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Determinants of Fishermen and Fish Farmers Exchange Rate: A Panel Data Regression Approach

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ABSTRACT

This study examines the impact of key economic variables on the exchange rate of fishermen and fish farmers using monthly panel data by subsector/province for the period 2022–2024 sourced from BPS. The price index received by farmers (Y) is explicitly defined as the dependent variable. A panel data regression model was employed using three independent variables: Farmers' Paid Price Index (X_1), the Fishermen and Fish Farmers Exchange Rate (X_2), and the Fishermen's Business Exchange Rate (X_3). The results showed that both X_1 and X_2 had a significant positive effect ($\alpha < 0.05$) on Y, with X_1 exhibiting a stronger influence than X_2. These findings suggest that policies aimed at controlling input prices and stabilizing exchange rates can effectively improve the welfare of fishermen and fish farmers. Furthermore, the regression model developed in this study provides a practical analytical framework for supporting data-driven policy decisions related to price dynamics and welfare enhancement in the fisheries sector.

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1. INTRODUCTION

The fisheries sector played a strategic role in Indonesia's economy as a maritime nation with the world's second-longest coastline [1]. This sector not only contributed to national economic growth and food security but also served as a primary source of livelihood for millions of people, particularly coastal communities working as fishermen and fish farmers [2][3]. Although Indonesia had abundant fisheries resources, the welfare of fishermen and fish farmers remained a major concern. This condition was reflected in the fluctuations of the Fishermen's Exchange Rate (NTN) and the Fish Farmers' Exchange Rate (NTPI), which both served as key indicators of welfare in the fisheries sector [4][5].

The dynamics of NTN and NTPI were influenced by multiple factors such as fishery commodity prices, production costs, government policies, and climate variability [6]. Understanding these influencing factors was crucial for designing effective policies aimed at improving the welfare of fisheries households. Furthermore, the Index of Prices Received and Paid by Farmers, which underlies NTN and NTPI, reflected the purchasing power of fishermen and fish farmers in meeting both consumption and production needs [7][8].

Previous studies on NTN and NTPI generally focused on descriptive or cross-sectional analyses, which limited their ability to capture both regional variations and temporal dynamics [9][10]. As a result, the literature has not adequately explained how economic, institutional, and environmental variables jointly affect the welfare of fishermen and fish farmers over time. This research gap highlights the need for a more comprehensive approach that can analyze variations across regions while accounting for changes over time.

To address the specific research gap, namely the limited empirical evidence on how policy-related factors and regional differences affected NTN and NTPI, this study used a panel data regression model that combined regional and temporal variations. This method allowed better control of unobserved heterogeneity and reduced multicollinearity. Through this approach, the study provided a clearer contribution to NTN/NTPI research by identifying key determinants of welfare indicators in Indonesia's fisheries sector.

The Fishermen's Exchange Rate (NTN) and the Fish Farmers' Exchange Rate (NTPI) serve as vital indicators of welfare, where NTN/NTPI > 100 indicates a surplus or prosperous condition and NTN/NTPI < 100 indicates a deficit or less prosperous condition [11][12]. Both indices are calculated as the ratio between the price index received and the price index paid by fishermen or fish farmers [13]. Empirical evidence suggests that NTN tends to be more volatile than NTPI, as capture fisheries are more sensitive to seasonal and climatic variations [14] [15]. Small-scale fishermen often record lower NTN values due to limited technology and market access [16][17]. Given these challenges, strengthening NTN and NTPI requires integrated strategies, including business diversification, institutional reinforcement, modernization of fishing and aquaculture technology, market access improvement, and development of storage and processing facilities [18][19][20][21]. Therefore, this study aimed to provide a clearer contribution to the literature by empirically analyzing the determinants of NTPI using a panel data regression approach for the period 2022–2024. By focusing specifically on the fish farmers' exchange rate index (NTPI) and applying consistent notation, the study offered evidence-based insights to support policies that enhance welfare and economic resilience in Indonesia's fisheries sector.

2. RESEARCH METHOD

2.1 Research Design

The research variables were defined as measurable concepts that could be quantified with different values in order to provide a comprehensive overview of the studied topic [22]. In this study, three independent variables and one dependent variable were employed. The independent factors included the Farmers' Paid Price Index, the Fishermen and Aquaculture Exchange Rate (NTNP), and the Fishermen's Business Exchange Rate (NTNP). The data collection subsection correctly states that secondary data from BPS (https://bps.go.id) are used, covering monthly Fishermen and Fish Farmers Exchange Rate and related indices for 2022–2024.

2.2 Data Collection Technique

Secondary data referred to the type of data that was collected by other parties or obtained from pre-existing sources. This data was not directly collected by the researcher or the data user but was used by individuals or organizations for analysis, research, or other purposes. Secondary data could take the form of various types of information, including statistical data, research reports, surveys, business documents, government data, social media data, and many others. This data was obtained from sources such as government institutions, non-governmental organizations, private companies, research institutions, or public databases [23][24]. The data used in this research employed secondary data in the form of the Fishermen and Fish Farmers Exchange Rate in Indonesia for the period of 2022–2024, (Source: https://bps.go.id/).

2.3 Analytical Method

1. Identification of Problems, Objectives, and Research Hypotheses

1) The phenomenon to be studied as well as the objectives of the research were determined, for example analyzing the influence of several independent variables on one dependent variable.
2) A theoretical review and literature study were conducted to strengthen the conceptual foundation of the research.
3) Hypotheses were formulated as temporary assumptions regarding the relationship between independent variables (X_1, X_2, X_3) and the dependent variable (Y)
   - Hypothesis of Partial Effect

H_0: There was no partial effect of the independent variable X_1, X_2, X_3 on the dependent variable Y
H_1: There was a partial effect of the independent variable X_1, X_2, X_3 on the dependent variable Y

- Hypothesis of Simultaneous Effect

  H_0: There was no simultaneous effect of the independent variable X_1, X_2, X_3 on the dependent variable Y
  H_1: There was a simultaneous effect of the independent variable X_1, X_2, X_3 on the dependent variable Y

2. **Classical Assumption Test**
   - Normality Test: examined whether the data were normally distributed.
   - Multicollinearity Test: ensured that there was no strong correlation among the independent variables.
   - Heteroscedasticity Test: checked whether the error variance was constant.
   - Autocorrelation Test: ensured that the errors were not correlated across periods (specifically for time series data).
3. **Panel Data Regression Analysis**

panel data were a combination of time series data (over time) and cross-section data (across individuals or regions). Cross-section data were data collected at one point in time from many individuals, while time series data were data collected over time from a single individual. Panel data regression analysis was a regression analysis tool in which data were collected from individuals (cross-section) and followed over certain periods (time series). It was called a combination because this data consisted of several objects or sub-objects over several periods. Panel data were obtained when a number of objects were observed over time. The general form of the panel data regression model could be expressed as follows:

$$Y_{it} = \alpha_{it} + x_{it}\beta + \mu_{it} \quad (1)$$

The regression coefficients were estimated using the OLS (Ordinary Least Squares) method. Statistical Tests as follows: [25] **t-test** (tested the partial effect of each independent variable on Y), equation was formulated as follows:

$$t = \frac{b_i}{SE(b_i)} \quad (2)$$

F-test: tested the simultaneous effect of all independent variables on Y, equation was formulated as follows:

$$F = \frac{R^2/k}{(1-R^2)/(n-k-1)} \quad (3)$$

Coefficient of Determination (R²): measured the extent to which the independent variables explained the dependent variable, equation was formulated as follows:

$$F = \frac{SSR}{SST} = 1 - \frac{SSE}{SST} \quad (4)$$

3. RESULT AND ANALYSIS

3.1 Results

The data processing was carried out based on NTNP (Fishermen and Fish Farmers Exchange Rate). The variables used were the Farmers' Received Price Index (Y), the Farmers' Paid Price Index (X_1), the Fishermen and Fish Farmers Exchange Rate (X_2), and the Fishermen's Business Exchange Rate (X_3). Before the analysis was conducted, the data were first described. The results of the data description could be seen in Table 1.

Table 1. Data Description

Y		X_1		X_2		X_3	
Mean	119.8637	Mean	112.7455	Mean	104.2033	Mean	106.015
Standard Error	0.398827	Standard Error	0.447734	Standard Error	0.309253	Standard Error	0.224669
Median	120.585	Median	113.207	Median	105.175	Median	105.8
Standard Deviation	2.392964	Standard Deviation	2.686402	Standard Deviation	1.855517	Standard Deviation	1.348011
Sample Variance	5.726279	Sample Variance	7.216755	Sample Variance	3.442943	Sample Variance	1.817134

Based on the results of the descriptive analysis in Table 4.1, the variable Y had a mean value of 119.86 with a median of 120.59, so it could be said that the Y data tended to be symmetrical and stable because the difference between the mean and the median was very small. The standard deviation value of Y was 2.39, which indicated that the data variation was relatively low around its mean. The variable X1 had a mean of 112.75 with the highest standard deviation compared to the other variables (2.69), so even though its value was close to Y, its variation was greater and showed relatively high fluctuations. Meanwhile, the variables X2 and X3 had mean values of 104.20 and 106.02, respectively, with lower standard deviations (1.86 and 1.35), indicating that both were more stable compared to X_1. The median values that were almost the same as the means for all variables also indicated that the data distribution was relatively normal and not skewed to one side. Thus, it was concluded that this panel data showed good stability, in which Y tended to be stable, X_1 played an important role with greater variation, while X_2 and X_3 were relatively more consistent in their movements. The distribution of the data for variables X_1, X_2, and X_3 could be seen in Figure 1.

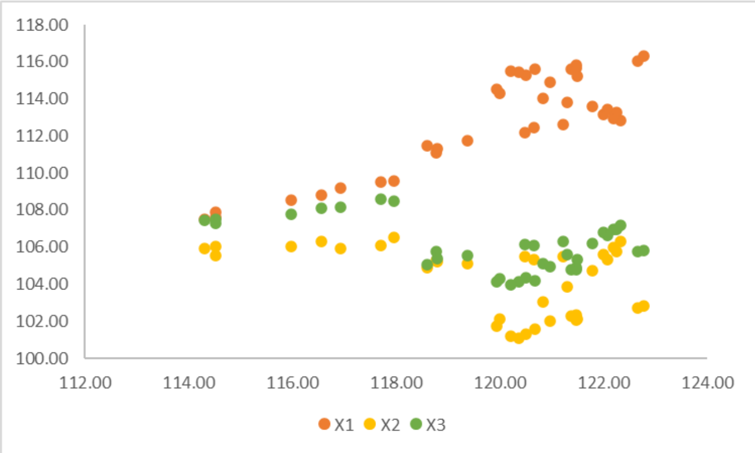

Figure 1. Visualization of the Distribution of Independent Variables X_1, X_2, and X_3

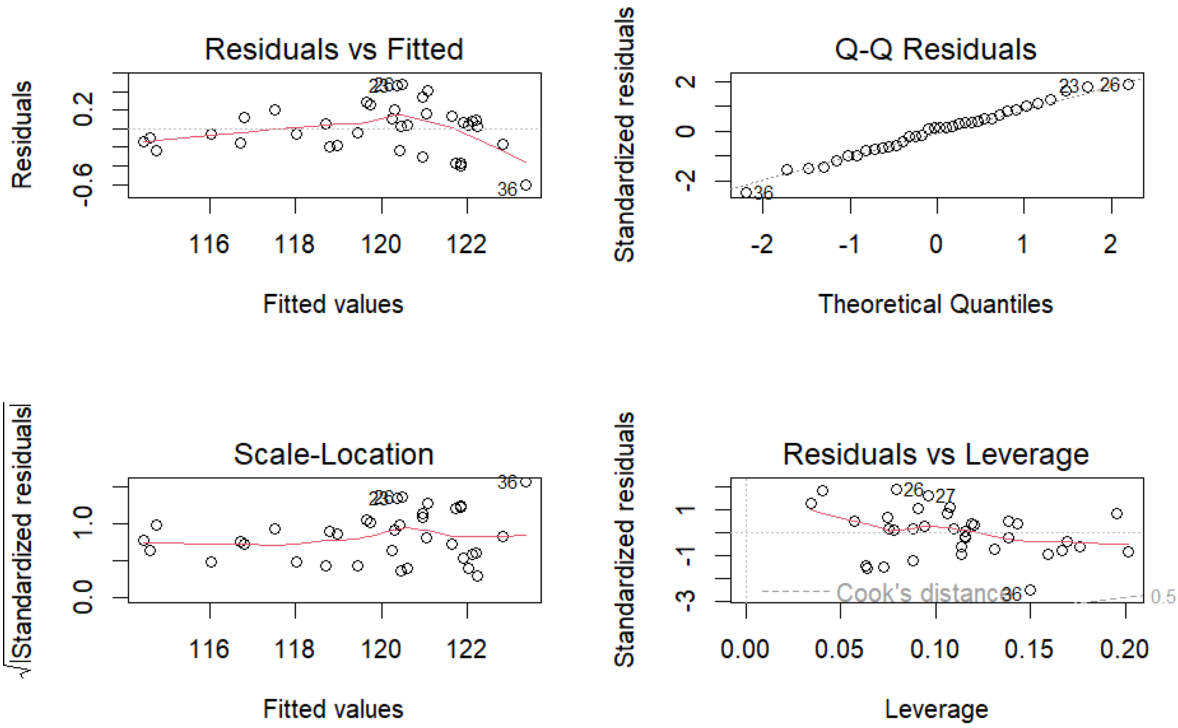

Figure 2. Residual Plot

3.1.1 Chow Test

The Chow test was used to choose between the common effect and fixed effect models. If the p-value was greater than the significance level (α), the common effect model (CEM) was selected; otherwise, the fixed effect model (FEM) was chosen. The results were obtained using software statistics.

Table 2. Chow Test

Effects Test	Statistic	p-value
Cross-section F	4,43	0.0002

H_0 : common effect model dan H_1: fixed effect model, with a 95% confidence level, the test results indicated that H_0 was rejected because the p-value was smaller than α. Therefore, it was concluded that the most appropriate model to use was the Fixed Effect Model (FEM).

3.1.2 Hausman Test

he Hausman test was used to determine the best model between the fixed effect and random effect models. If the p-value was greater than α, the random effect model (REM) was used, while if the p-value was smaller than α, the fixed effect model (FEM) was selected. The test results were presented based on the output of statistical software.

Table 3. Hausman Test

Test Summary	Chi-sq-statistic	p-value
Cross section random	26.40	0.0004

H_0 : random effect model dan H_1 : fixed effect model, with a 95% confidence level, the decision was to reject H_0 because the p-value was smaller than the predetermined α value. Therefore, the appropriate model used was the Fixed Effect Model (FEM).

3.1.3 Breush-pagan LM Test

This test was used to determine whether the random effect model was better than the common effect model using the Lagrange Multiplier (LM) test developed by Breusch-Pagan, which was based on the residuals of the common effect model. The test results were presented based on the output of statistical software.

Table 4. Breush-pagan LM Test

Test Summary	Statistic	p-value
Breush-pagan LM	3. 61	0.043

H_0: model common effect dan H_1: model random effect, based on the output, the Breusch-Pagan probability (Both) value was 0.043, which was smaller than α (0.05) at a 95% confidence level, so H_0 was rejected. Therefore, the appropriate model used was the Random Effect Model (REM).

3.1.4 Panel Data Regression Assumption Test

The classical assumption test in panel data regression analysis aimed to verify whether the data met the basic assumptions required to produce efficient and valid estimations. These classical assumptions were important because violations of them could lead to biased results. In this research, several assumption tests were employed, including the Residual Normality Test, the Multicollinearity Test, the Heteroscedasticity Test, and the Autocorrelation Test.

1) Residual Normality Test

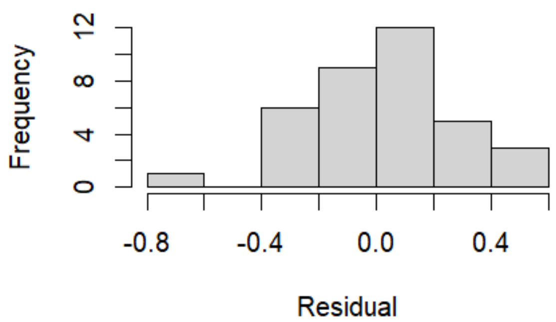

Figure 3. Histogram Residual

The residual histogram showed a distribution that tended to be normal. It was observed that most of the residual values were centered around zero, with higher frequencies near that value compared to those farther from zero. The relatively symmetrical and bell-shaped form of the histogram indicated that the residuals were almost normally distributed. There was no pattern showing outliers or highly skewed distribution, which usually indicated a violation of the normality assumption. Nevertheless, for further confirmation, a statistical test such as the Shapiro–Wilk test was conducted. The p-value obtained in the Shapiro–Wilk normality test was 0.935, which was greater than α (5% = 0.05), so the data fulfilled the normality assumption.

2) Multicollinearity Test

Based on the VIF value, if VIF < 10 then the data were considered to meet the multicollinearity assumption. The results of the residual test showed the following VIF values:

Table 5. VIF Value

Variable	X_1	X_2	X_3
VIF	3.206	5.563	4.929

Based on the results, since all variables had VIF values < 10, the data fulfilled the multicollinearity assumption.

3) Heteroscedasticity Test

This test was carried out based on the studentized Breusch–Pagan test. The results showed a p-value of 0.2865; therefore, there was no indication of heteroscedasticity.

4) Autocorrelation Test

The testing was carried out based on the results of the Durbin–Watson test. The results showed a p-value of 0.06709; therefore, it could be stated that there was no autocorrelation in the model.

3.1.5 Test of Parameter Significance

1) **Simultaneous Test (F-Test)**

The simultaneous test was used to determine the effect of all independent variables on the dependent variable with the following hypotheses:

$H_0: \beta_1 = \beta_2 = \cdots = \beta_k = 0$

H_1: at least one $\beta_j \neq 0, with\ j = 1, 2, \dots, k$

The testing criterion was that H_0 was rejected if the F-statistic value was greater than the F-table value or if the p-value was less than α. The simultaneous parameter testing was conducted using R-Studio. The results of the testing could be seen in the table below:

Table 6. Simultaneous Test

Residual standard error	0.2627
Adjusted R-squared	0.988
F-statistic	957.7
p-value	0.000

Based on the results of the testing in the table above, the p-value was 0.000 and the F-statistic value was 957.7, which was greater than the F-table value of 2.874 at the 5% significance level. Since the F-statistic value was greater than the F-table value and the p-value was less than α, H_0 was rejected. This meant that the independent variables had a significant effect.

The value of the Adjusted R-squared (R^2) coefficient of the model was 0.988 or 98.8%. This meant that 98.8% of the Farmers' Received Price Index (Y) was explained by the regression model, while the remaining 1.2% was explained by other factors outside the model.

2) **Partial Test (t-test)**

The partial test was used to determine which independent variables had a significant individual effect on the dependent variable, with the following hypotheses:

$H_0: \beta_j = 0$

$H_1: \beta_j \neq 0, dengan\ j = 1, 2, \dots, k$ (k is koefisien slope)

H_0 was rejected if the t-statistic value was greater than the t-table value or if the p-value was less than α, which meant that the independent variable had a significant effect on the dependent variable. The partial parameter testing was conducted using R-Studio. The results of the analysis were obtained as follows:

Table 7. Partial Test

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	51.23411	8.55141	-17.685	<2e-16 ***
X_1	1.38822	0.02961	46.885	<2e-16 ***
X_2	1.05786	0.05644	18.742	<2e-16 ***
X_3	0.04102	0.07313	0.561	0.579

The partial effect of the independent variables on the dependent variable was as follows:
The t-test result for the **variable** Farmers' Paid Price Index (X_1) showed a t-statistic value of 46.885 > t-table of 1.688 and a p-value < α or significance value <2e-16 *** (0.000) < 0.05, so H_0 was rejected. This meant that the variable Farmers' Paid Price Index (X_1) had a significant effect on the Farmers' Received Price Index (Y).

- The t-test result for the variable Fishermen and Fish Farmers Exchange Rate (X_2) showed a t-statistic value of 18.742 > t-table of 1.688 and a p-value < α or significance value <2e-16 *** (0.000) < 0.05, so H_0 was rejected. This meant that the variable Fishermen and Fish Farmers Exchange Rate (X_2) had a significant effect on the Farmers' Received Price Index (Y).
- The t-test result for the variable Fishermen's Business Exchange Rate (X_3) showed a t-statistic value of 0.561 < t-table of 1.688 and a p-value > α or significance value of 0.579 > 0.05, so H_0 failed to be rejected. This meant that the variable Fishermen's Business Exchange Rate (X_3) did not have a significant effect on the Farmers' Received Price Index (Y).

3) **Model Interpretation**

Based on the tests that were conducted, the final panel data regression model obtained was the Fixed Effect Model, using statistical software:

$$Y = 51.23 + 1.38822X_1 + 1.05786X_2$$

Based on the model in the equation, the interpretation was as follows:

1. When X_1 and X_2 were equal to 0 (the baseline or reference point), the value of Y was estimated to be 51.23, meaning that the average value of Y was 51.23 percent.
2. The positive value showed a direct relationship between X_1 and Y. It meant that when X_1 increased by 1%, the average value of Y increased by 1.38822%, assuming X_2 remained constant
3. The positive value also showed a direct relationship between X_2 and Y. This meant that every 1% increase in X_2 increased Y by 1.05786%, assuming X_1 remained constant

3.2 Discussion of the Findings

The findings are consistent with previous studies, confirming that input price stability and exchange rate management significantly influence welfare. Unlike prior descriptive analyses, this research provides stronger empirical evidence through a panel framework that accounts for both temporal and regional effects. The insignificance of certain control variables in preliminary testing reflects regional diversity and adaptive behavior of fishermen toward price shocks. Strengthening local cooperatives and government intervention in price control can mitigate such disparities.

This research could be linked to studies that examined the factors influencing agricultural commodity prices, particularly in the context of developing countries, where economic variables such as exchange rates and the prices paid to farmers played an important role. In the research [26], analyzed the effect of land area, production quantity, and selling prices of long beans, cayenne pepper, and tomatoes on the exchange rate of horticultural farmers in South Sulawesi Province. The results of the study showed that these factors simultaneously affected the farmers' exchange rate, and the selling prices of cayenne pepper and tomatoes had a significant partial effect, with a recommendation for the government to design policies that supported the welfare of farmers.

The results of the analysis showed that X_1 (Farmers' Paid Price Index) had a significant positive effect on the Farmers' Received Price Index (Y), which was consistent with the findings in the research [7] to identify the variables that influenced farmers' welfare in Indonesia by using secondary data from the Central Bureau of Statistics of Indonesia for the period 2019–2022. The results of the analysis showed that rice productivity and the Farmers' Paid Price Index had a significant positive effect, while rice production had a significant negative effect on farmers' welfare. This was because higher prices gave farmers an incentive to increase their production, thereby potentially improving overall economic welfare.

The regression model obtained in this research had an Adjusted R-squared of 0.988, which meant that 98.8% of the variability in the prices received by farmers (Y) could be explained by X_1 and X_2. This very high coefficient of determination showed that the regression model was highly effective in explaining the factors influencing the prices received by farmers, and it emphasized that changes in X_1 and X_2 had a very strong effect on Y. In many other social studies, as found by [27], A model with a high Adjusted R-squared value showed that most of the significant variable.

The results of this regression analysis also provided useful insights for government policies related to the prices received by farmers. For example, policies that increased the prices paid to farmers (X_1), such as direct subsidies or the purchase of agricultural products at higher prices, could potentially increase farmers' income significantly. This was consistent with the policies proposed in the research, which suggested that higher prices for farmers, followed by price stabilization policies, could improve farmers' welfare in developing countries. In addition, policies to strengthen the exchange rate (such as monetary policies or international trade policies) could have a positive impact on the prices received by farmers, particularly in the fisheries sector and in commodities traded internationally. The research [28] also showed that policies maintaining exchange rate stability could reduce price volatility and provide certainty for farmers in long-term planning.

4. CONCLUSION

Overall, the results of this analysis showed that the Farmers' Paid Price Index (X_1) and the Fishermen and Fish Farmers Exchange Rate (X_2) had a significant effect on the Farmers' Received Price Index (Y). This suggested that policies influencing these factors could improve farmers' welfare, in line with the findings of related studies which stated the importance of price and exchange rate factors in increasing income in the agricultural sector. This model could serve as a reference in designing economic policies that better supported farmers, particularly in improving the prices they received. Based on the panel data regression model that was analyzed, both independent variables, namely X_1 and X_2, had a positive effect on Y (Fishermen and Fish Farmers Exchange Rate). The coefficient of X_1 was 1.38822, which indicated that every one-unit increase in X_1, with X_2 held constant, increased Y by 1.38822. Meanwhile, the coefficient of X_2 was 1.05786, which indicated that every one-unit increase in X_2, with X1 held constant, increased Y by 1.05786. Overall, both independent variables contributed positively to the increase in the Fishermen and Fish Farmers Exchange Rate, with X_1 exerting a greater effect than X_2. In the Fixed Effect Model approach, the R^2 value was 0.988, indicating that the independent variables selected in this study jointly explained 98.8% of the variation in the dependent variable, while the remaining 0.2% was explained by other variables not included in the model.

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