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Determinants of the Prevalence of Province Food Insufficiency in Indonesia in 2023 With A Quantile Regression Approach

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Abstract

This study analyzes the determinants of food insufficiency prevalence across 34 provinces in Indonesia using a quantile regression approach. The research focuses on three key variables: the Food Security Index (IKP), rice productivity (PVP), and per capita food expenditure (PPM), using 2023 cross-sectional data from Statistics Indonesia (BPS). Results from ordinary least squares (OLS) and quantile regression at the 25th, 50th, and 75th percentiles reveal that the Food Security Index has a consistent and significant negative effect on food insufficiency across all quantiles, with the strongest influence observed at the higher quantile ($\tau = 0.75$). In contrast, rice productivity is not statistically significant at any quantile, while per capita food expenditure is only marginally significant at the 25th quantile. These findings suggest that improvements in food security contribute significantly to reducing food inadequacy, especially in regions with high prevalence rates. However, the impact of rice productivity and food spending varies across different segments, implying that context-specific policies are needed. The study recommends targeted government interventions to enhance food access, affordability, and regional food security equity.

Keywords Food expenditure, Food insecurity, Food security index, Quantile regression, Rice productivity.

INTRODUCTION

Food insecurity remains a crucial challenge for developing countries like Indonesia, despite being an agricultural nation with rich natural resources. The geographic and socioeconomic disparities across the archipelago result in unequal access to food and varied agricultural productivity. This study examines the factors influencing the prevalence of food inadequacy (PKP) across Indonesia's 34 provinces using a quantile regression approach, focusing on the Food Security Index (FSI), rice productivity (PVP), and per capita food expenditure (PPM) in 2023.

Data were obtained from the Central Bureau of Statistics (BPS) and analyzed using a cross-sectional design. Quantile regression was applied to evaluate the relationships at different distribution points of food inadequacy (i.e., at the 25th, 50th, and 75th quantiles), which allows a more nuanced understanding than traditional OLS models. This method is suitable for data with non-normal distributions and helps identify differential effects of explanatory variables on various groups (Koenker & Hallock, 2001).

In general, poverty is defined as the inability to meet basic needs, which are economically measured by income or expenditure (Roseline & Maimunah, 2022). Keynes' consumption theory in his book entitled The General Theory of Employment, Interest and Money explains the relationship between current income (disposable income) and current consumption. In other words, the income owned at a certain time will affect the consumption

made by humans at that time. If income increases, consumption will also increase, and vice versa (Pujoharso, 2013).

The increase in national consumption will indirectly have an impact on the domestic economy and industry which will continue to grow. Household consumption expenditure is one of the macroeconomic variables (Murwiati & Zulkarnain, 2023). The descriptive statistics revealed that the average food inadequacy rate in Indonesian provinces was 11.49%. The average food security index stood at 74.11%, while rice productivity averaged 46.31 quintals per hectare, and per capita food expenditure was IDR 13.47 million annually. These indicators suggest considerable variability in food access and agricultural performance across regions (BPS, 2023).

Quantile regression results indicate that the food security index (FSI) and food expenditure (PPM) have a significant negative effect on food inadequacy prevalence, particularly in higher quantiles. This implies that provinces with the highest food insecurity levels benefit the most from improvements in these areas. However, rice productivity (PVP) was not a significant determinant in any of the quantiles, suggesting that availability alone may not sufficiently reduce food inadequacy (Fanzo, 2019; Handayani & Fariyanti, 2019).

These findings highlight the importance of policies that go beyond increasing food production. Enhancing access, affordability, and equitable food distribution is essential for reducing chronic food insecurity. The government should prioritize investments in food affordability and infrastructure while addressing regional disparities in food access and economic capacity (Headey & Ecker, 2013; Pingali, 2012).

In conclusion, strengthening food security and increasing household food expenditure are critical in lowering food inadequacy across Indonesian provinces. While rice productivity remains important for overall availability, it must be complemented with economic empowerment and equitable policy implementation. Future research may consider panel data approaches and integrate broader social indicators to enrich the analysis.

METHOD

The study adopts a quantitative approach with descriptive analysis by employing quantile regression to interpret and explain the quantitative findings. Although Indonesia comprises 34 provinces as of 2025, due to data limitations the research covers all 34 provinces using data from the year 2023. These provinces include Aceh, North Sumatra, West Sumatra, Riau, Riau Islands, Jambi, South Sumatra, Bengkulu, Bangka Belitung, Lampung, DKI Jakarta, Banten, West Java, Central Java, the Special Region of Yogyakarta, East Java, West Kalimantan, Central Kalimantan, South Kalimantan, East Kalimantan, North Kalimantan, Bali, West Nusa Tenggara, East Nusa Tenggara, North Sulawesi, Gorontalo, Central Sulawesi, West Sulawesi, South Sulawesi, Southeast Sulawesi, Maluku, North Maluku, Papua, and West Papua.

This study focuses on four key variables to analyze food inadequacy in Indonesia: the Prevalence of Food Inadequacy (PKP), the Food Security Index (IKP), Rice Productivity (PVP), and Per Capita Food Expenditure (PPM). PKP represents the percentage of the population unable to meet the minimum daily energy intake, serving as a direct indicator of

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chronic food insecurity. IKP is a composite index that measures a region's food security based on food availability, access, and utilization. Both indicators are sourced from the Central Bureau of Statistics (BPS). Rice Productivity (PVP) reflects the amount of rice produced per hectare, serving as a proxy for agricultural efficiency and regional food availability. Per Capita Food Expenditure (PPM), on the other hand, indicates household economic capacity to access food, measured in Indonesian Rupiah. These variables provide a comprehensive picture of the structural and economic factors influencing food adequacy across 34 Indonesian provinces in 2023.

Regression analysis involves estimating unknown parameters to understand the relationship between a dependent variable and one or more independent variables (Gujarati, 2004). In this study, quantile regression is used to divide household food consumption data across Indonesia's provinces into three quantile levels: 25%, 50%, and 75%. Each level represents different segments of food security distribution, enabling the analysis of how key variables—such as the number of beneficiary households, regional GDP per capita, and inflation—impact food consumption at different points in the distribution. The quantile regression process includes three main steps. First, estimation is conducted by grouping the data into quantiles using Stata 16 software. Second, the estimated results are interpreted to assess whether the independent variables behave consistently with the research hypotheses at each quantile. Lastly, model performance is evaluated to determine the best-fitting quantile model using the R^2 value, which indicates how much of the variability in food inadequacy is explained by the independent variables. A higher R^2 suggests a stronger explanatory power of the model.

$$PKP_i = \beta_0 + \beta_1 IKP_i + \beta_2 PVP_i + \beta_3 PPM_i + \varepsilon_i$$

Where:

PKP_i = Prevalence of Food Inadequacy in province *i* (in percentage)
β_0 = Intercept (constant term)
$\beta_1, \beta_2, \beta_3$ = Regression coefficients for each independent variable
IKP_i = Food Security Index in province *i* (in percentage)
PVP_i = Rice Productivity in province *i* (in quintals per hectare)
PPM_i = Per Capita Food Expenditure in province *i* (in Indonesian Rupiah)
ε_i = Error term
i = Cross-sectional unit (province)

RESULTS AND DISCUSSION

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
pkp	34	11.48824	7.809105	2.17	35.63
ikp	34	74.10971	9.673371	42.27	87.65
pvp	34	46.31029	8.35506	28.11	62.07
ppm	34	13.46804	0.159891	13.15516	13.8699

Source: Output Stata, 2025

The dataset consists of 34 observations representing Indonesian provinces. The average Prevalence of Food Inadequacy (PKP) is 11.49%, with a standard deviation of 7.81%, indicating substantial variation across regions. The minimum and maximum PKP values are 2.17% and 35.63%, respectively. The Food Security Index (IKP) averages 74.11% with a standard deviation of 9.67%, suggesting moderate variation, ranging from 42.27% to 87.65%. Rice Productivity (PVP) shows an average of 46.31 quintals per hectare, with values ranging from 28.11 to 62.07 quintals per hectare and a standard deviation of 8.36, indicating interregional differences. Lastly, the Per Capita Food Expenditure (PPM) averages IDR 13.47 million annually, with a narrow spread (standard deviation of 0.16), suggesting relatively consistent spending levels across provinces, ranging from IDR 13.16 million to IDR 13.87 million.

Classical Assumption Tests

To ensure the reliability of the regression model, classical assumption tests were conducted. The normality test using the Skewness/Kurtosis approach showed a p-value of 0.4967, which is greater than the 5% significance level, indicating that the residuals are normally distributed (Widarjono, 2018). However, the heteroskedasticity test using the Breusch-Pagan method yielded a p-value of 0.0297, which is below 0.05, suggesting the presence of heteroskedasticity in the model.

For autocorrelation, the Breusch-Godfrey LM test returned a p-value of 0.4658, which is greater than 0.05, confirming that the residuals are free from autocorrelation issues. Meanwhile, the multicollinearity test using the Variance Inflation Factor (VIF) indicated no multicollinearity problems, as all independent variables had VIF values below 10, with a mean VIF of 1.25. Therefore, aside from the heteroskedasticity issue, the model satisfies the classical assumptions for normality, independence, and multicollinearity.

Statistical Testing Results

Table 2. Results of t-Statistic Test

	(1) PKP
IKP	-0,627***
	(-5,57)
PVP	-0,097
	(-0,78)
PPM	-11,110**
	(-2,15)
_cons	212,067***
	(2,96)
Observations	34
R-squared	0,68

Standard errors are in parentheses

*** p<0,01, ** p<0,05, * p<0,1
Source: Output Stata, 2025

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The results of the t-tests for each independent variable reveal varying effects on the prevalence of food inadequacy in Indonesia. The Food Security Index (IKP) showed a t-statistic of -5.75, which exceeds the critical t-value of -1.697 at a 5% significance level, with a p-value of 0.000. This indicates that the IKP has a negative and statistically significant effect on food inadequacy, meaning that higher food security levels are associated with lower prevalence of food inadequacy.

In contrast, the Rice Productivity (PVP) variable recorded a t-statistic of -0.78, which is lower than the critical t-value, and a p-value of 0.441, which is greater than 0.05. This result suggests that rice productivity does not have a statistically significant impact on food inadequacy. Meanwhile, the Per Capita Food Expenditure (PPM) variable had a t-statistic of -2.15 and a p-value of 0.006, indicating a significant negative effect, where higher food expenditure is linked to reduced food inadequacy.

F-Statistic Test Results

Table 3. F-Statistic Test Results

df(k-1 ; n-k)	F-Statistic	F-Tabel (α=5%)	Probability	Conclusion
3; 30	15,30	2,92	0,0000	H_0 Rejected

Source: Output Stata, 2025

Based on the table above, the F-statistic value is 15.30, which is greater than the F-table value of 2.92 at a 5% significance level with degrees of freedom (df) 3 and 30. This indicates that the null hypothesis (H0) is rejected and the alternative hypothesis (Ha) is accepted. Therefore, it can be concluded that the independent variables jointly have a significant effect on the dependent variable, which is the prevalence of food inadequacy.

Quantile Regression

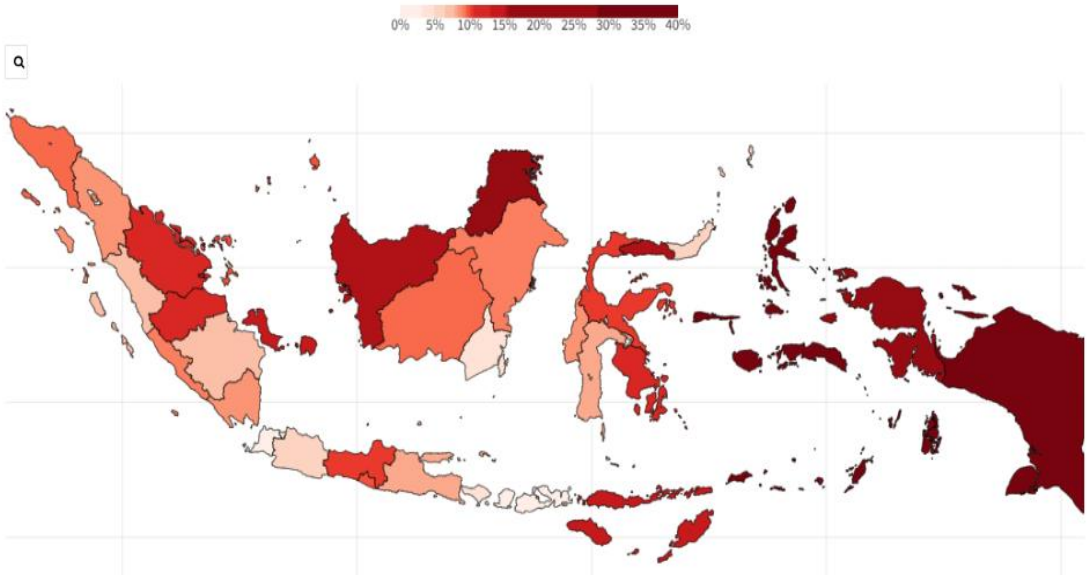

Figure 1. Distribution of Prevalence of Food Insufficiency in 2023
Source: ArcMap, 2025

The image presents a thematic map illustrating the distribution of food consumption inadequacy prevalence across Indonesian provinces in 2023. The map uses a red color gradient, where darker shades indicate higher levels of food inadequacy. The highest prevalence is observed in eastern provinces such as Papua, West Papua, Maluku, and East Nusa Tenggara, while moderate levels are seen in parts of Kalimantan, Sulawesi, and Sumatra. Provinces with low prevalence, shown in light red, are primarily located in western Indonesia, including Jakarta, Bali, and Yogyakarta. This pattern highlights disparities in food access across regions. The data, sourced from Statistics Indonesia (BPS), serves as a reference for shaping national food security policies and identifying priority areas for food intervention. Additionally, quantile regression modeling offers an alternative method for parameter estimation using the simplex approach. This technique moves from one extreme point to another within the feasible region through iterative calculations, gradually identifying the optimal solution.

Table 4. Quantile Regression Parameter Estimates

	(1) OLS	(2) qr_25	(3) qr_50	(4) qr_75
IKP	-0,627***	-0,462 ***	-0,528 ***	-0,723 ***
	(0,000)	(0,001)	(0,001)	(0,000)
PVP	-0,097	-0,032	-0,014	-0,077
	(0.441)	(0.817)	(0,934)	(0,645)
PPM	-11,110**	-10,677*	-8,249	-13,446*
	(0,04)	(0,099)	(0,308)	(0,085)
_cons	212,067***	212,067**	160,518	253,474**
	(0,006)	(0,040)	(0,153)	(0,021)
N	34	34	34	34

Standard errors are in parentheses
*** p<0,01, ** p<0,05, * p<0,1
Source: Output Stata, 2025

$$PKP_i = 212{,}067 - 0{,}627IKP_i - 0{,}097PVP_i - 11{,}110PPM_i$$

$$PKP_{0.25} = 185{,}099 - 0{,}462IKP_i + 0{,}319PVP_i - 10{,}677PPM_i$$

$$PKP_{0.50} = 160{,}518 - 0{,}528IKP_i + 0{,}014PVP_i - 8{,}249PPM_i$$

$$PKP_{0.75} = 253{,}474 - 0{,}723IKP_i - 0{,}077PVP_i - 13{,}446PPM_i$$

The quantile regression analysis at $\tau = 0.25$, 0.50, and 0.75 reveals consistent patterns regarding the influence of independent variables on the prevalence of food consumption inadequacy. Across all quantiles, the Food Security Index (IKP) shows a statistically significant negative effect, indicating that a 1% increase in IKP reduces food inadequacy prevalence by 0.462% at $\tau = 0.25$, 0.528% at $\tau = 0.50$, and 0.723% at $\tau = 0.75$, holding other variables constant. This underscores the critical role of food security in mitigating food inadequacy. In contrast, rice productivity consistently shows a positive but statistically insignificant effect at all quantiles, suggesting it does not have a meaningful impact on food

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inadequacy levels. Likewise, per capita food expenditure has a negative but statistically insignificant relationship across the three quantiles—though the effect becomes stronger at higher quantiles (−10.677 at $\tau = 0.25$ and −13.446 at $\tau = 0.75$), it remains not significant at the 5% level. These results suggest that while food security is a key determinant of food adequacy across different population segments, rice productivity and food spending may not uniformly influence food inadequacy at all levels.

The study finds that the Food Security Index (IKP) has a significant negative effect on the prevalence of food inadequacy (PKP) across Indonesian provinces. A 1% increase in the IKP is associated with a 0.627% decrease in PKP, assuming other variables remain constant. This inverse relationship supports prior research emphasizing the critical role of food availability, accessibility, and utilization in regional food security. Studies by Widada et al. (2017), Sinaga et al. (2022), and Amalia et al. (2024) highlight how improvements in infrastructure, public health, and education positively impact IKP and reduce PKP.

Azhar (2022) and Suryana (2014) demonstrate that better access to electricity, healthcare, and roads can strengthen food security and lower food inadequacy levels. Regarding rice productivity, the regression results show a negative but insignificant relationship with PKP, contrary to the research hypothesis. This may be due to uneven distribution of rice production across provinces and other influencing factors such as purchasing power and food diversity. Studies by Suwarno (2020), Sadimantara (2019), and Baihaqi (2025) suggest that while rice productivity remains important, it is not sufficient alone to reduce PKP. Structural challenges like climate change, pest infestations, and limited land availability reduce its effectiveness. Hence, a more comprehensive approach, including food diversification and equitable distribution, is needed to address food inadequacy sustainably.

Finally, per capita food expenditure shows a significant negative impact on PKP, with a 1% increase resulting in a 0.627% decline in food inadequacy. This implies that households allocating more of their income to food can access better and more nutritious diets, thereby reducing the risk of undernourishment. Research by Nisa and Triani (2024), Solana (2022), and Cahyani et al. (2023) supports these findings, showing links between food spending, nutritional status, and broader welfare indicators like the Human Development Index. Additional studies by Kusumawardhani and Martianto (2011) and Hakim et al. (2024) further affirm that improved food expenditure is critical for reducing malnutrition and poverty.

CONCLUSION

The analysis of food consumption inadequacy in Indonesian provinces for the year 2023 reveals several important findings. First, the Food Security Index variable has a statistically significant and negative effect on the prevalence of food inadequacy, indicating that an increase in the index is associated with a reduction in food inadequacy levels, and vice versa. Second, rice productivity is found to have no significant impact on food inadequacy, suggesting that increases in productivity alone do not necessarily translate into improved food access or reduced inadequacy across provinces. Third, per capita food

expenditure also does not show a significant effect on the prevalence of food inadequacy, implying that higher food spending may not always guarantee improved food adequacy.

The quantile regression results offer additional insights. The Food Security Index consistently exhibits a significant negative effect across all quantiles, with the impact becoming stronger at higher quantiles, particularly at the 75th percentile. This suggests that the role of food security is more pronounced in regions or population segments experiencing higher levels of food inadequacy. Meanwhile, rice productivity remains statistically insignificant across all quantiles, reinforcing the finding that its effect is negligible regardless of the severity of food inadequacy. Lastly, per capita food expenditure shows statistical significance only at the 10% level in the 25th percentile, indicating a marginal effect among the lower quantile group, but this relationship is not present in the middle and upper quantiles.

Given that the Food Security Index has a significant negative impact on the prevalence of food inadequacy, it is recommended that both local and national governments prioritize comprehensive food security programs. These efforts may include strengthening food distribution systems, diversifying food sources, and improving access to nutritious food, particularly in provinces with high levels of food inadequacy. Although rice productivity and per capita food expenditure do not show overall significant effects, there are indications of impact within specific groups (e.g., food expenditure is significant at the 25th quantile). Therefore, policies aimed at enhancing productivity and food spending efficiency should be tailored contextually to target the most affected population segments, using a quantile-based approach to improve the effectiveness of interventions.

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