SIJDEB, 8(2), 2024, 129-146
p-ISSN: 2581-2904, e-ISSN: 2581-2912
DOI: https://doi.org/10.29259/sijdeb.v8i2.129-146
Received: 16th June 2024; Revised: 20th Aug 2024; Accepted: 9th Oct 2024

SRIWIJAYA INTERNATIONAL JOURNAL OF DYNAMIC ECONOMICS AND BUSINESS
http://ejournal.unsri.ac.id/index.php/sijdeb

Unveiling the Welfare Puzzle: Exploring Fertilizer Subsidy Effects on Farmer's Earnings in Indonesia

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Abstract: This study investigates the unresolved issue of how fertilizer subsidies affect paddy production and farmer income, a critical aspect of Indonesia's agricultural policy that has not been fully understood. By analyzing panel data from 33 provinces between 2019 and 2022 using the Generalized Least Squares (GLS) method, the research explores both income dynamics and productivity. Results reveal that NPK and SP36 fertilizers boost paddy yields by 0.198% and 0.155%, respectively, while UREA and ZA have no significant impact on production. Additionally, rising wages reduce production by 1.343% but increase farmer income by 0.332%. These findings highlight the complexity of balancing productivity with farmer welfare, suggesting that while fertilizer subsidies can enhance yields, they are not a universal solution. Policymakers must consider multifaceted approaches that address both productivity and sustainable income growth to ensure long-term welfare improvements for Indonesian farmers.

Keywords: Agricultural Policy, Farmer Income, Fertilizer Subsidies, Paddy Production, NPK and SP36

Introduction

Fertilizer subsidies have been a cornerstone of agricultural policies, designed to enhance farmer income and boost agricultural production. However, the impact of these subsidies is multifaceted, influenced by a range of factors operating at national, regional, and international levels. Recent studies highlight that subsidies significantly influence farmers' fertilizer use decisions, with the effects varying according to specific contexts and implementation mechanisms (He et al., 2022). These subsidies are instrumental in promoting crop cultivation, reducing land abandonment, and increasing overall agricultural output, thereby contributing to the livelihoods of farmers (Li et al., 2022). However, to thoroughly evaluate the impact of these subsidies on sustainable agricultural production and farmer income, it is essential to understand the diverse conditions under which farmers operate.

Despite their intended benefits, the distribution of subsidized fertilizers presents significant challenges that can negatively impact farmer welfare. Key issues include inefficiencies in distribution, unequal allocation of benefits, and incomplete data collection (Sarjiman et al., 2023; Wahyudi et al., 2021). Furthermore, subsidies often lead to the overuse of chemical fertilizers and a dependency on imported fertilizers, raising serious environmental and economic concerns (Dulanjani & Shantha, 2022). The limited yield increases among smallholder farmers and reduced demand for commercial fertilizers further erode the effectiveness of subsidy programs (Vondolia & Stage, 2021). These challenges highlight the necessity for policies that not only support agricultural production but also ensure long-term sustainability.

A critical aspect of this issue is the so-called welfare puzzle, which underscores the difficulty in translating increased agricultural productivity into actual improvements in farmer welfare. This puzzle involves balancing multiple, often conflicting factors such as input costs, market prices, labor expenses, and sustainability considerations. Understanding this puzzle is crucial for designing effective agricultural policies that can genuinely enhance farmer welfare.

Although previous research has extensively examined the relationship between fertilizer subsidies and the prices farmers pay, as well as the direct effects of these subsidies on agricultural prices (Gautam et al., 2022; Putri et al., 2023), there remains a significant gap in understanding how these subsidies specifically affect income dynamics, particularly in the context of paddy production in Indonesia. Given that paddy is the staple food for most of Indonesia's population and a critical agricultural commodity, it is central to the country's subsidy policies. Focusing on paddy production allows this study to address a crucial gap in the literature, providing insights that could be applicable to other commodities with similar production and subsidy structures.

This study seeks to bridge this gap by examining the impact of fertilizer subsidy distribution on farmer income, with particular emphasis on price index variables that directly affect the costs and profitability of farming activities. Utilizing the Generalized Least Squares (GLS) methodology, this research analyzes complex relationships within panel data, focusing on Indonesia's paddy production sector, which is vital to the nation's agricultural economy. The findings are expected to offer valuable insights for policy evaluation and the strategic enhancement of paddy production in Indonesia. By deepening our understanding of these dynamics, the study contributes to the development of more effective policies aimed at increasing agricultural production and improving the welfare of farmers in Indonesia.

Literature Review

The Impact of Fertilizer Subsidies on Paddy Production

Fertilizer subsidies are critical in boosting paddy production by reducing input costs for farmers. According to production theory, the availability and effective use of inputs like UREA, NPK, SP36, and ZA fertilizers are essential for improving crop yields, as they enhance soil health and ensure balanced nutrient application—key factors in successful paddy cultivation (Nasrin et al., 2019; Wu et al., 2019). These fertilizers play a vital role in increasing overall paddy production, especially when applied correctly across different regions. However, their effectiveness can vary depending on factors like soil type, farming practices, and climate.

While NPK and SP36 have consistently shown positive effects on production, the results for UREA and ZA are mixed. For instance, controlled-release urea can maintain yields under lower nitrogen conditions, indicating that specific methods may enhance UREA's effectiveness (Hu, 2023). Similarly, biochar-based urea hasn't significantly improved yields in certain contexts, suggesting that UREA's efficiency depends on factors like soil type and application methods (Zhang et al., 2022). Additionally, the area of land harvested (AREAL) significantly impacts production; even small increases in cultivated land can lead to substantial output gains (Iskandar et al., 2022). These insights underline the importance of considering both the type of fertilizer and the conditions under which it is applied to maximize production.

Given these points, we propose the following hypotheses:

- **H1**: The distribution of subsidized fertilizers (UREA, NPK, SP36, ZA) positively influences paddy production (PROD).
- **H2**: The Prices Paid by Farmers Index (IB_FARMER) negatively impacts paddy production (PROD).

The Prices Paid by Farmers Index (IB_FARMER), which reflects the cost fluctuations of goods and services consumed by farmers, theoretically affects production by influencing the cost structure and profitability of farming operations. Higher input costs, as represented by IB_FARMER, are expected to reduce production by increasing costs unless offset by higher productivity or subsidies (Gurung, 2023; Narayanamoorthy, 2022). Despite variations in empirical results, IB_FARMER remains a crucial variable in understanding the cost dynamics in paddy production.

Agricultural economic theory, including the Cobb-Douglas production function, provides a robust framework for analyzing these impacts. This model helps explain how inputs like land (AREAL), labor (WAGES), and capital (including fertilizers such as NPK and SP36) contribute to agricultural output and farmer income. Understanding these relationships is crucial for developing policies that enhance paddy production and improve farmer welfare in Indonesia (Pan et al., 2022; Ren, 2023).

Economic Factors Influencing Farmer Income and the Welfare Puzzle

The relationship between paddy production (PROD) and farmer income (INCOME) in Indonesia is complex, shaped by multiple interdependent factors. While increasing production is often seen as a pathway to higher income, this simplistic view fails to capture the nuances of the "welfare puzzle" faced by farmers. This puzzle refers to the paradox where gains in agricultural productivity do not always translate into proportional improvements in farmer welfare due to the interplay of various economic forces.

A central element of this puzzle is the role of input costs and market dynamics. Subsidized fertilizers like UREA, NPK, SP36, and ZA improve paddy production by enhancing soil fertility and ensuring optimal nutrient application (Nasrin et al., 2019; Wu et al., 2019).

However, the benefits of increased production can be undermined by rising input costs, as captured by the Prices Paid by Farmers Index (IB_FARMER). As input costs rise, even with higher yields, the profitability and, consequently, the income of farmers may decrease, illustrating a critical aspect of the welfare puzzle (Gurung, 2023; Narayanamoorthy, 2022).

From this understanding, we hypothesize:

- **H3**: Higher paddy production (PROD) positively affects farmer income (INCOME).

Another layer of complexity arises from market prices, particularly the Price Received by Farmers Index (IT_FARMER), which reflects the revenue farmers receive from their produce. Fluctuations in IT_FARMER can significantly impact income; a decrease in this index typically leads to reduced income, regardless of production levels. This scenario highlights the vulnerability of farmers to market conditions, where even high productivity does not guarantee financial stability if market prices are unfavorable(Narayanamoorthy, 2022).

Therefore, we propose:

- **H4**: The Price Received by Farmers Index (IT_FARMER) negatively impacts farmer income (INCOME).

Labor costs, represented by WAGES, add further complexity. Higher wages can boost income by improving the economic conditions of farm workers and stimulating local economies. However, they also increase production costs, potentially reducing the overall profitability of farming operations (Tang et al., 2024). This dual impact of wages is a crucial part of the welfare puzzle, where balancing labor costs and income is essential to ensure that gains in one area do not erode benefits in another.

Thus, we hypothesize:

- **H5**: Higher wages (WAGES) negatively impact paddy production (PROD) but positively influence farmer income (INCOME).

In addition, average expenditure on food (FOOD) reflects household consumption patterns and economic stability in rural areas. Higher food expenditures may indicate better living standards, which theoretically should correlate with higher income. However, increased spending on food also suggests a higher cost of living, which can strain household budgets if not matched by corresponding income gains.

Based on this, we hypothesize:

- **H6**: Higher average expenditure on food (FOOD) positively influences farmer income (INCOME).

The welfare puzzle becomes clear when we consider how these factors interact. While subsidies and increased production can lead to higher income, these benefits are often offset by rising input costs, fluctuating market prices, and increasing labor costs. Previous studies have shown that these dynamics can either amplify or diminish the intended benefits of agricultural policies, depending on local economic conditions and market stability (Pan, et al., 2022; Ren, 2023; Zhang et al., 2022). The welfare puzzle challenges the assumption that increased production alone is enough to improve farmer welfare. This study aims to unravel this puzzle by providing a comprehensive analysis of how these economic variables—

subsidies, input costs, market prices, labor dynamics, and household expenditures—interact to influence both paddy production and farmer income in Indonesia.

Understanding these relationships is crucial for developing policies that not only enhance paddy production but also address the broader welfare puzzle, ultimately improving the overall welfare of farmers in Indonesia.

Methodology

Sampling and Data Collection

This study investigated the impact of fertilizer subsidies on paddy production and farmer income across 33 provinces in Indonesia from 2019 to 2022. The target population included all farmers who received fertilizer subsidies during this period, with each province serving as a unit of analysis. Data on subsidized fertilizers (UREA, NPK, SP36, ZA) were sourced from the Ministry of Agriculture, while income data, along with other agricultural variables such as paddy production areas $(AREAL)$ and price indices, were obtained from the Central Statistics Agency (Badan Pusat Statistik, 2023). To ensure consistency and reliability, the analysis focused on balanced panel data from 2019 to 2022.

Econometric Model, Production Function, and Use of GLS

The study utilized a Cobb-Douglas production function to model the relationship between agricultural inputs and outputs, specifically focusing on paddy production as influenced by fertilizer use, harvested area, and wages. The Cobb-Douglas function is widely recognized in agricultural economics for its ability to model production processes where inputs like land, labor, and capital (including fertilizers) are used to produce output (Greene, 2012). The production function was specified as model I:

$$\ln(PROD_{it}) = \alpha + \beta_1 AREAL_{it} + \beta_2 ln(UREA_{it}) + \beta_3 ln(NPK_{it}) + \beta_4 ln(SP36_{it}) + \beta_5 ln(ZA_{it}) + \beta_6 ln(IB\_FARMER_{it}) + \beta_7 ln(WAGES_{it}) + \varepsilon_{it} \tag{1}$$

In model I, $ln(PROD_{it})$ represented the natural logarithm of paddy production in province i at time t. The variable $AREAL_{it}$ was kept in its original form to preserve data normality and to accurately reflect its linear relationship with production.

Model I was expanded in Model II to incorporate additional variables that may have influenced agricultural outcomes. Model II included the impact of production $(ln(PROD_{it}))$, the index of prices received by farmers $(ln(IT\_FARMER_{it}))$, food consumption $(ln(FOOD_{it}))$, and agricultural labor wages $(ln(WAGES_{it}))$:

$$\ln(INCOME_{it}) = \delta + \gamma_1 ln(PROD_{it}) + \gamma_2 ln(IT\_FARMER_{it}) + \gamma_3 ln(FOOD_{it}) + \gamma_4 ln(WAGES_{it}) + \epsilon_{it} \tag{2}$$

In model II, $\ln(INCOME_{it})$ represented the average monthly net income of self-employed workers by province province i at time t.

Generalized Least Squares (GLS) and Model Validation

The Generalized Least Squares (GLS) method was utilized within the Random Effects Model (REM) to address potential issues of heteroskedasticity and serial correlation in the panel data. The GLS method was chosen for its efficiency in handling unbalanced and heteroskedastic data, which is common in large panel datasets across diverse regions (Baltagi, 2021). The application of GLS ensured that the estimation was robust, providing unbiased results that accurately reflected the complexities of agricultural production across Indonesia's provinces.

To validate the REM, the Lagrangian Multiplier (LM) test was conducted, calculated as follows:

$$LM = \frac{NT}{2(T-1)}\left[\frac{\sum_{i=1}^{N}(\sum_{t=1}^{T}\hat{\varepsilon}_{it})^2}{\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{\varepsilon}_{it}{}^2}\right] \quad (3)$$

Where N is the total number of provinces, T represents the total years, and $\hat{\varepsilon}_{it}$ is the OLS residual. The Hausman test, which determines the appropriateness of FEM versus REM, is given by:

$$Haus = (\hat{\beta}_{fe} - \hat{\beta}_{re})[Var_{fe} - Var_{re}]^{-1}(\hat{\beta}_{fe} - \hat{\beta}_{re}) \quad (4)$$

Where $\hat{\beta}_{fe}$ are the parameter estimates from the Fixed Effect Model (FEM), and $\hat{\beta}_{re}$ are those from the Random Effect Model (REM).

This methodology assumed homogeneity in crop responses to fertilizers, supported by prior studies indicating similar input-output relationships across staple crops like paddy in Indonesia (Hannoeriadi A. et al., 2022). To address potential variability, sensitivity analyses were performed, and similar crops were grouped to ensure the robustness of results. The combination of the Cobb-Douglas production function, GLS method, and rigorous statistical testing provided a solid framework to assess the impact of fertilizer subsidies on paddy production and farmer income in Indonesia.

Operationalization of Variables

Table 1 illustrated the relationships between key factors in agriculture. PROD was influenced by the area harvested (AREAL), subsidized fertilizers (UREA, NPK, SP36, ZA), the Prices Paid by Farmers Index (IB_FARMER), and WAGES. INCOME was determined by PROD, the Price Received by Farmers Index (IT_FARMER), WAGES, and food expenditure (FOOD). WAGES negatively impacted PROD but positively influenced INCOME. PROD served as both a dependent variable affected by factors like AREAL and IB_FARMER, and an independent variable influencing INCOME.

Table 1. **Definition and Expectations of Variable Relationships**

Symbol	Definition	Unit	Expectation
UREA, NPK, SP36, ZA	Distribution of Subsidized Urea, NPK, SP36, ZA Fertilizer	Thousand tons	(+) PROD
AREAL	The area of the crop that was harvested during the reporting period	Hectare	(+) PROD

Symbol	Definition	Unit	Expectation
IB_FARMER	An index that describes fluctuations in the prices of goods consumed by farmers as well as fluctuations in the prices of goods needed to produce agricultural products	Index	(-) PROD
PROD	Production refers to the yield in the form of products from each crop, based on the area harvested during the reporting period	Tons	(+) INCOME
IT_FARMER	Index compiled based on agricultural production results (Price Received by Farmers Index)	Index	(-) INCOME
WAGES	Average Net Wage/Salary of Informal Workers based on Main Agricultural Employment	Thousand rupiah	(-) PROD/ (+) INCOME
FOOD	Average Expenditure per Capita a Month for Food in Rural Areas	Thousand rupiah	(+) INCOME
INCOME	Average Monthly Net Income of Self-Employed Workers*)	Thousand rupiah	-

Note:*)According to the Province and Main Job Field

Descriptive Statistics

The ratio of the standard deviation to the mean is used to evaluate data variability. Table 2 presents the calculation of this ratio for the variables, indicating the relative level of variation in the dataset. The highest deviation relative to the mean is found in ZA, with a ratio of 309.46%, indicating high variation, while IB_FARMER has the lowest at 3.34%, showing higher consistency.

Table 2. **Descriptive Statistics**

Variables	obs	Mean	Std. Dev.	Std. Dev/ Mean	Min	Max
UREA	132	115.61	211.43	182.88%	0.04	1041.29
NPK	132	80.23	134.43	167.56%	0.10	687.22
SP36	132	14.64	27.14	185.41%	0.00	142.18
ZA	132	20.52	63.50	309.46%	0.01	472.48
AREAL	132	319674.7	474305.6	148.37%	179.48	1754380
IB_FARMER	132	106.92	3.57	3.34%	101.95	115.62
PROD	132	1654576	2684567	162.25%	506.91	9944538
IT_FARMER	132	112.67	17.25	15.31%	0.00	153.24
WAGES	132	1391.59	367.29	26.39%	720.19	3443.96
FOOD	132	564.12	98.08	17.39%	395.10	848.49
INCOME	132	1452.50	340.90	23.47%	736.58	2439.05

Findings

This section presents findings from two econometric models. Model I illustrates the impact of land area (AREAL), subsidized fertilizer distribution (UREA, NPK, SP36, ZA), the Prices Paid by Farmers Index (IB_FARMER), and wage levels (WAGES) on rice crop production (PROD). Model II explains the influence of paddy production (PROD), the Price Received by Farmers Index (IT_FARMER), food consumption (FOOD), and wage levels (WAGES) on farmers' income (INCOME). The models were carefully selected and validated to ensure the reliability and robustness of the findings.

Model Specifications and Validation

To determine the most suitable econometric model for analyzing production and income variations, a comprehensive evaluation of four models was conducted: Pooled Ordinary Least Squares (POLS), Fixed Effects (FE), Random Effects Generalized Least Squares (RE GLS), and Random Effects Maximum Likelihood Estimation (RE MLE). The analysis involved specification tests such as the Chow and Hausman tests. The POLS model showed significant results with F-values of 13.55 for model I (PROD) and 12.21 for model II (INCOME), both with p-values of 0.00. However, the Chow test indicated that the FE model was less suitable, particularly for model I, with an F-value of 1.42 and a non-significant p-value of 0.09.

The Hausman test confirmed the superiority of the RE GLS model, showing strong chi-square values of 77.87 for model I and 37.61 for model II, both highly significant at p = 0.00. This was further supported by the MLE test, which also favored the RE GLS model with chi-square values of 41.51 for model I and 14.94 for model II, both at p = 0.00. Robustness checks, including tests for normality, heteroscedasticity, multicollinearity (Mean VIF of 1.44 for model I and 1.12 for model II), and autocorrelation, all indicated the reliability of the RE GLS model. The combined evidence from these tests demonstrates that the RE GLS model is the most robust and efficient choice for handling the complexities of panel data in this study, providing accurate and reliable insights into the economic behaviors associated with paddy production and farmer income. This can be seen more clearly in Table 3.

Table 3. **Model Specification Test Results**

Testing	**Analysis Method**	**Model I (PROD)**		**Model II (INCOME)**	
		F/chi2 value	**Prob>F/ chi2**	**F/chi2 value**	**Prob>F/ chi2**
POLS	Ordinary Regression	13.55	0.00	12.21	0.00
FE [Chow Test]	Fixed Effects	1.42	0.09	2.74	0.00
RE [Hausman Test]	Random Effects GLS	77.87	0.00	37.61	0.00
MLE [LM Test]	Random Effects MLE	41.51	0.00	14.94	0.00
Robustness Indicators for OLS Models					
Normality test	Skewness/Kurtosis tests	$Prob > \chi^2$	0.49	$Prob > \chi^2$	0.18
Heteroscedasticity Test	Breusch-Pagan/CW test	$Prob > \chi^2$	0.87	$Prob > \chi^2$	0.36
Multicollinearity Test	Mean VIF	VIF	1.44	VIF	1.12
Autocorrelation Test	Wooldridge test	Prob>F	0.88	Prob>F	0.06

Source: Processing Results, 2024

Results and Discussion

The regression analysis for both the production model (PROD) and the income model (INCOME) provides insights into the factors influencing paddy production and farmer income, revealing a complex welfare puzzle. In the production model (PROD), where the dependent variable is the total production in tons (PROD), the constant term is not statistically significant (Coef = 53.311, p = 0.148), indicating that the baseline production level isn't meaningful when other variables are at zero. The harvested area (AREAL) positively and significantly influences production (Coef = 1.34E-06, p = 0.012). Additionally, the use of subsidized fertilizers, specifically NPK (Coef = 0.198, p = 0.045) and SP36 (Coef = 0.155, p = 0.049), significantly boosts production. However, other fertilizers like UREA (Coef = 0.129, p = 0.148) and ZA (Coef = 0.101, p = 0.142) do not have a significant impact. This model (PROD) explains 43.49% of the variation in production, indicating moderate explanatory power.

In the income model (INCOME), where the dependent variable is the average monthly net income of self-employed workers (INCOME), the constant term is again not significant (Coef = -1.145, p = 0.737). However, the average net wage/salary of informal agricultural workers (WAGES) shows a strong positive relationship with income (Coef = 0.332, p < 0.001), suggesting that higher wages contribute to increased farmer income. Additionally, the index of prices received by farmers (IT_FARMER) has a significant positive effect on income (Coef = 0.287, p = 0.047). Meanwhile, average monthly food expenditure per capita in rural areas (FOOD) does not significantly affect income (Coef = 0.151, p = 0.146). This model (INCOME) explains 27.63% of the variation in income.

Table 4. **Random-Effect Estimation Results - GLS**

Variable	**Model I (lnPROD)**			**Model II (lnINCOME)**		
	Coef	**Standard Error**	**P-Value**	***Coef***	**Standard Error**	**P-Value**
Constant	53.311	36.865	0.148	-1.145	3.411	0.737
PROD (natural log)	-	-	-	-0.154	0.010	0.113
AREAL	1.34E-06**	5.34E-07	0.012	-	-	-
UREA (natural log)	0.129	0.089	0.148	-	-	-
NPK (natural log)	0.198**	0.099	0.045	-	-	-
SP36 (natural log)	0.155**	0.078	0.049	-	-	-
ZA (natural log)	0.101	0.069	0.142	-	-	-
IB_FARMER (natural log)	-0.052	3.608	0.989	-	-	-
IT_FARMER (natural log)	-	-	-	0.287**	0.145	0.047
FOOD (natural log)	-	-	-	0.151	0.104	0.146
WAGES (natural log)	-1.343**	0.574	0.019	0.332***	0.079	0.000
R-sq (Overall)	**0.4349**			**0.2763**		

Note:* represents statistical significance for a 99% level, ** represents statistical significance for a 95% level, and *** represents a 90% level.
Source: Processing Results, 2024

These results reveal a welfare puzzle where increased production does not necessarily lead to higher income. For example, while fertilizers like NPK (NPK) and SP36 (SP36) significantly increase paddy production (PROD), this does not translate directly into higher income (INCOME) for farmers. This paradox may be due to rising labor costs, as indicated by the negative impact of WAGES (WAGES) on production (PROD), which suggests that the benefits of increased production are offset by higher expenses. This complexity underscores the need for agricultural policies that not only aim to boost production (PROD) but also consider the economic factors influencing farmer income (INCOME).

In summary, this study highlights the interconnectedness of production (PROD) and income (INCOME), and the challenges of improving farmer welfare. Proper management of fertilizer use and wages could potentially improve both agricultural output (PROD) and farmer income (INCOME), but these factors must be balanced within the broader economic context to avoid unintended consequences.

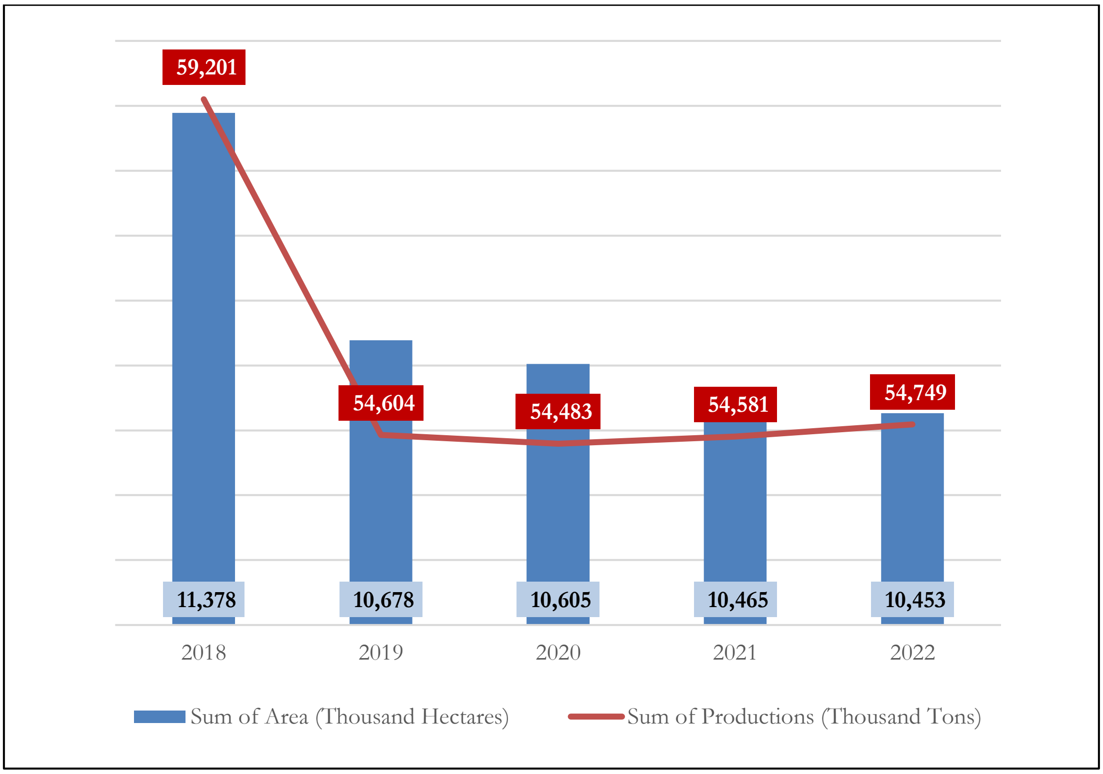
The Effect of Fertilizer Subsidy Distribution on Paddy Production

The analysis of the production model (PROD) revealed that subsidized fertilizers, particularly NPK and SP36, significantly enhanced paddy production in Indonesia. A 1% increase in NPK use resulted in a 0.198% increase in paddy production, while a similar increase in SP36 use led to a 0.155% rise. These findings align with the results of Priyanto et al. (Priyanto et al., 2023) and Farado (2024), who also observed positive correlations between NPK fertilizer use and paddy productivity, underscoring the importance of these fertilizers in boosting yields. However, the study found that UREA and ZA fertilizers did not significantly impact paddy production. This contrasts with previous studies such as Hu (2023), who demonstrated that controlled-release urea could maintain paddy yields under reduced nitrogen conditions, suggesting that specific methods might be necessary to optimize UREA's effectiveness. Similarly, Zhang et al. (2022) found that biochar-based urea did not significantly enhance yields, indicating that the effectiveness of UREA might depend on factors like soil type and application methods. These findings suggested that while NPK and SP36 were generally effective, UREA and ZA might require more tailored application strategies or might be less effective under certain conditions.

The analysis also examined the Prices Paid by Farmers Index (IB_FARMER) and found it statistically insignificant in its impact on paddy production ($p = 0.989$). This suggested that fluctuations in input costs, such as fertilizer prices, did not directly affect production levels during the study period. Typically, higher input costs are expected to reduce profitability and production; however, this finding might indicate that Indonesian paddy farmers were able to absorb these costs, possibly due to the availability of subsidies or other compensatory mechanisms. This result contrast with earlier studies, such as Narayanamoorthy (2022) which highlighted the sensitivity of agricultural production to rising input costs, emphasizing the importance of subsidies and other supports in buffering these effects.

The role of the harvested area (AREAL) was also crucial in paddy production. The positive coefficient of 1.34E-06 per hectare indicated that even small expansions in cultivated land could significantly boost paddy output. This finding was consistent with Iskandar et al. (2022), who emphasized the importance of land area in determining crop yields. However, expanding cultivation must be balanced with sustainable land management practices to prevent environmental degradation. Figure 1 illustrates these trends, showing the development of land area and paddy production in Indonesia from 2018 to 2022. During this period, agricultural land decreased by 8.15%, from 11,378 thousand hectares in 2018 to 10,453 thousand hectares in 2022, leading to a 7.49% drop in paddy production. This decline, driven by factors like urban development and declining soil quality (Nopriani et al., 2023; Widhiyastuti et al., 2023), highlights the limitations of relying solely on fertilizer subsidies to boost production.

Figure 1. **Development of land area and paddy production, 2018-2022**

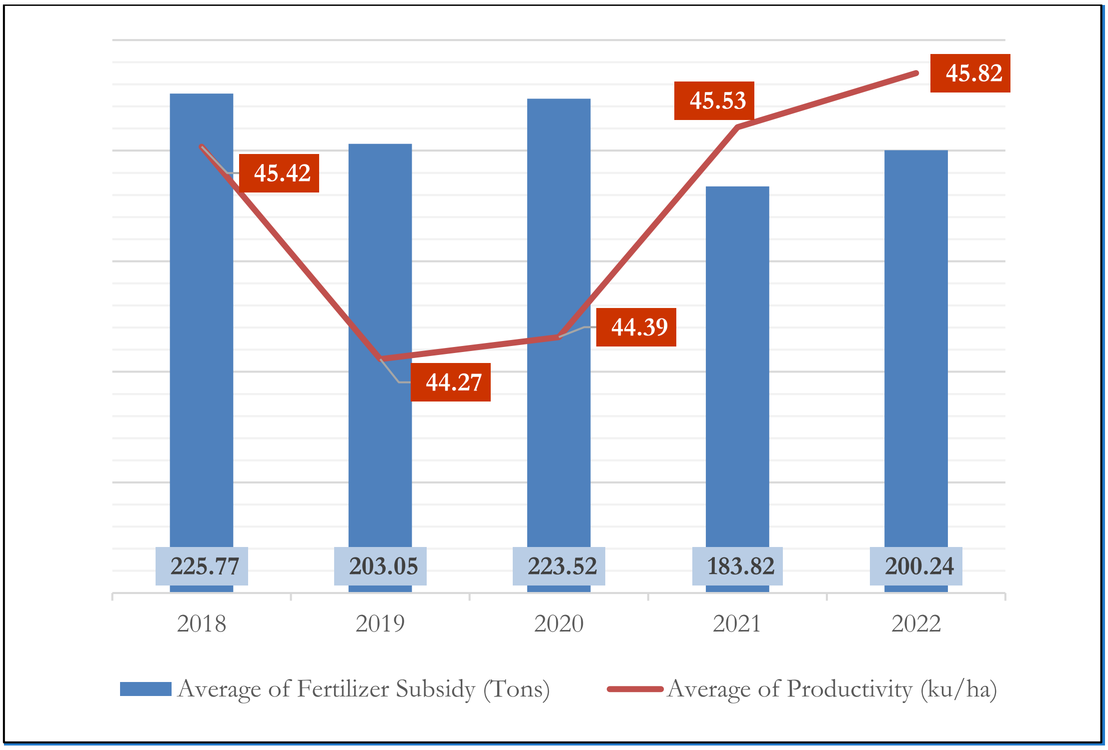


Source: Badan Pusat Statistik (2023)

In contrast, WAGES had a significant negative effect on paddy production, with a 1% increase in wages leading to a 1.343% decrease in production. This finding was supported by Khoiriyah (2023) and Abdulhamid (2023), who noted that rising labor costs can severely strain farming operations by increasing overall production expenses. The negative impact of WAGES suggested that higher labor costs made it difficult for farmers to maintain production levels, especially for labor-intensive crops like paddy

These findings illustrate the broader welfare puzzle in Indonesian agriculture, where increased production through fertilizer subsidies does not necessarily translate into improved welfare for farmers. The disconnect between production gains and welfare improvement was influenced by factors such as rising labor costs, which erode profitability, and environmental concerns, which threaten long-term sustainability. For instance, while NPK and SP36 fertilizers significantly contribute to production, the benefits are often offset by increasing labor costs, which reduce overall profitability for farmers. Additionally, the reliance on subsidies without addressing underlying issues such as efficient labor use and environmental degradation limited the long-term sustainability of these gains. Addressing this puzzle required a holistic approach that went beyond subsidies, incorporating labor market interventions, environmental protections, and market reforms. Such an approach would help ensure that increases in production led to real improvements in farmer welfare, aligning agricultural policies with broader development goals.

Figure 2. **Average of Fertilizer Subsidies and Paddy Productivity in Indonesia, 2018-2022**



Source: Badan Pusat Statistik (2023); Kementerian Pertanian (2023)

Figure 2 further explored the relationship between fertilizer subsidies and paddy productivity. Despite fluctuations in subsidy levels, ranging from 183.82 to 225.77 thousand tons, paddy production remained stable, between 44.27 to 45.82 kg/ha. This stability suggested that while fertilizer subsidies were important, other factors such as technological advancements, efficient irrigation practices, and favorable market conditions also significantly influenced production. For instance, even during years with lower subsidies, productivity did not decline significantly, indicating that improved farming techniques or favorable weather conditions might have mitigated potential negative impacts of reduced subsidies. These findings highlighted the complex interactions between agricultural inputs and economic factors influencing paddy production in Indonesia. The effectiveness of NPK and SP36 fertilizers was evident, but their impact was moderated by external factors such as labor costs, land availability, and possibly unobserved variables like weather conditions and traditional farming practices. This aligned with broader literature, including Sary (2024) and Amirahmadi et al. (2022), which emphasized the interplay between environmental factors and agricultural inputs in determining crop yields.

In conclusion, while NPK and SP36 fertilizers were effective in enhancing paddy production, their benefits could be diminished by high labor costs and insufficient land management strategies. Therefore, a comprehensive agricultural policy approach that goes beyond just fertilizer subsidies was essential. Policymakers and agricultural stakeholders should integrate fertilizer subsidies with broader strategies, including mechanization, efficient land use, cost management, and sustainable farming practices, to maximize paddy production and ensure long-term agricultural sustainability in Indonesia. The limited impact of UREA and ZA suggested that a one-size-fits-all approach to fertilizer subsidies might not be effective. Instead, tailored interventions considering local soil conditions, crop requirements, and the timing and method of fertilizer application could be necessary to optimize the effectiveness of these inputs. By addressing these factors, it was possible to enhance the production and profitability of paddy farming in Indonesia, supporting broader goals of food security and rural development.

Analysis of Factors Influencing Net Income of Self-Employed Farmers

The analysis of the income model (INCOME) identified key factors that affected the net income of self-employed farmers in Indonesia, providing important insights into agricultural income dynamics. A significant positive impact was observed from the Price Received by Farmers Index (IT_FARMER), with a coefficient of 0.287 ($p = 0.047$), indicating that higher market prices for agricultural products directly increased farmers' income. This aligned with findings by Gurung (2023), who emphasized the importance of market prices in enhancing profitability. Wages also exhibited a strong positive effect on income, with a coefficient of 0.332 ($p < 0.001$), suggesting that higher wages not only boosted agricultural workers' earnings but also stimulated local economic activity, further raising farmers' income. This finding was consistent with Ifeoma et al. (2022), who highlighted the positive impact of rising wages on farm income through increased economic activity and demand for agricultural products.

However, the production model (PROD) revealed that WAGES had a significant negative impact on paddy production, with a coefficient of -1.343 ($p = 0.019$). This underscored the financial strain that rising labor costs placed on farming operations, particularly for labor-intensive crops like paddy. This supported findings by Khoiriyah (2023) and Abdulhamid (2023), who reported that increasing labor costs eroded profitability by inflating production expenses. Additionally, the harvested area (AREAL) positively influenced production, with a coefficient of 1.34E-06 ($p = 0.012$), highlighting the importance of effective land management in enhancing agricultural output. Iskandar et al. (2022) similarly emphasized the critical role of land area in determining crop yields. These findings illustrated a complex welfare puzzle in Indonesian agriculture, where factors that positively impacted production and income did not always align to improve farmer welfare. For instance, while higher wages boosted income, they simultaneously increased production costs, thereby reducing profitability. This disconnect highlighted the challenges in translating production gains into better financial outcomes for farmers.

In conclusion, the determinants of net income for self-employed farmers in Indonesia were multifaceted, involving market dynamics, labor costs, and land management. The positive effects of IT_FARMER and WAGES on income underscored the importance of favorable market conditions and economic activity in improving farmers' financial well-being. To sustainably enhance farmers' income, policies should adopt a holistic approach, integrating education, technology, market access, and sustainable farming practices. This comprehensive strategy would address the diverse challenges farmers face, ensuring their long-term financial stability and success in the agricultural sector.

Conclusion

This study analyzed the impact of fertilizer subsidies on paddy production and farmer income across 33 provinces in Indonesia from 2019 to 2022, aiming to address the broader "welfare puzzle" in agriculture. The findings indicate that a 1% increase in NPK and SP36 usage significantly enhanced paddy production by 0.198% and 0.155%, respectively. In contrast, UREA and ZA had minimal effects, suggesting these fertilizers may require more context-specific application strategies. Additionally, expanding harvested land (AREAL) positively impacted production, but this growth must be managed sustainably to prevent adverse environmental impacts. Despite these production gains, the study highlighted a significant welfare puzzle: increased production did not necessarily lead to higher farmer income. Rising labor costs (WAGES) decreased paddy production by 1.343% per 1% increase in wages, while income was primarily driven by higher market prices (IT_FARMER), with a positive impact of 0.287 ($p = 0.047$). The Prices Paid by Farmers Index (IB_FARMER) had an insignificant effect on production, indicating that input costs were absorbed or mitigated through subsidies.

This study also acknowledges methodological limitations, particularly the use of the Cobb-Douglas production function, which assumes fixed elasticity between inputs and may oversimplify complex agricultural interactions. Additionally, unobserved factors such as farming practices and weather conditions may influence the results, suggesting that the findings should be interpreted with caution. Overall, the results underscore the need for agricultural policies that go beyond simple subsidies and address broader economic and environmental challenges. Integrating mechanization, efficient land management, and sustainable farming practices is crucial to ensure that production gains lead to lasting improvements in farmer welfare, aligning agricultural policies with broader development goals.

Acknowledgments

The authors acknowledge the financial support provided by the Indonesian Education Scholarship (BPI) the Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi provided.
Statement: During the preparation of this work, the authors used artificial intelligence tools, such as ChatGPT, to assist in drafting the manuscript. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the publication's content, ensuring adherence to data integrity and publication ethics. The use of AI was strictly limited to non-substantive text refinements.

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