of data that have complex patterns. In general, the nonparametric regression model is as follows.

$$Y_i = f(x_{1i}, x_{2i}, \dots, x_{ki}) + \varepsilon_i, \quad i = 1, 2, \dots, n \quad (2)$$

Where Y_i is the dependent variable, x_i is the independent variable and $f(x_i)$ is a regression function that does not form a pattern.

Nonparametric Spline Regression is a modeling technique that uses spline functions to estimate the relationship between dependent and independent variables. In spline regression, the data is divided into several segments, and each segment is connected by a polynomial function. This spline function allows the model to better accommodate nonlinear changes in the data compared to traditional linear regression models. Spline regression is often used in data analysis that exhibits nonlinear relationships [2].

If y_i is an independent variable and f is a regression curve whose shape is unknown, then the regression curve f can be modeled using a spline function. With this approach, a nonparametric regression model is obtained.

$$y_i = \sum_{j=1}^k f_j(x_{ji}) + \varepsilon_i$$

$$= f_1(x_{1i}) + f_2(x_{2i}) + \dots + f(x_{pi}) + \varepsilon_i, \quad i = 1, 2, \dots, n$$
(3)

with

$$f_j(x_{ji}) = \sum_{h=0}^q \beta_{hj} x_{ji}^h + \sum_{l=1}^{m_j} \beta_{q+l,j} (x_{ji} - K_{jr})_+^q, \quad i = 1, 2, \dots, n$$
(4)

and

$$(x_{ji} - K_{jr})^q = \begin{cases} \{x_{ji} - K_{jr}\}^q & , x_{ji} \geq K_{jr} \\ 0 & , x_{ji} < K_{jr} \end{cases}$$
(5)

The values on $k_{1j}, k_{2j}, \dots, k_{mj}$ is a knot point that shows the pattern of changes in the function at different sub-intervals. The q value is the degree of the polynomial. The equation of the regression model can be described as follows.

$$y_i = \beta_{01} + \beta_{11}x_{1i} + \dots + \beta_{q1}x_{1i}^q + \alpha_{11}(x_{1i} - K_{11})^q + \dots + \alpha_{m1}(x_{1i} - K_{m1})^q + \beta_{02} + \beta_{12}x_{2i} + \dots + \beta_{q2}x_{2i}^q + \alpha_{12}(x_{2i} - K_{12})^q$$

$$+ \dots + \beta_{m2}(x_{2i} - K_{m2})^q + \beta_{0p} + \beta_{1p}x_{pi} + \dots + \beta_{qp}x_{pi}^q + \alpha_{1p}(x_{pi} - K_{1p})^q + \dots + \alpha_{mp}(x_{pi} - K_{pi})^q + \varepsilon_i$$
(6)

2.3 Optimal Knot Point Selection

The resulting model with optimal knot points is the result of the best spline regression model. The best knot point is the knot point that has the minimum GCV value [5]. The method used to select the optimal knot point is Generalized Cross Validation (GCV) with the minimum value of the equation being the GCV function given by Eubank [8].

$$GCV(K_1, K_2, \dots, K_J) = \frac{MSE(K_1, K_2, \dots, K_J)}{(N^{-1} \text{Trace}[1 - A(K_1, K_2, \dots, K_J)])^2}$$
(7)

with

$$\hat{y} = A(K_1, K_2, \dots, K_J)y$$

$$A(K_1, K_2, \dots, K_J) = X(X^T X)^{-1} X^T$$

$$MSE(K_1, K_2, \dots, K_J) = n^{-1} \sum_{i=1}^n (y_i - \hat{f}(K_1, K_2, \dots, K_J))^2$$

3. METHODOLOGY

This study utilizes secondary data sourced from publications of the National Statistics Agency (BPS) and Bank Indonesia (BI) covering the period from 2020 to 2024. The observations consist of monthly data spanning 60 months, from January 2020 to December 2024. The variables examined in this research include inflation as the response variable (Y), and the Consumer Price Index (X_1), interest rate (X_2), exchange rate (X_3), and money supply (X_4) as explanatory variables.

The research procedures that will be carried out in this research are:

1. Conduct descriptive analysis.
2. Creating a Scatter Plot on the relationship between variables x and y
3. Determining the optimal knot point

- (a) Determine the spline model for 1, 2 and 3 knot points and determine the GCV.
 - (b) Determine the optimal knot point by selecting the smallest GCV
 - (c) Create GCV graph for 1,2,3 knot points.
4. Creating a spline regression model with optimal knot points
 5. Testing the best model with the coefficient of determination (R^2)
 6. Parameter significance testing.
 7. Model interpretation

4. RESULT & DISCUSSION

Descriptive statistics are presented in the following table :

Table 1. Descriptive Statistics of Predictor Variables and Response Variables

Variables	Average	Maximum	Minimum	Variance
Y	0.1693	0.6600	-0.2200	0.0462165
X_1	108.7	116.6	104.3	15.54202
X_2	4.783	6.250	3.500	1.111158
X_3	15.02	16.85	13.66	0.5297894
X_4	7,812,025	9,210,816	6,046,651	832.133.791.552

Based on the **Table 1**, the **Figure 1** is a bar chart for variables Y , X_1 , X_2 , X_3 , and X_4

Based on the bar chart in **Figure 1**, it can be seen that inflation and the variables that influence it fluctuate from time to time. Next, a scatter plot will be shown for each variable to see the pattern formed by each predictor variable on inflation. Based on **Figure 2**, the scatter plot between inflation and the variables suspected of having an influence does not form a particular pattern, therefore nonparametric regression can be used for analysis.

Next, the optimal knot point will be selected by comparing the generalized cross validation (GCV) values for different numbers of knots. Below is a table comparing the GCV for each knot.

Table 2. GCV Value for Each Knot

GCV	Number of Knots
0.9729	1
0.8914	2
0.6560	3

It has been shown that the minimum GCV value is at knot 3 with a GCV value of 0.6560 . Thus, it can be seen that the best nonparametric spline regression model is with three knots with a total of 17 parameters including the parameter β_0 .

4.1 Testing the Significance Of Parameters

Then a simultaneous significance test is carried out to assess whether all parameters in the model together have a significant influence

$$H_0 : \beta_1 = \beta_2 = \dots = \beta_{12} = 0$$

$$H_1 : \text{most a little there is } \beta_i \neq 0; \text{ where } i = 1, 2, \dots, 12$$

This test was conducted with a significance level α of 0.05. The results of the Analysis of Variance (ANOVA) for the nonparametric regression model can be seen in the following table:

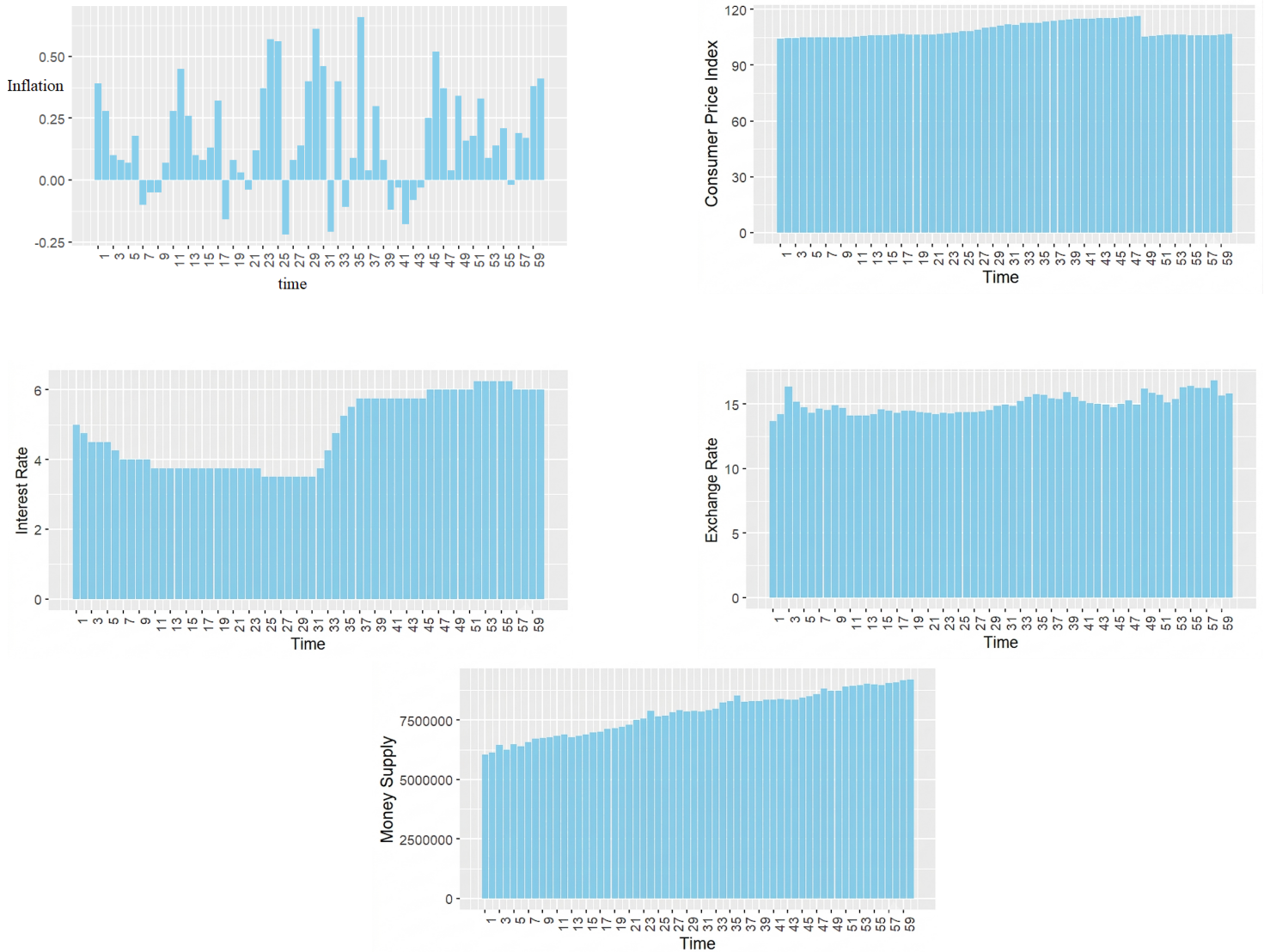


Figure 1. Bar chart of inflation and factors influencing it

Table 3. Analysis of Variance (ANOVA)

Source of Variation	df	Sum of Square (SS)	Mean Square (MS)	F-Statistic	<i>p</i> -value
Regression	16	37.83561	2.364725	4.803684	1.9552×10^{-5}
Error	43	21.16775	0.4922733		
Total	59	59.002?			

Based on the results of ANOVA (Analysis of Variance) in **Table 3**, it can be seen that the Mean Square Error (MSE) value obtained is 0.4922733 while the Mean Square Regression (MSR) has a value of 2.364725 . The MSE and MSR values obtained are F_{count} of 4.803684 and also for the P-value of 1.9552×10^{-5} for the significance level (α) used is 0.05. Next, a comparison of the P-value and α value is carried out where the P-value $< \alpha$ so that it is rejected H_0 . This means that there is at least one significant parameter or together four predictor variables have a significant effect on the amount of inflation in Indonesia.

Next, individual tests are conducted to determine which parameters significantly influence the model. The following are the

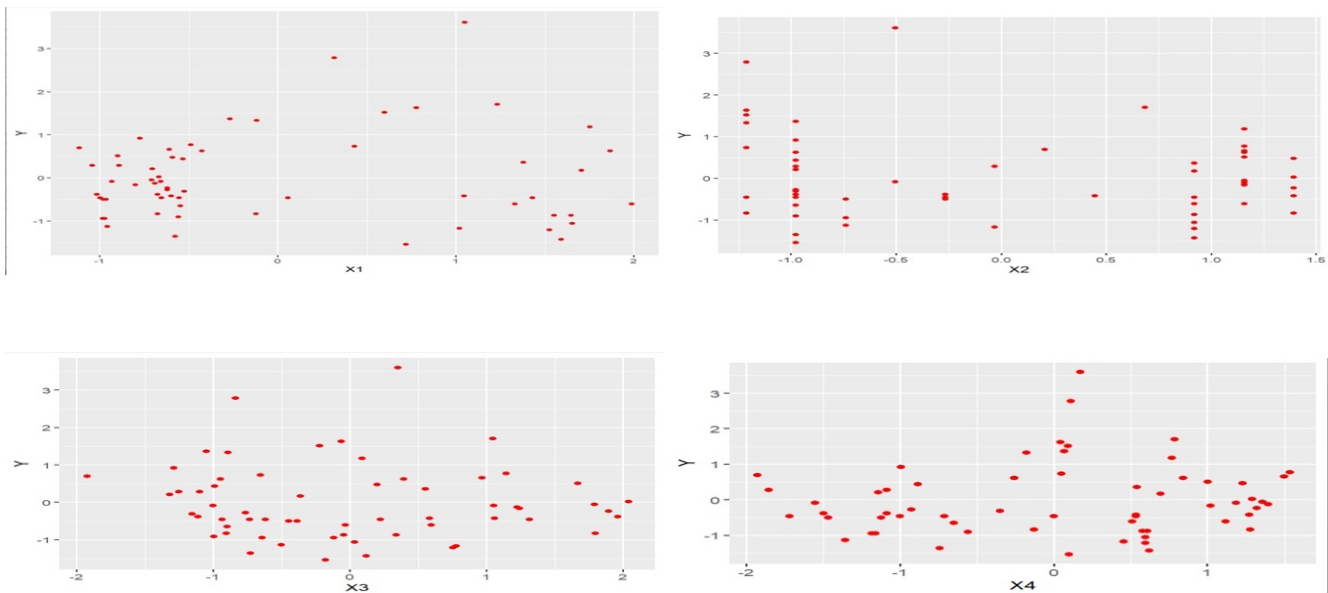


Figure 2. Scatter plot of the relationship between predictor variables and response variables

partial test hypotheses:

$$H_0 : \beta_i = 0$$

$$H_1 : \beta_i \neq 0 \text{ where } i = 1, 2, \dots, 6$$

The results of partial parameter significance testing can be seen in **Table 4**.

Table 4. Partial Parameter Test Results

Variables	Parameter	Estimate	Z-Statistic	<i>p</i> -value	Decision
Constant	β_0	-0.7568	-0.6510	5.1844720×10^{-1}	Not Significant
X_1	β_{11}	-0.1659	-0.2378	8.1313970×10^{-1}	Not Significant
	β_{12}	-0.1584	0.2129	8.3235310×10^{-1}	Not Significant
	β_{13}	-0.7070	-2.3330	2.4393770×10^{-2}	Significant
	β_{14}	0.0586	0.0949	9.2482120×10^{-1}	Not Significant
X_2	β_{21}	-21.5205	-3.2711	2.1145770×10^{-3}	Significant
	β_{22}	77.4821	5.1327	6.5471530×10^{-6}	Significant
	β_{23}	59.0800	-5.2081	5.1066220×10^{-6}	Significant
	β_{24}	5.2290	1.2195	2.2928860×10^{-1}	Not Significant
X_3	β_{31}	0.3783	0.8016	4.2717480×10^{-1}	Not Significant
	β_{32}	-4.4725	-1.0050	3.2048200×10^{-1}	Not Significant
	β_{33}	7.3405	1.4730	1.4801160×10^{-1}	Not Significant
	β_{34}	-13.7092	-1.3891	1.7195350×10^{-1}	Not Significant
X_4	β_{41}	7.1926	1.2902	2.0385240×10^{-1}	Not Significant
	β_{42}	21.2203	3.7676	4.9670070×10^{-4}	Significant
	β_{43}	-73.6003	-5.4760	2.1023380×10^{-6}	Significant
	β_{44}	55.2030	4.7734	2.1185030×10^{-5}	Significant

Based on **Table 4**, it can be seen that the significant parameters and insignificant parameters in each variable are accompanied by their values. t_{count} and P-value, which is then compared between the p -value with a significance level of 0.05. Based on the

results of the regression analysis, it was found that there were 7 parameters that were significant to the model.

These parameters include the consumer price index (X_1), interest rate (X_2), and consumer price index (X_4). These three variables are considered to have a significant influence on inflation in Indonesia.

4.2 Calculation of the Coefficient of Determination

The coefficient of determination will be calculated with R^2 . To demonstrate the appropriateness of the regression model in explaining inflation variability in Indonesia, the following shows the calculation of the coefficient of determination.

$$\begin{aligned} R^2 &= \frac{SS_{regresi}}{SS_{total}} \times 100\% \\ &= \frac{37.83561}{59} \times 100\% \\ &= 64.13\% \end{aligned}$$

From the calculation above, a value R^2 of 64.13% has been obtained, so it can be interpreted that the nonparametric spline regression model obtained is able to explain the variability of inflation in Indonesia by 64.13%, while the remaining 35.37% is explained by other variables that are not included in the model.

4.3 Residual Assumption Testing

The residual assumption testing will be carried out to determine whether the model has fulfilled the assumption that residuals must be identical, independent, and normally distributed.

1. Identical Assumption Testing

The identical assumption test is necessary to determine whether there is heteroscedasticity in the residual variance. The identical assumption test uses the Glejser test. The following are the hypotheses used for the identical assumption test.

$$H_0 : \sigma_1^2 = \sigma_2^2 = \dots = \sigma_n^2 = \sigma^2$$

$$H_1 : \text{there is at least one } \sigma_i \neq \sigma^2, \quad i = 1, 2, \dots, n$$

The results of the ANOVA table for testing the assumption of identical residuals will be displayed in **Table 5**.

Table 5. ANOVA Results Testing the Identical Residual Assumption

Source of Variation	df	Sum of Squares (SS)	Mean Square (MS)	F_{count}	$p\text{-value}$
Regression	15	37.836	2.5224	5.2431	0.000008201
Error	44	21.168	0.4811		
Total	59	59.004			

Based on **Table 5**, the value of 5.2431 can be found F_{count} , which will then be compared with the value F_{tabel} which is worth 2.0106, the value $F_{count} > F_{tabel}$. Next, a comparison will be made with the P-value which has a value of 0.000008201 and a significance level of α (0.05), the P-value $< \alpha$. In the Glejser test, a decision has been given which is reject H_0 . So that the residuals produced by the model do not meet the identical assumption so that heteroscedasticity occurs (the identical residual assumption is not met).

2. Testing the Independent Assumption

The independent assumption was tested using an Autocorrelation Function (ACF) plot. Figure 4.17 shows that the residuals do not show significant autocorrelation, with none exceeding the upper or lower limits. Therefore, it can be concluded that the independent residual assumption is met, meaning there is no autocorrelation among the residuals. The following is the visual result of the independent assumption test using the ACF plot:

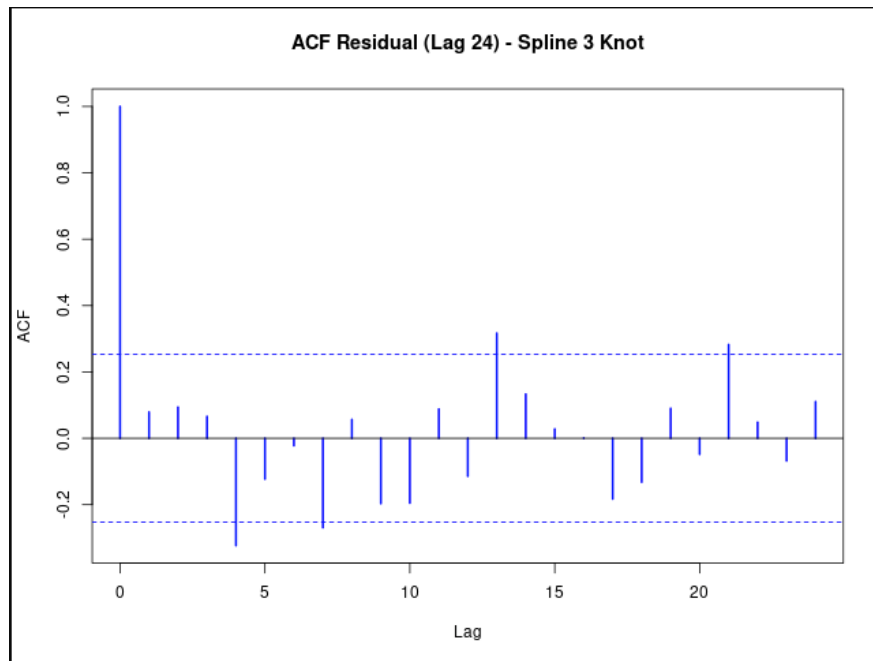


Figure 3. Plot of ACF Residuals

3. Testing the Assumption of Normal Distribution Residuals

In addition to the identical residual assumption and independent residual assumption tests, there is also a normal distribution residual assumption test. This test is conducted to determine whether the residuals are normally distributed or not. The Kolm- O- Gorovsky-Smirnov test will be performed. The following are the hypotheses used in this test:

$H_0 : F_0(x) = F(x)$ (Residuals are normally distributed)

$H_1 : F_0(x) \neq F(x)$ (Residuals are not normally distributed)

The Kolmogorov-Smirnov test result is based on a P-value of 0.9385, using a significance level of α of 0.05, which fails to reject H_0 because the P-value is greater than α . Therefore, the residuals generated by the model meet the assumption of a normal distribution residual.

The results of parameter testing and fulfillment of residual assumptions indicate that the nonparametric spline regression model is suitable for use. The coefficient of determination (R^2) value of 92.42 % indicates the model's ability to explain variations in poverty levels in South Sulawesi. Therefore, this model can be categorized as a good model. The optimal model is obtained with three knot points, and the resulting spline equation is written as follows

$$\begin{aligned} \hat{y} = & -0.7568 - 0.1659x_1 - 0.1584(x_1 - 0.6560)_+ + 0.7070(x_1 - 0.7179)_+ + 0.0586(x_1 - 8445)_+ - 21.5205x_2 \\ & - 77.4821(x_2 - 0.5913)_+ - 59.0800(x_2 - 0.3265)_+ + 5.229(x_2 - 0.4330)_+ + 0.3783x_3 - 4.4725(x_3 - 0.2201)_+ \\ & + 7.3405(x_3 - 0.4206)_+ - 13.7092(x_3 - 0.5825)_+ - 7.1926x_4 - 21.2203(x_4 - 0.2588)_+ - 73.6003(x_4 - 0.1175)_+ \\ & + 55.203(x_4 - 0.2590)_+ \end{aligned}$$

From the model above, it can be interpreted as follows:

- (a) If the variables x_2 , x_3 , and x_4 are assumed to be constant, then the influence of the variable x_1 , namely the percentage of the Consumer Price Index on inflation in Indonesia, can be modeled as follows.

$$\hat{y} = -0.7568 - 0.1659x_1 - 0.1584(x_1 - 0.6560)_+ + 0.7070(x_1 - 0.7179)_+ + 0.0586(x_1 - 8445)_+$$

$$(x_1 - k_3) = \begin{cases} -0.7568 - 0.1659x_1, & x_1 < 0.6560 \\ 0.3243x_1 + 0.1064, & 0.6560 \leq x_1 < 0.7179 \\ 0.3287x_1 - 0.3093, & 0.7179 \leq x_1 < 0.8445 \\ 0.4413x_1 - 0.3427, & x_1 \geq 0.8445 \end{cases}$$

In the equation above, there are four intervals which can then be interpreted with the following graphic visualization.

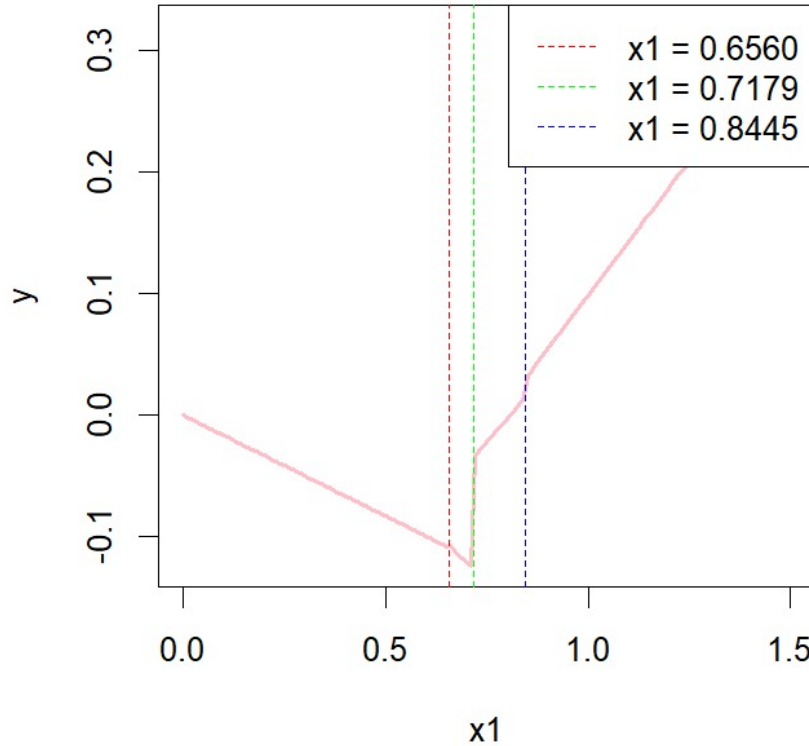


Figure 4. Function graphs in Eq x_1

Based on the graph in **Figure 4** for the consumer price index variable (X_1) against inflation is divided into four segments, separated by three knot points at the value of $X_1 = 0.6560$, 0.7179 and 0.8445 . In general, the graph shows that when the CPI value is low less than 0.656% and increases by 1% then the inflation value is at 0.1659% . There is a second segment when the consumer price index ranges between 0.6560% and 0.7179% . 0.3243% and rise to 1% , then inflation will increase to 0.1064% but on a smaller scale compared to the first segment. The graph looks more downward, indicating a decrease in the sensitivity of inflation to the CPI. This decline is even steeper in the 0.7179 to 0.8445 segment, reflecting a stronger negative influence of the CPI on inflation. Furthermore, in the consumer price index segment ranging from 0.7179% and 0.8445% , then increasing by 1% , the inflation rate will increase and be at 0.3093% the graph increases, then in the fourth segment the consumer price index is less 0.8445% then increasing by 1% , the inflation value will be at 0.3247% with a negative constant value and increasing graph visualization.

- (b) If the variables x_1 , x_3 , and x_4 are assumed to be constant, then the influence of the variable x_2 , namely the percentage of interest rates on inflation in Indonesia, can be modeled as follows.

$$\hat{y} = -0.7568 - 21.5205x_2 - 77.4821(x_2 - 0.5913)_+ - 59.0800(x_2 - 0.3265)_+ + 5.229(x_2 - 0.4330)_+$$

$$(x_2 - k_3) = \begin{cases} -0.7568 - 21.5205x_2 & x_2 < 0.3265 \\ -80.6005x_2 + 19.7104, & 0.3265 \leq x_2 < 0.4330 \\ -75.3715x_2 + 17.4586 & 0.4330 \leq x_2 < 0.5913 \\ -152.8530x_2 + 63.8644 & x_2 \geq 0.5913 \end{cases}$$

In the equation above, there are four intervals which can then be interpreted with the following graphic visualization. Based on the resulting graph, the relationship between the interest rate variable (X_2) and inflation can be divided

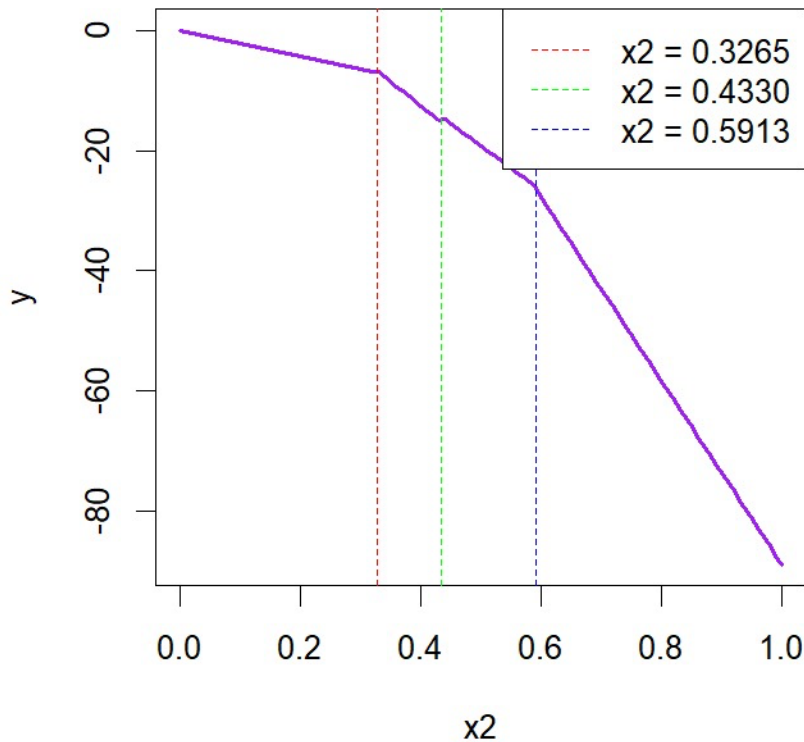


Figure 5. Function graphs in Eq x_2

into four segments, separated by three knot points at $X_2 = 0.3265$, 0.4330 , and 0.5913 . In the first segment, a 1% increase in the interest rate corresponds to a change in inflation of -21.5205% , indicating a negative but relatively weak relationship. In this range, increases in interest rates lead to a gradual reduction in inflation. The graph in this segment appears relatively flat, suggesting that inflation is not highly sensitive to interest rate changes at low levels.

In the second segment, when the interest rate lies between 0.3265 and 0.4330 , the slope of the curve becomes steeper. A 1% increase in the interest rate within this interval results in a change in inflation of 19.7104% , reflecting a more pronounced decrease in inflation. This suggests that interest rate policy becomes more effective in controlling inflation within this range.

Moving to the third segment, where the interest rate ranges from 0.4330 to 0.5913 , a 1% increase in the interest rate leads to a change in inflation of 17.4586% . This still indicates a strong negative relationship between interest rates and inflation, although the effect is slightly weaker compared to the previous segment. The curve continues to decline sharply, implying that interest rate increases remain effective in reducing inflation, albeit with diminishing intensity.

$$\hat{y} = -0.7568 + 7.1926x_4 + 21.2203(x_4 - 0.2588)_+ - 73.6003(x_4 - 0.1175)_+ + 55.203(x_4 - 0.2590)_+$$

$$(x_4 - k_3) = \begin{cases} -0.7568 + 7.1926x_4 & x_4 < 0.1175 \\ -66.4077x_4 + 8.6453 & 0.1175 \leq x_4 < 0.2588 \\ -45.1874x_4 + 2.8560 & 0.2588 \leq x_4 < 0.2590 \\ 100.3940x_4 - 11.4412 & x_4 \geq 0.2590 \end{cases}$$

In the equation above, there are four intervals /segments which can then be interpreted with the following graphic visualization

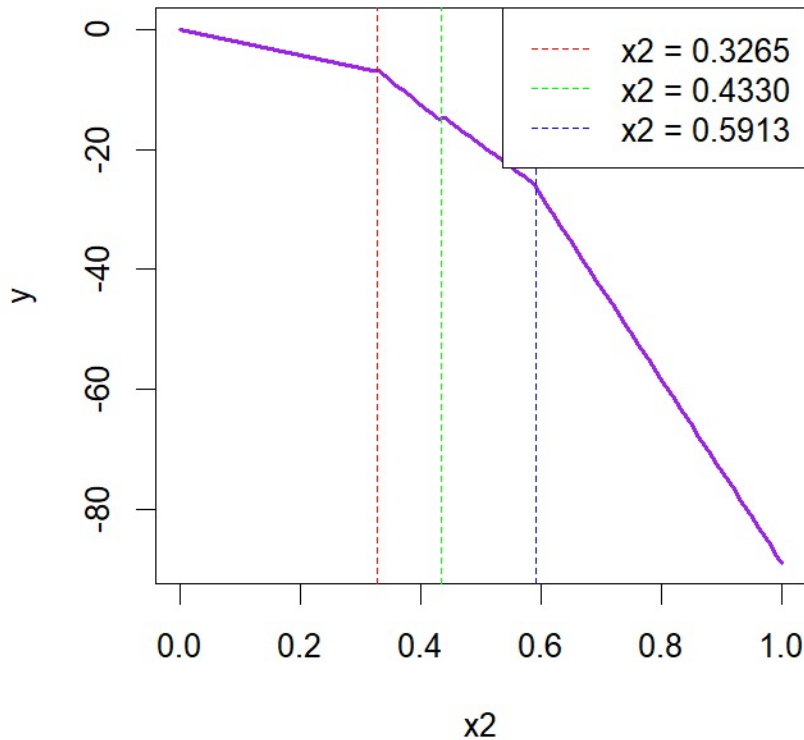


Figure 6. Function graphs in Eq x_4

Based on the graph above, the Consumer Price Index (CPI) variable (X_4), which represents the money supply, can be divided into four distinct segments separated by three knot points at $X_4 = 0.1175$, 0.2588 , and 0.2590 .

In the first segment, when the money supply is below 0.1175% and increases by 1% , the inflation rate rises by 7.1926% . The curve in this segment shows a mild upward trend, indicating that inflation exhibits relatively low sensitivity to changes in the money supply at this level.

In the second segment, where the money supply ranges from 0.1175% to 0.2588% , a 1% increase in the money supply results in an inflation rate of 8.6453% . The slope of the curve becomes noticeably steeper, reflecting a strong positive relationship between the money supply and inflation. This suggests that increases in the money supply within this interval have a more pronounced impact on inflation.

In the third segment, when the money supply lies between 0.2588% and 0.2590% , a 1% increase leads to an inflation rate of 2.8560% . Although the relationship remains positive, the magnitude of the effect weakens compared to the previous segment, indicating a reduced sensitivity of inflation to changes in the money supply.

In the final segment, when the money supply exceeds the upper threshold and increases by 1% , the inflation rate rises sharply to 11.4412% , representing the strongest effect among all segments. The graph displays a steep upward trajectory, indicating that inflation becomes highly sensitive to changes in the money supply within this range.

5. CONCLUSION

According to the three knot values, the optimal GCV value is at three knot points with a value of 0.6560. The following is the form of the nonparametric regression model k spline on the factors that influence inflation in Indonesia as follows

$$\begin{aligned}\hat{y} = & -0.7568 - 0.1659x_1 - 0.1584(x_1 - 0.6560)_+ + 0.7070(x_1 - 0.7179)_+ + 0.0586(x_1 - 8445)_+ - 21.5205x_2 \\ & - 77.4821(x_2 - 0.5913)_+ - 59.0800(x_2 - 0.3265)_+ + 5.229(x_2 - 0.4330)_+ + 0.3783x_3 - 4.4725(x_3 - 0.2201)_+ \\ & + 7.3405(x_3 - 0.4206)_+ - 13.7092(x_3 - 0.5825)_+ - 7.1926x_4 - 21.2203(x_4 - 0.2588)_+ - 73.6003(x_4 - 0.1175)_+ \\ & + 55.203(x_4 - 0.2590)_+\end{aligned}$$

Based on the coefficient of determination (R^2) value of 64.13% obtained from the model, it can be concluded that approximately 64% of the variation in inflation is explained by the predictor variables included in the model. Among these predictors, the Consumer Price Index (X_1), interest rates (X_2), and the money supply (X_4) are identified as having a significant influence on the response variable.

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