

UNVEILING EFFICIENCY CHALLENGES IN WEST JAVA'S CHILI PRODUCTION: A PATHWAY TO ENHANCING INDONESIA'S FOOD SECURITY

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ABSTRACT

Chili is a cornerstone of Indonesian cuisine, playing a pivotal role in the nation's food security. However, the chili production sector in West Java, a key hub for chili cultivation, faces significant challenges due to price volatility stemming from production inefficiencies. This study examines the technical inefficiencies prevalent in chili production in West Java and how they are influenced by farmers' socio-economic characteristics and access to financial resources. A random sample of 398 farmers from four major chili-producing districts underwent analysis using multinomial logistic regression and one-way ANOVA. The findings indicate that 83% of chili farmers are efficient in running their farms. With an average technical inefficiency of 25%, there is potential to double chili production using existing resources and technologies. It is important to note that several factors were identified as influencing inefficiency, such as age, education level, household size, participation in training, farm record keeping, land tenure, land size, and crop productivity. It is interesting to note that farmers who have access to one financial provider have lower levels of inefficiency, with MFIs being the provider with the lowest average inefficiency among other providers. This study provides valuable insights for overcoming production bottlenecks and stabilizing chili prices, thereby improving Indonesia's food security. By understanding and addressing these inefficiencies, stakeholders can work to increase productivity, improve farmers' livelihoods, and ensure a stable supply of this essential ingredient for Indonesian cuisine.

Keywords: *chili production, inefficiency analysis, food security, socioeconomic, agricultural finance*

1. INTRODUCTION

Efficiency in agricultural production plays a critical role in ensuring food security, fostering economic development, and responsibly managing natural resources. At the heart of this efficiency lies the concept of technical efficiency (TE), which emphasizes the optimal utilization of available inputs. West Java, a significant agricultural hub in Indonesia, serves as an essential case study. However, it remains

uncertain whether the region's farmers consistently reach peak efficiency, particularly when confronted with environmental and resource limitations.

In Indonesia, vegetables are a pivotal element of the agricultural sector, fulfilling essential roles as both a primary food source and a horticultural product extensively cultivated by local communities. They significantly contribute to dietary requirements and have substantial commercial value. By transforming vegetables into value-added products, such as chili powder, the economic value is increased, which in turn enhances the welfare of the community (Destryana et al. 2021). Additionally, vegetables are packed with essential nutrients that maintain a high demand. For instance, chilies are a rich source of minerals, provitamins A, vitamins C and E, carotenoids, and phenolic compounds, which are beneficial for health (Materska and Perucka 2005; Sun et al. 2007).

Despite West Java's impressive chili production, which surpasses the national average by 1.6 times, yielding 13,944.4 kg per hectare as opposed to the national average of 8,746.8 kg per hectare (BPS 2022; BPS 2023), inefficiencies in chili production across Indonesia present significant challenges that must be addressed to ensure food security. These inefficiencies stem from a variety of factors, including uneven production across different times and regions, which leads to price fluctuations impacting inflation by 0.01–0.07% (Lukas et al. 2023). Additionally, the imbalance of supply and demand between regions affects farmers' welfare.

Access to financial resources emerges as another critical determinant of agricultural productivity on a global scale. However, the limitations faced by farmers in developing nations, including Indonesia, are particularly pronounced and can significantly hinder production efficiency. The inability to secure adequate investments for essential inputs, infrastructure, and technology remains a persistent challenge. In the context of West Java, a vital agricultural hub, this issue gains prominence. Understanding how limited access to finance impacts efficiency becomes increasingly relevant. Consequently, this study posits that enhancing financial accessibility will yield positive effects on the technical efficiency of agricultural production in Indonesia.

This research examines the various factors that influence production inefficiency. It meticulously evaluates the level of technical inefficiency in agricultural production, with a strong focus on the socio-economic characteristics of farmers, in addition to the accessibility of financial resources. The aim is to provide key insights to policymakers and financial institutions working to strengthen agricultural competitiveness in the region. By examining the dynamics of inefficiency in West Java, identifying key contributing elements, and understanding the influence of access to finance, this study aims to develop actionable strategies. These strategies are designed to overcome financial barriers and cultivate sustainable agricultural development.

2. RESEARCH METHODOLOGY

This investigation examines the intricate mechanisms of agricultural production from July to December 2023. It employs a robust quantitative methodology and comprehensive random sampling techniques to engage with 398 chili farmers in West Java, Indonesia. The research focused on the districts of Bandung, Garut, Cianjur, and Ciamis, which are recognized hubs of vegetable cultivation. To gain a comprehensive understanding of the subject matter, the research team compiled a range of data, including farmers' age, farming experience, education, household size, training, farm record-keeping, land tenure, land size, seed type, germination rate, crop productivity, and financing sources. Prior to initiating the research process, the team secured official authorization for data collection from the agricultural departments of the respective districts.

This study employs the stochastic frontier production function method to estimate technical inefficiency (TI). This method is a cornerstone of production analysis,

having been pioneered by Aigner et al. (1977) and Meeusen and Van Den Broeck (1977). As noted by Coelli et al. (2005) and Rahman (2003), the stochastic frontier production model is widely recognized for its ability to measure TE. The TI is calculated by subtracting the technical efficiency (TE) result from 100%. Table 1 shows the classification of inefficiency level in chili production.

Table 1. The classification of inefficiency level

Inefficiency Level	Category
<15%	Efficient
15% - 30%	Moderately efficient
>30%	Inefficient

In this study, factors related to the technical inefficiency of chili production were investigated using multinomial logistic regression analysis. The logistics equations are as follows:

$$\text{Logit}(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_{11} X_{11} \quad (1)$$

where:

Y = Technical inefficiency (%)

β_0 = Constanta

β_1 = Coefficient

X_1 = Age (years)

X_2 = Farming experience (years)

X_3 = Education (1 = Illiterate; 2 = Elementary School; 3 = Junior High School; 4 = Senior High School; 5 = University)

X_4 = Household size (person)

X_5 = Training (0 = Otherwise; 1 = have attended)

X_6 = Farm record-keeping (0 = Otherwise; 1 = have recorded)

X_7 = Land tenure (0 = No; 1 = Yes)

X_8 = Land size (Ha)

X_9 = Seed type (0 = Open Pollinated Variety; 1 = Hybrid)

X_{10} = Germination rate (%)

X_{11} = Crop productivity (Kg/Ha)

Once the levels of inefficiency have been established, our study employs a differential testing approach to investigate the differences in inefficiency based on financial accessibility. This is achieved through the use of the one-way analysis of variance (ANOVA), a powerful statistical tool for comparing multiple groups. This technique is instrumental in identifying any statistically significant disparities, typically at thresholds of $p \leq 0.1$, 0.05, or 0.01, among the average values of these groups. As a parametric test, ANOVA necessitates a predefined population distribution. The data set must adhere to criteria such as normality, independence, and variance homogeneity to ensure the validity of the ANOVA results (Kim 2017). The alignment with the Central Limit Theorem further substantiates the suitability of employing one-way ANOVA in our analysis.

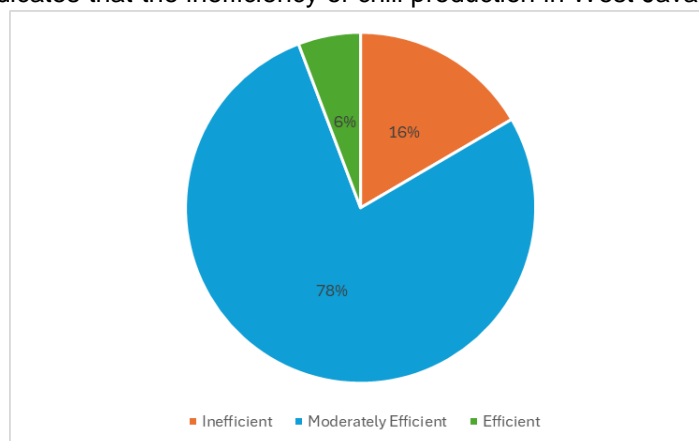
The one-way ANOVA is an optimal statistical approach for our study's objectives. Our aim was to assess the mean differences across three distinct groups categorized by their level of financial access (no access, access to one source, and access to multiple sources) in relation to a continuous dependent variable, which in this case is the degree of technical inefficiency. Although adherence to the normality assumption is typically crucial for the application of one-way ANOVA, the substantial size of our sample lends us the confidence to depend on the Central Limit Theorem's effect in normalizing the distribution of our sample means.

3. RESULTS AND DISCUSSION

Chili cultivation plays a pivotal role in the agricultural framework of West Java, Indonesia, with significant implications for both food security and the region's economic health. As demand for this crop intensifies, optimizing the efficiency of chili production becomes increasingly crucial. Efficiencies manifest in several dimensions, including the utilization of resources, cost management, and the quality of the yield. The technical efficiency of chili production is influenced by a number of key factors, including the quality of seeds, the application of organic and inorganic fertilizers, the use of organic and inorganic pesticides, the availability and skill of labor, and the adequacy of equipment (Jain and Jha 2015; Abate et al. 2019; Dessale 2019). Figure 1 illustrates the extent of technical inefficiency.

Figure 1. The extent of technical inefficiency

Figure 1 indicates that the inefficiency of chili production in West Java is 16%. The



majority of chili farms can be considered to be relatively efficient, with only 6% of farms exhibiting high levels of efficiency. Consequently, the average level of inefficiency of chili farming in West Java is estimated to be 25%. This discrepancy between the most and least efficient farms highlights the potential for enhancing productivity through targeted interventions. Misallocation and selection in agriculture reduces aggregate agricultural productivity by affecting resource allocation (Adamopoulos et al. 2022). Misallocation in farm production is a key determinant of potential growth, and removing institutional obstacles, such as trade regulations, functioning courts, and access to finance, can affect potential growth (León-Ledesma 2016). Furthermore, to address this it's essential to analyze the underlying causes of inefficiency. Table 2 shows the results of regression.

Table 2. The results of regression

Variables	Coefficient	DF	P value	Note
Age	1497.956	2	0.000	Significant at 99%
Farming experience	322.890	2	0.116	Not Significant
Education	338.057	8	0.013	Significant at 95%

Household size	340.560	12	0.038	Significant at 95%
Training	324.711	2	0.047	Significant at 95%
Farm record-keeping	329.211	2	0.005	Significant at 99%
Land tenure	325.203	2	0.036	Significant at 95%
Land size	348.877	2	0.000	Significant at 99%
Seed type	320.755	2	0.337	Not Significant
Germination rate	320.365	2	0.410	Not Significant
Crop productivity	446.600	2	0.000	Significant at 99%
Constant	318.580	0		
Intercept only	524.744			
Final	318.580	38	0.000	Significant at 99%

Pseudo R² = 55.2%

Table 2 reveals that out of eleven socioeconomic factors, eight significantly impact the technical inefficiency in chili production. At a 99% confidence level, age, farm record-keeping, land size, and crop productivity are key influencers. Education, household size, training, and land tenure also play a role at the 95% confidence level. The model's robustness is evidenced by a notable decrease to a final value of 206.164, with $p \leq 0.01$, indicating superior predictive power over other regression models. This model aligns with the findings of Ismail and Mahmud (2023) and Asravor et al. (2016), and further supports Bahtera et al. (2020), who noted the significant influence of participation in farmer group meetings and part-time work on inefficiency.

The study indicates that age has a substantial impact on technical inefficiency in chili production. Older farmers tend to exhibit greater inefficiency levels. This observation aligns with the idea that older farmers might be more resistant to change and less likely to adopt novel technologies or farming methods. Additionally, physical limitations faced by older farmers could affect their efficiency in managing farm operations. To mitigate this issue, targeted extension programs and training initiatives could be designed to assist older farmers in adapting to new technologies and practices, ultimately enhancing their efficiency and productivity.

The study findings reveal that increased levels of education correlate with reduced technical inefficiency among chili farmers. This underscores the crucial role of education in enhancing farmers' knowledge and skills, empowering them to make informed decisions and adopt more efficient farming practices. Policymakers and agricultural extension services should prioritize creating educational opportunities for farmers to enhance their efficiency and promote sustainability.

Household size has a significant impact on technical inefficiency in chili production. Larger households tend to experience challenges in coordinating labor and resources, leading to inefficiencies in farm management. To tackle this issue, strategies could involve promoting mechanization and offering training on farm management practices specifically tailored for larger households.

The trained farmers have shown a tendency to achieve greater efficiency in chili production. This underscores the importance of providing training and extension services that enhance their knowledge and skills. Focusing training efforts on modern farming techniques, pest and disease management, and sustainable agricultural practices could significantly improve the productivity and yield of these farmers.

Farmers who recorded their farming activities have been identified as more efficient in their operations. The analysis highlights the vital importance of meticulous record-keeping in boosting farming efficiency. Effective record-keeping enables farmers to monitor inputs and outputs, pinpoint areas of inefficiency, and make well-informed

choices, all of which are crucial for optimizing chili production. Initiatives that encourage precise record-keeping and equip farmers with essential tools and education can substantially enhance the efficiency of chili farming. Wulandari et al. (2023) showed that recording their farm finances farmers can properly manage every resource they have, leading to a large increase in income.

Farmers with secure land tenure rights tend to exhibit higher efficiency in chili production. The assurance of land tenure gives farmers the confidence needed to make investments and implement sustainable practices for the long term. Implementing policies that reinforce land tenure security and facilitate access to land can be instrumental in enhancing both the efficiency and the productivity of chili farming.

Land size has been found to be associated with higher levels of technical inefficiency in chili cultivation. This implies that managing larger plots may require additional resources and expertise, potentially leading to inefficiencies in farm management. To address this, strategies could focus on promoting cooperative farming models or providing support for farm mechanization, both of which have the potential to improve overall efficiency.

Farmers with higher crop yields tend to demonstrate greater efficiency in chili farming. This underscores the importance of effective farming techniques for boosting productivity. These skilled farmers adeptly manage their resources. To further enhance both efficiency and yield in chili cultivation, promoting sustainable agricultural methods such as integrated pest management and optimized irrigation systems is crucial.

Access to financial providers plays a pivotal role in the technical efficiency of agricultural production. When farmers have reliable access to credit and financial services, they are better equipped to invest in quality inputs, adopt advanced technologies, and implement efficient farming practices. This financial support can lead to significant improvements in technical efficiency, as it allows for timely and adequate responses to farming needs. Conversely, limited access to financial resources can hinder a farmer's ability to operate efficiently, as it may restrict their capacity to invest in necessary improvements or innovations. Therefore, policies and programs that improve farmers' access to financial services are crucial for enhancing technical efficiency in agriculture. Figure 2 demonstrates the role of financial providers on technical inefficiency.

According to Figure 2, it is interesting to note that farmers who have access to a single financial provider tend to exhibit lower levels of inefficiency compared to those who do not have such access. This finding underscores the importance of financial inclusion in improving agricultural efficiency. When farmers can access credit, savings, or other financial services, they are better positioned to invest in quality inputs, adopt modern technologies, and optimize their farming practices.

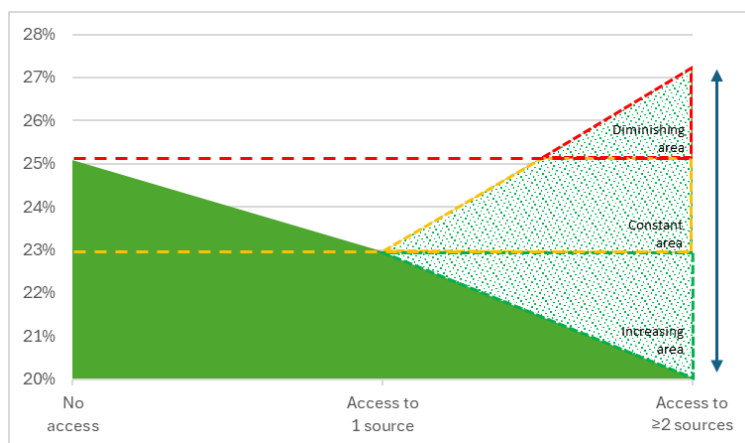


Figure 2. The role of access to financial providers on technical inefficiency

Farmers who access two or more financial providers surprisingly exhibit higher technical inefficiency. This unexpected result suggests that managing multiple financial relationships introduces complexities that hinder overall efficiency. Accessing multiple sources of finance can lead to an increased debt burden, affecting the farmer's ability to invest in efficiency-enhancing technologies. Additionally, with greater credit access, farmers may become risk-averse, avoiding innovative yet riskier practices. Limited financial literacy and resource diversion to non-agricultural uses contribute to inefficiencies. It is possible that farmers with more than one financial providers may have a lower inefficiency than having none, although still higher than accessing only one source (constant area). Indeed, Overcoming complexity could significantly lower technical inefficiency for those with multiple sources. This is in line with the projections in the increasing area.

Note: orange = not accessed, blue = accessed



Figure 3. The disparities in technical inefficiency based on financial providers

Figure 3 illustrates the disparities in technical inefficiency based on the financial providers. Financing that can be accessed by farmers comes not only from formal financing, such as from banks, government, or MFI, but also from non-formal financing, such as from traders, agricultural kiosks, landowners, or neighbors/relatives/family (Wulandari et al. 2021). Out of the six financial providers analyzed, access to government support through farmer groups, microfinance institutions (MFIs), and other correlates with reduced inefficiency levels. Notably, farmers utilizing banks, traders, or agricultural kiosks as their financial sources do not exhibit a decrease in technical inefficiency. Other alternatives, such as contract financing and corporate farming, have been found to be more viable for producers than traditional financing because of limitations in using agricultural land as collateral

(Middelberg 2013). Therefore, the form of financing obtained is not only cash, but also in kind.

MFIs significantly reduce inefficiency by offering financial services to those typically underserved by traditional banks, such as the unemployed or low-income individuals and businesses. Specializing in microloans, MFIs cater to farmers without collateral or a credit history. Beyond providing capital, MFIs emphasize capacity building through education in financial literacy, entrepreneurship, and management. Smallholder farmers' loan repayment practices are influenced by loan purpose, experience, dependency ratio, and wealth, highlighting the need for improved credit and savings services in rural areas (Feye 2020). Their flexible repayment terms accommodate the variable incomes of small-scale entrepreneurs and farmers, mitigating the unpredictability of seasonal earnings. As an alternative to informal lenders, MFIs extend a range of services, including savings, insurance, healthcare, and education, fostering a comprehensive support system for their clients' financial and overall well-being. However, there is also evidence that having access to in-kind financing from the government can increase farmers' production compared to farmers who do not have access to similar in-kind financing (Wulandari et al. 2018).

To enhance the technical efficiency of chili production, consider mentoring and training farmers in financial literacy. Practical exercises, such as role-play or simulations, can simplify complex financial concepts for farmers with limited education. Trained farmers should be encouraged to effectively utilize multiple financing sources. Additionally, government incentives for financial institutions, like MFIs, can further reduce production inefficiencies, contributing to improved food security. For example, US beginning farmers and ranchers in the US use nontraditional financing sources, such as human capital, government support programs, and alternative marketing strategies, in contrast to established operations (Thilmany et al. 2022).

4. CONCLUSION

The study reveals that chili production in West Java is crucial for Indonesia's food security. Despite high yields, inefficiencies persist due to socio-economic factors and limited financial access. Addressing these inefficiencies is vital for stabilizing chili prices and improving farmers' livelihoods. The average technical inefficiency is 25%. Key factors such as age, education, household size, and land tenure significantly affect production efficiency. Enhanced training and financial literacy can empower farmers to utilize resources more effectively and adopt efficient farming practices.

Access to financial providers, particularly MFIs, plays a significant role in reducing inefficiency. Single-source financial access appears to be more beneficial than multiple sources, highlighting the need for streamlined financial support systems for farmers. The findings suggest that targeted interventions, such as mentoring, training, and government incentives for financial institutions, can improve technical efficiency. This, in turn, contributes to sustainable agricultural development and food security in Indonesia.

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