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Dynamics of Competitiveness and Efficiency of Rice Farming in Java Island, Indonesia

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Abstract

Rice is the major crop in Indonesia and the staple food for more than 90% of Indonesians. Given the vital role of rice, efforts to develop rice production are a priority, especially in solving farming efficiency problems. However, inefficiency is one of the major causes of low performance in Indonesian rice production. If farming has high competitiveness and efficiency, Indonesia is encouraged to be able to become an exporter of rice. As a result, national rice farming must continue to improve its competitiveness and efficiency. This study aims to determine the economic efficiency and competitiveness of rice farming in several provinces in Java, i.e., West Java, Central Java, and East Java. The data used in this study is PATANAS survey data obtained from the Center for Socio-Economic Studies and Agricultural Policy, Indonesian Ministry of Agriculture. This study used a quantitative analysis approach and analytical descriptive analysis. The level of competitiveness was analyzed using Policy Analysis Matrix (PAM), while the efficiency level was analyzed using the Stochastic Frontier Method (SFM). The results showed that rice farming in Java Island has a positive profit value on private and social prices. In addition, rice farming in all research locations has competitiveness as measured by indicators of comparative and competitive advantage as characterized by the coefficient values of DRC (Domestic Resource Cost Ratio) and PCR (Private Cost Ratio), which are less than one in the study period 2007-2020. The result of a technical efficiency study shows the average technical efficiency of three provinces in Java is around 0.82, and the factor input that significantly increased the technical efficiency was land and intermediate input.

Keywords: *competitiveness, efficiency, Policy Analysis Matrix (PAM), stochastic frontier*

1. Introduction

The rice crop has a significant role in Indonesian society since it promotes agricultural activities and contributes to feeding a growing population. Rice is a staple food for more than 270 million Indonesians, accounting for most of their caloric intake. Furthermore, the rice sector provides food and is the primary source of income and employment for most Indonesians living in rural areas [1]. Rice is a strategic product from a political standpoint. Political instability could result from either a shortage of rice in domestic markets or a highly variable price. The lack of rice stocks in domestic markets has become a more pressing issue in the stability of the Indonesian economy. As a result, the Indonesian government must maintain rice supplies to achieve food security [2].

Food security is a critical concern in Indonesia. The notion of food security at the national scale, by definition, places a greater emphasis on the commitment to supply adequate food in the context of food production. In contrast, at the individual and family level, the attention is on the household's capacity and accessibility to obtain enough nutritious and safe food without difficulty. The commitment of Indonesia to achieving food security is stated in Undang-Undang No. 18 year 2012. The achievement of food security is directed at increasing the production of agricultural commodities for diverse foods by applying the principles of comparative and competitive advantage, efficiency, and competitiveness. In addition, the government prioritizes food security and attempts to attain self-sufficiency in rice production through strengthened regulation, a fertilizer subsidy program, government procurement and a reserve, and Raskin distribution (cheap rice distribution program). The advancement of the agricultural sector is marked by increased production and productivity of food commodities, as well as the ability to meet domestic needs (self-sufficiency food), which in turn increases farmers' income [3].

Rice production has evolved in an unpredictable trading environment, marked by price volatility over time, and driven

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by significant fluctuations in commodity supply and demand. This is one of the primary problems with sectoral constraints [4]. As a result, the profitability of rice farmers varies. Furthermore, in a dynamic environment influenced by political, technological, economic, and trade challenges, the Indonesian rice sector constantly faces obstacles to increasing its competitiveness. Globalization and international trade have significantly impacted Indonesia's national development, but they also have consequences for the rice sector, which must compete with other international producers [5].

Indonesia is linked by the Uruguay Round Agreement on Agriculture as a participant of the World Trade Organization (WTO). These agreements include domestic support policies and regulations, non-tariff measures, and market access. The comparative advantage of Indonesian rice production determines whether or not it is profitable from a comprehensive economic standpoint under conditions of no subsidies or limited subsidies permitted by the rules for all trading partners. Therefore, assessing Indonesia's comparative advantage in rice production will be essential in this study.

Thus, this study will discuss the competitiveness and efficiency of rice farming by providing an overview of the phenomena that occur and analyzing the history of rice in Indonesia using time series data. The study's research objectives are to determine the level of competitiveness of rice farming in Java; to measure and analyze the efficiency of rice production; and, thirdly, to formulate the implications of Indonesian rice farming policies on changes in international commodity prices, international fertilizer prices, labor wages, currency exchange rates, and international policies. As a result, this research is expected to be used as a reference material for farmers to maximize profits and minimize costs in rice farming activities, as a consideration in making agricultural development policies, and as a reference material for conducting similar research with a broader and deeper scope.

2. Methodology

The policy analysis matrix (PAM) is a policy research instrument that enables researchers to identify policy distortions and inefficiencies and, as a result, recommend policy changes that will increase the profitability of an industry, sector, or country. The PAM approach can be used to investigate three major issues concerning agricultural policy: the first is a comparison of competitiveness and farm profits before and after the policy change; the second is a comparison of efficiency on agricultural systems before and after new public investment; and the third is the impact of agricultural research on changing new technology [6]. We can evaluate the level of policy transfers caused by the set of policies acting on the system and the system's inherent economic efficiency by filling out the elements of the PAM for an agricultural system.

PAM analysis begins with measuring prices in private prices (the observed market prices) and social prices (world prices). The following step is to create two tables for both private and social budgets and then enter all the prices into the PAM table, as shown in Table 1. The PAM table contains two cost columns: one for tradable inputs and one for domestic factors. Intermediate inputs, including fertilizers, pesticides, and purchased seeds, are tradable inputs. Domestic factor components include arable land and labor. The social prices of tradable input or output are determined by comparing world prices. The social prices for tradable input and/or output are calculated, as shown in Table 3 and 4, by calculating import parity for goods that substitute for imports and export parity prices for goods that enter export markets [7].

Table 1. Policy Analysis Matrix (PAM)

	Revenue	Cost		Profits
		Tradable Input	Domestic Factors	
Private Prices	A	B	C	D = A-B-C
Social Prices	E	F	G	H= E-F-G
Divergencies Effect	I = A - E	J = B - F	K = C - G	L = I-J-K=D-H

The policy analysis matrix is an array of numbers that follows two rules of accounting identities. One defining profitability identity is the accounting relationship across the columns of the matrix. The other one defines divergences identity, which is the relationship down the rows of the matrix. These accounting relationships are known matrix identities since they are true by definition.

Profitability identity is the accounting relationship across the column of the matrix or can be measured horizontally in the PAM, as shown in Table 1. All entries in the PAM matrix under the column "profits" are thus identically equal to the difference between the columns "revenues" and "costs" (including both costs of tradable inputs and costs of domestic factors). Thus, profits are defined as revenues minus costs.

The first row of a PAM contains price measures in private prices (the observed market prices). The symbol A represents private revenue, B represents tradable input costs in private prices, C represents domestic factor costs in private prices, and D represents private profit. The symbol D, profits in private prices, is found by applying the profitability identity. According to that accounting principle, D is identical to A - (B + C). The calculation of private profits from data in farm

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and processing budgets reflects the actual market received by the agricultural system's farmers [6][8]. Thus, private profitability calculations provide information on the agricultural system's competitiveness.

The second row of a PAM contains price measures in social prices (prices that would result in the best allocation of resources and, thus, the highest income generation). Social prices are a policy benchmark for comparisons because they are assumed to be the prevailing prices in a free market without any policy interventions, distortions, or market failures [6]. The symbol E represents revenues in social prices, F represents tradable input costs in social prices, G stands for domestic factor costs in social prices, and H represents social profit. The symbol H, profits in social prices, is found by applying the profitability identity. According to that accounting principle, H is identically equal to E - (F + G). The calculation of social profits estimates from the world prices (free on board) for exports are used for international traded outputs E and inputs F. While the domestic factors are not tradable internationally and thus do not have world prices, their social opportunity cost is estimated through observations of rural factor markets and cost insurance freight prices (CIF) are used. Countries achieve rapid economic growth by encouraging high-profit activities, which are characterized by large positive H. In contrast, negative H indicates that the country would be better off in terms of national growth by not producing the commodity. Thus, social profitability is a signal for determining international comparative advantage [9].

The third row of a PAM is **Divergence Identity,** which is defined as the difference between entries in the first row, measured in "private prices," and those in the second row, measured in "social prices." As a result, all entries in the third row are defined as "effects of divergences." Three sources cause divergences: the existence of market failure, distorting policy, and efficient policy. In principle, the most efficient outcome could be achieved if the government is capable of implementing an effective policy that offsets market imperfections and if the government decides to override non-efficiency objectives and remove distorting policies; therefore, the disparities between private prices and social prices will be reduced [6][9].

The arrangement of PAM presents an essential indicator for measuring the protection rate by different ratios, i.e., DRC, PCR, NPCO, NPCI, and EPC, which are used to assess competitiveness and comparative advantages [6][7][10].

PCR is the ratio that assesses the farm-level competitiveness of a commodity system. If PCR was less than one, the commodity system was competitive. The PCR can be expressed using the PAM framework as follows:

$$PCR = (C / (A\text{-}B))$$

The DRC, or domestic resource cost ratio, is used to determine comparative advantage (DRC). If the DRC is less than one, the agricultural system is efficient in domestic resource use and has a comparative advantage. If DRC is greater than one, the agricultural system is inefficient in domestic resource use and suffers from a comparative disadvantage. The following is the DRC formula:

$$DRC = (G / (E\text{-}F))$$

The NPC, or nominal protection coefficient, is a ratio of the commodity's private and social prices. This ratio illustrates the effect of policy on domestic and international prices, which causes a divergence. NPCO determines the protection of the output. If the value of NPCO is greater than one, it indicates output subsidies. NPCO can be expressed as:

$$NPCO = (A/E)$$

NPCI determines the protection of the input or input subsidies if the value of NPCI is less than one. If the value is greater than one, implying that the production is inefficient, the producers are protected while the consumers are taxed. NPCI can be expressed as:

$$NPCI = (B/F)$$

The EPC, or effective protection coefficient, is the ratio of value added in private prices (A-B) to value added in social prices (E-F). This coefficient indicates the degree of policy transfer from output and tradable input distortions. If the value of EPC is greater than one, it indicates that government policies provide positive incentives to producers. If the value is less than one, it indicates that policy interventions do not protect producers. EPC can be expressed as:

$$EPC = (A\text{-}B) / (E\text{-}F)$$

In addition, the stochastic frontier model (SFM), also known as the composed errors model, is used to estimate technical efficiency using a parametric method. The SFM is very advantageous because it considers measurement errors or random effects [9]. The SFM provides techniques for designing the frontier concept within a regression framework to estimate inefficiency. In the first stage, the parameter of the stochastic production function is estimated by Maximum Likelihood Estimation (MLE). The inefficiency term of the model (u_i) and technical efficiency model (ξ_i) are then predicted from results of the first stage [11]. The Cobb-Douglas stochastic frontier equation considers the decomposed error as written below.

$$\ln(q_i) = \beta_0 + \sum_{j=1}^{k} \beta_j \ln(z_{ji}) + v_i - u_i$$

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In the second stage, either of the two measurements is regressed on independently and identically distributed variables of firm characteristics. The technical efficiency of the firm will be determined using the following equation:

$$\xi_i = exp(-u_i) = \exp[(-E(-u_i|\xi_i)]$$

Stochastic Frontier is defined as a function model in which disturbance term, and it is composed of two parts, pure random error v_i and inefficiency u_i. Pure random results from measurement error and statistical noise, while the inefficiency error term is due to inherent firm characteristics which cause firms to deviate from frontier production level. The chance of including a pure random error component, denoted v_i, at every input level is given. Therefore, it is assumed to be a homoscedastic, independently, and identically distributed error term across firms, with a mean at 0, and has a variance σ^2_{vi}. Parameters of pure random error are thus denoted as $N(0, \sigma_v^2)$ [12].

The second component of the error term represents the technical inefficiency of firms, influenced by their characteristics. Battese and Coelli (1995) have advocated that inefficiency is assumed to be a one-sided, non-negative error since an inefficient firm can only produce below and never above the frontier level. Because of this condition, the distribution of the inefficiency term is a truncation of normal distributions. It takes different forms, which can be half-normal, exponential, truncated normal, or gamma distributions [13]. Therefore, the inefficiency error term has a mean at μ, and has variance σ^2_{ui}. Parameters of inefficiency are represented as $N^+(\mu, \sigma_u^2)$.

The output of this study is rice production. It is the result of multiple inputs. The production frontier model specification for this study is shown below, assuming that the farmers are producing a single output from multiple inputs:

$$\ln(q_i) = \beta_0 + \beta_1 \ln v + \beta_2 \ln l + \beta_3 \ln k + \beta_4 \ln a + v_i - u_i$$

Where q_i denotes the paddy rice produced in kg; β_j(j = 1,2,3,..N) describe the parameters to be estimated; v represents the quantity of intermediate input applied per hectare (kg/ha); l constitutes family labor plus hired labor (person-days); k stands for a total capital asset in monetary terms (IDR); and a is cultivated area for rice production (ha); $v_i - u_i$ is error term; v_i is a two-sided random error component beyond the control farmer; u_i is a one-sided inefficiency component. The technical inefficiency determinants are specified as:

$$u_i = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 + \delta_5 z_5 + \delta_6 z_6 + w_i$$

Where u_i denotes technical inefficiency; δ_j (j = 1,2,3,..N) are the parameters to be estimated; z_1 is the gender of the household head; z_2 is the age of the household head; z_3 is the status of land ownership; z_4 is education level of the household; z_5 is the ratio of family labor; and z_6 is crop intensity within a year. The stochastic frontier is estimated from both equations jointly by maximum likelihood using STATA version 15 software.

The datasets were gathered from a variety of national and international publications. We required a comprehensive data set to estimate the PAM, including yields, input requirements, and market and social prices of inputs and outputs. PATANAS and the National Bureau of Statistics (BPS) provided the aggregated output and input data for the three granary areas (West Java, Central Java, and East Java). PATANAS is a panel data set compiled by the National Farmers' Household Panel Survey conducted by the Indonesian Ministry of Agriculture. We used a relatively large-scale survey that covers the same agroecological zones and focuses on generating information on rice production costs for provinces from 2007 to 2020. These output and input coefficients were then compiled on a per-hectare basis.

3. Results and discussion

Analysis of the cost of tradable inputs and domestic factors is based on perfect market conditions (social prices) or conditions without any government policies (Table 2). The calculation of social prices for tradable inputs and outputs, as well as domestic factors, is reflected by shadow prices or based on the estimation of the social opportunity cost. The shadow prices are used to adjust to international market prices. Tables in Appendix 1 are examples of parity price calculations for rice and fertilizer in Indonesia.

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Table 2. Policy Analysis Matrix (PAM)

		Revenue	**Cost**		**Profit**
			Tradable Input	Domestic Factor	
West Java	Private	8.439.576	1.315.845	3.953.494	3.170.237
2007	Social	8.236.770	1.135.500	3.738.146	3.363.124
	Divergences	202.806	180.345	215.349	-192.888
2010	Private	13.503.688	1.468.588	5.633.906	6.401.194
	Social	13.754.884	1.453.710	5.383.397	6.917.777
	Divergences	-251.196	14.878	250.510	-516.584
2016	Private	22.490.376	2.876.739	7.294.575	12.319.062
	Social	22.426.650	1.443.600	7.038.715	13.944.335
	Divergences	63.726	1.433.139	255.860	-1.625.273
2020	Private	28.754.100	1.783.931	12.198.998	14.771.171
	Social	33.040.467	1.766.646	12.068.696	19.205.125
	Divergences	-4.286.367	17.285	130.301	-4.433.953
Central Java	Private	4.286.373	816.389	1.474.961	1.995.023
2007	Social	4.423.965	896.160	1.379.951	2.147.854
	Divergences	-137.592	-79.771	95.009	-152.830
2010	Private	4.554.564	868.787	2.265.581	1.420.196
	Social	5.690.448	888.898	2.148.745	2.652.805
	Divergences	-1.135.884	-20.111	116.837	-1.232.610
2016	Private	7.869.868	1.553.297	3.926.976	2.389.595
	Social	9.342.150	1.373.969	3.839.718	4.128.463
	Divergences	-1.472.282	179.328	87.258	-1.738.868
2020	Private	22.567.500	1.857.531	8.760.230	11.949.739
	Social	24.463.170	1.766.259	8.639.295	14.057.616
	Divergences	-1.895.670	91.273	120.935	-2.107.878
East Java	Private	4.939.335	774.957	1.621.674	2.542.704
2007	Social	4.332.750	696.819	1.643.273	1.992.658
	Divergences	606.585	78.138	-21.599	550.046
2010	Private	7.728.777	1.151.532	3.252.506	3.324.739
	Social	7.633.360	1.151.532	3.132.198	3.349.630
	Divergences	95.417	0	120.308	-24.891
2016	Private	9.199.695	1.436.275	3.749.094	4.014.326
	Social	9.859.125	1.666.916	3.936.241	4.255.968
	Divergences	-659.430	-230.641	-187.147	-241.642
2020	Private	26.085.000	1.935.331	11.139.205	13.010.464
	Social	27.422.550	1.928.331	11.019.524	14.474.695
	Divergences	-1.337.550	7.000	119.681	-1.464.231

Figure 1. depicts a graph of the PCR calculation results, or the ratio between domestic costs and the difference between income and costs of tradable inputs at the private price level, in three Java provinces from 2007 to 2020. The PCR value assesses a farm's level of competitive advantage and is one indicator of competitiveness. Based on the data presented above, each province has a different dynamic of PCR scores each year, but it has a PCR of 1. That is, it can be identified that all of these provinces have a level of competitive advantage or competitiveness in general.

The competitive advantage performance in Central Java is inversely proportional to the West Java Province. The score tends to rise from 2007 to 2016, then fall in 2020. In 2016 the smallest PCR was 0.335, then the score increased to 0.452 in 2020. The PCR value means that to get a rice output value of Rp. 1,000,000, an additional domestic factor cost of Rp. 335,000 in private prices is required in 2016, and it increases to Rp. 452,000 in 2020. This phenomenon shows that the performance of competitive advantage in West Java declined in 2020. The smaller the PCR score indicates, the more

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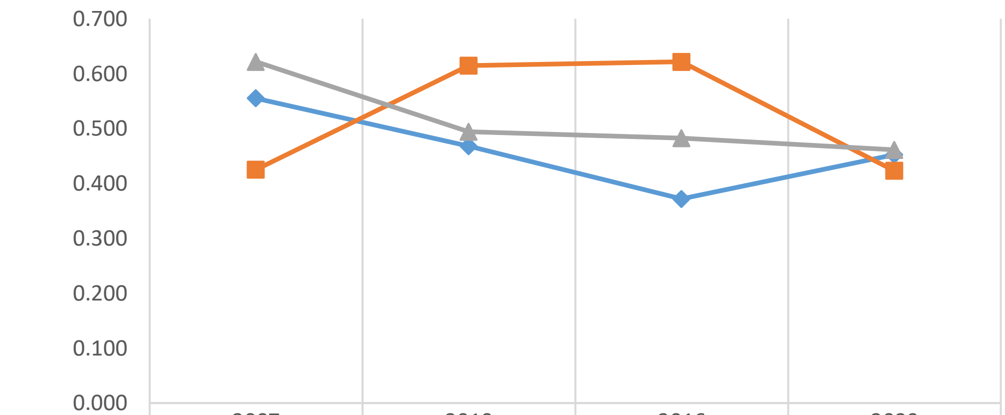
competitive the farm is because rice farming in each province has a competitive advantage or competitiveness over private prices.

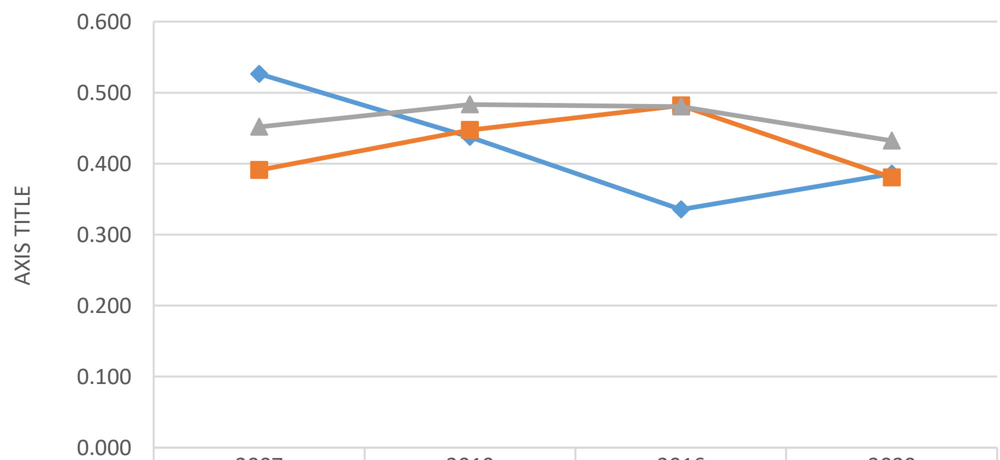
The competitive advantage performance in Central Java is inversely proportional to the West Java Province. The score tends to rise from 2007 to 2016, then fall in 2020. The highest PCR score in Central Java in 2016 was 0.622, but it dropped to 0.423 in 2020. Furthermore, from 2010 to 2020, the dynamics of competitive advantage in East Java show stagnation. During that time, the PCR value in East Java ranged from 0.49 to 0.46. In 2020, the PCR scores in all three provinces tended to be the same. This demonstrates that each province has the same level of competitive advantage. A commodity will be competitive if efficiency and productivity are high.

Figure 2. depicts a graph of the DRC calculation results, or the ratio between domestic costs and the difference between income and costs of tradable inputs at the social price level in West Java, Central Java, and East Java from 2007 to 2020. According to the graph, the DRC score for each of these provinces is less than one. The lower value of the DRC score, the greater the farm's comparative advantage. This implies that all provinces have comparative advantages and effective agricultural systems even though the score of DRC has disparity.



	2007	2010	2016	2020
Jabar	0.555	0.468	0.372	0.452
Jateng	0.425	0.615	0.622	0.423
Jatim	0.622	0.495	0.483	0.461

Figure 1. Private Cost Ratio



	2007	2010	2016	2020
Jabar	0.526	0.438	0.335	0.386
Jateng	0.391	0.448	0.482	0.381
Jatim	0.452	0.483	0.480	0.432

Figure 2. Domestic Resource Cost Ratio

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West Java's comparative advantage dynamics tended to decrease scores from 2007 to 2016, then slightly increase in 2020. DRC scores of 0.33 and 0.38 were recorded in 2016 and 2020, respectively. This suggests that rice farming in West Java is becoming more resource efficient and economically efficient and has a high comparative advantage [10]. The findings of this study are consistent with those of [14][15], who found that the efficiency level in West Java was quite efficient, with a percentage of more than 70%, and that the level of technology gap was relatively low. The irrigation condition in West Java is more developed than that in Central and East Java. The government is always concerned and pays closer attention to rice farming in West Java due to its proximity to the capital city. Moreover, an industrial area in West Java is located in the middle of rice barn regions such as Karawang and Indramayu, where PATANAS research also takes place. The industrial area is built on infertile land rather than on converted farmland; surplus labor is therefore reduced since many small-scale farmers lease their land and choose to work in the factory. As a result, large-scale farmers can expand their farm size. Therefore, rice farming in West Java is more dynamic than in Central and East Java. To examine this condition more comprehensively, it is also necessary to review the level of efficiency and productivity using a parametric approach.

Furthermore, the dynamics that occur in Central Java Province have a DRC value that is quite efficient and has a comparative advantage. The increasing score proves this from 2007 to 2016, which ranged from 0.48 to 0.48, then decreased in 2020 to 0.38. This phenomenon indicates that comparative advantage and efficiency in rice farming in Central Java are increasing. The DCR score tends to stagnate at 0.4 in the dynamics that occur in East Java Province. According to previous research [16], the efficiency and productivity of rice farming in East Java have stagnated due to unbalanced inputs.

The development of rice policy dynamics in Indonesia in 2007, 2010, 2016, and 2020 depicts in Table 3. According to Figure 3, the progression of output protection policies in West Java is quite volatile. In 2007, the output price in the domestic market was higher than the import parity price, indicating that the government's policy intervention on rice output in West Java was protective in 2007 and 2016. In 2010 and 2020, the output price in the domestic market was lower than international market prices. This shows that the government does not protect policy output. This situation contradicts the statement regarding the intervention policy output from the government, which explains that protection for rice in Indonesia is national or comprehensive in all provinces of Indonesia.

Different situations in Central Java Province, which show NPCO < 1 from 2007 – 2020, indicate that the output price in the local market is lower than the social price. The protection policy carried out by the government is in the form of import duties, so the cost per unit of commodities imported from outside will be much more expensive than commodities in the Central Java area. This phenomenon is consistent with research conducted by [17]. Furthermore, the phenomenon that occurred in East Java showed changes or dynamics in output prices, which were initially protected in 2007-2010, and then the output price became lower than the social price so that it was not protected in 2016-2020.

According to the three provinces, the output price in all provinces is not protected in 2020, or the output price in the local market is less than the global price. The COVID-19 pandemic is one of the causes of this condition, which affects the stability of the country's economy and thus indirectly affects rice HPP [2]. In addition, the government has implemented HPP to align with the COVID-19 conditions. This condition had previously occurred in Indonesia during the 1997-2000 monetary crisis. The rice economy in Indonesia experienced turmoil in 1998. Suryana and Rachman [18] investigate the key factor that renders price policies ineffective in these circumstances: the rice economy's liberalization by opening opportunities for rice imports to the private sector. This aims to meet domestic rice needs. There is a very large amount of rice imports. At that time, the international price of rice was relatively low compared to the domestic price, even though a tariff of 30%, or Rp. 450/kg was applied later. This tariff policy could not stem the entry of imported rice. Based on these conditions, domestic rice must compete in price with imported rice.

Furthermore, the development of the agricultural input price policy is shown by the NPCI ratio in Figure 4. The NPCI value that occurs in West Java shows a fluctuating value and is more than one. This indicates that there is no protection for input prices, especially tradable inputs such as seeds and fertilizers, from 2007–2020. In other words, farmers in West Java have to pay higher prices for tradable inputs than in the international market. This condition is consistent with research by [19] which states that the prices of tradable inputs, especially urea and TSP fertilizers, in West Java in the period 2000–2016 have increased by 11.42 and 11.80 percent per year, respectively. The increase in the price of urea and TSP fertilizers in this region was only followed by a slight decrease in fertilizer use during that period.

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Table 3. Unit price of Input-Output

	Quantities	Input/Output				Private Price per unit				Social Price per unit			
		2007	2010	2016	2020	2007	2010	2016	2020	2007	2010	2016	2020
Tradable Input	Seed (kg/ha)	16	17	16	18,5	3.652	5.817	7.636	12.000	2.500	5.750	8.618	12.000
	Ferilizer												
	a. Chemical Fertilizers (kg/ha)												
	- Urea	202	184	202	145	1.227	1.375	1.968	1.800	1.200	1.688	1.960	1.867
	- TSP/SP-36	115	67	115	111	1.925	1.151	1.892	2.400	1.550	1.400	1.763	2.000
	- ZA	57	103	57		3.689	1.772	2.370	0	1.050	2.254	2.359	1.400
	- NPK	80	120	80	116	2.628	2.074	2.587	2.500	1.750	2.619	2.542	2.650
	b. Other fertilizers (pack)	1	1	1	1	379.362	150.652	369.938	0	275.000	107.944	147.483	0
	c. Pesticide (pack)	1	1	1	1	119.385	350.000	391.298	744.531	100.000	200.000	121.741	744.531
	d. Herbicide (Pack)	1	1	1	1	68.928	107.534	1.036.161	0	100.000	97.182	100.000	0
	Total												
Domestic factors	Labor (hr/ha)					1.763.682	2.761.955	3.865.183	5.509.375	1.763.682	2.761.955	3.865.183	5.509.375
	Working capital					13%	12%	10%	9%	7%	6%	8%	7%
	Land rent (ha)					1.775.000	2.364.286	2.755.200	6.050.000	1.775.000	2.364.286	2.755.200	6.050.000
	Total												
Output	**Production (kg/ha)**	3.558	3.806	4902	6687	2.372	3.548	4588	4300	2.315	3.614	4.575	4.941

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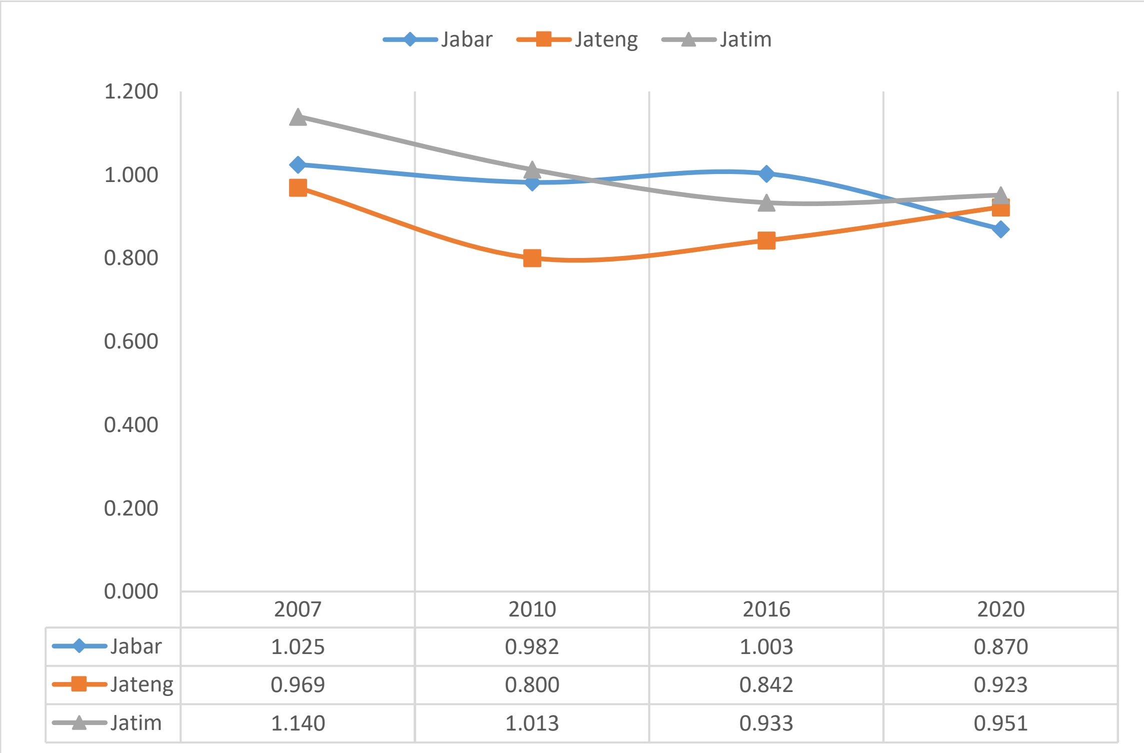

Figure 3. Nominal Protection Coefficient on Output

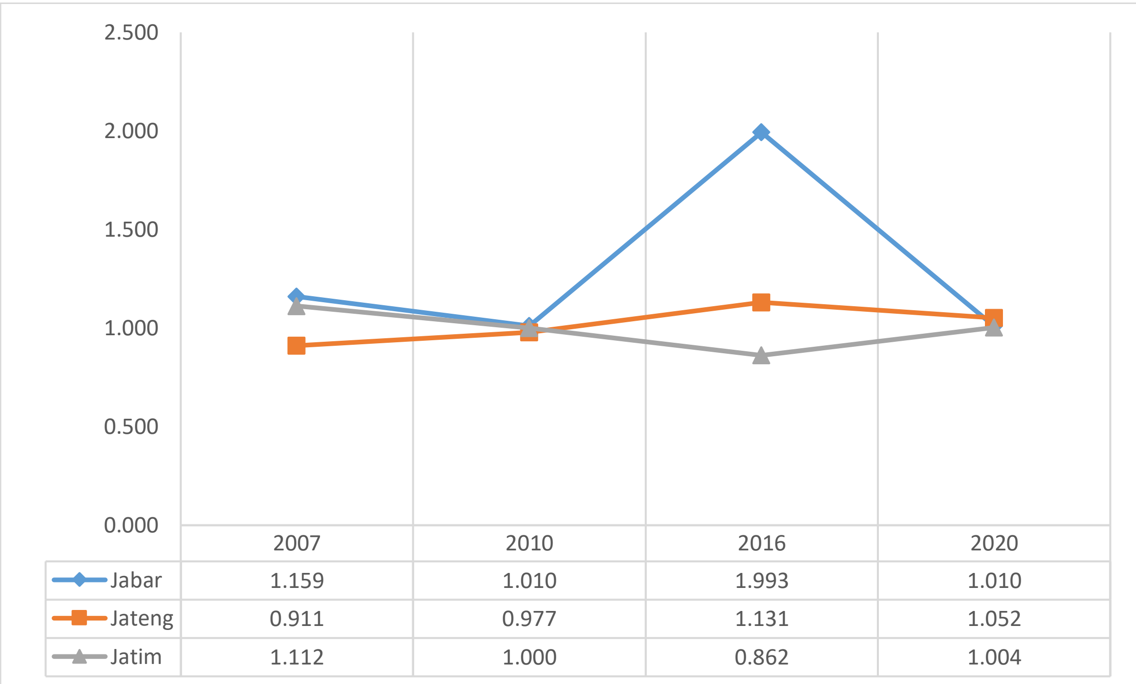

Figure 4. Nominal Protection Coefficient on Input

In contrast to market conditions in East Java, the dynamics of the input policy or NPCI value that occurred experienced a decrease in value from the 2007-2016 period, which was initially worth more than one, then decreased. The NPCI value that became less than one, meaning that the tradable input price policy was protected in this period. However, there was an increase again in the 2020 period, so it can be said that the input price policy is not protected. This condition is also similar to the research conducted by [19], which stated that in East Java, tradable input prices in maize farming in East Java,

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especially Urea and TSP fertilizers, in the same period also showed a significant increase of 10.97 and 11.32 percent per year, respectively.

Figure 5. depicts the progression of the combined input-output policy or EPC ratio. The policy dynamics that occurred in West Java began in 2007 and were protected. The policy could then not protect input-output from 2010 to 2020. This is clearly reflected by the EPC value, which continues to fall over time. A similar situation occurred in East Java, where the EPC value continued to fall, resulting in rice farming being unprotected from 2016 to 2020.

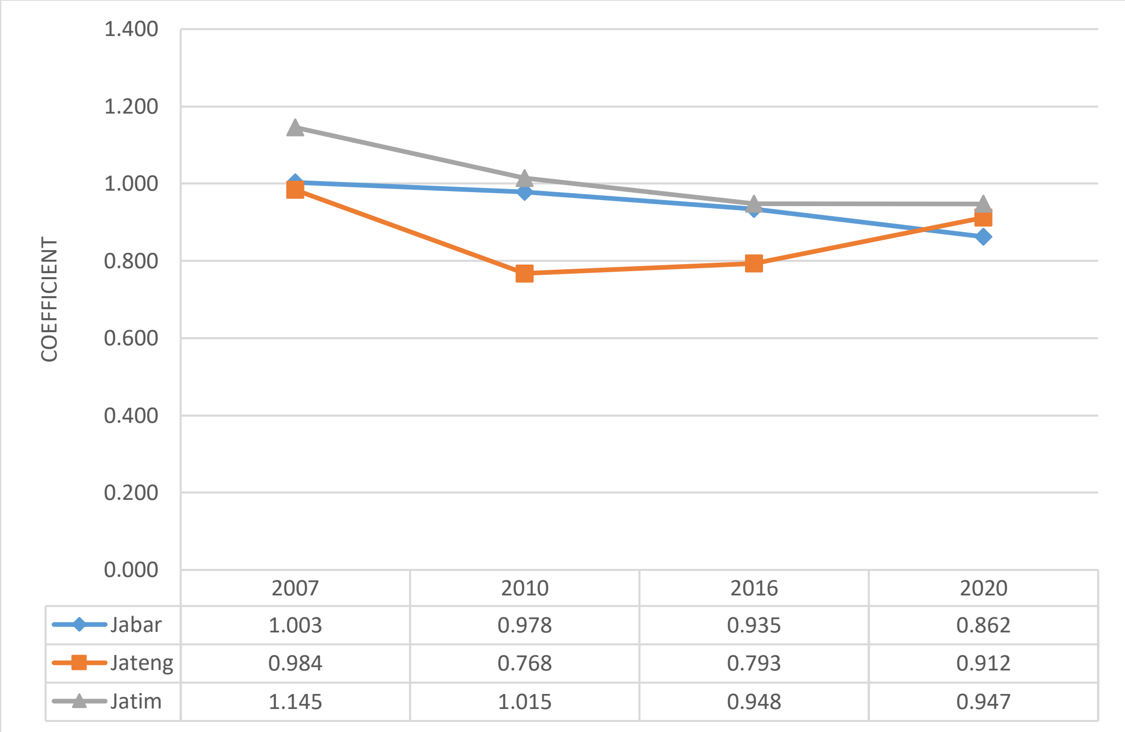

Figure 5. Efective Protection Coeficient

Meanwhile, from 2007 to 2020, the EPC value in Central Java remained stagnant and unprotected. This implies that the difference in income and tradable costs is higher at social prices than at private prices. This means that government policies, such as tax policies, reduce farmers' incentives; in other words, government protection becomes a disincentive that burdens farmers. Farmers, for example, must pay higher fertilizer prices, implying that they are taxed.

Furthermore, Table 4 shows the result of technical efficiency in rice farming on Java Island. It showed that the variable of intermediate input was significantly positive at a significance level of 1%. The increase in intermediate input led to a rise in total production. A one percent increase in intermediate input enhances total output by approximately 0.138%.

The labor coefficient was negative but not significant, implying that increasing the labor will decrease the yield of rice production. Small-scale family farming units majorly manage the rice production on Java Island and have always been labor-intensive because of the scarcity of arable land and abundant labor. As a result, it is not surprising that labor productivity in rice production is declining. This finding is consistent with the study conducted by Wang [20]. It concluded that surplus labor in the same plot of land leads to crowded plots and inefficient farming.

The coefficient of arable land has a positive sign and is statistically significant at 1%. An increase of 1% in the arable land input will escalate the total output by approximately 0.806%. It indicated that the average farm size was very small in almost all provinces; thus, increasing arable land increases total production. This result is in accordance with the previous work [21].

The coefficient of the capital variable has a positive sign but is not significant statistically. The dummy variable of provinces 1 and 2 is denoted for West Java and Central Java. The coefficient of West Java is positive and significant from the baseline of East Java. In contrast, the coefficient of Central Java is negative but not significant from the baseline of East Java. The dummy variable for years 1 and 2 is denoted for 2007 and 2010. The coefficient of the dummy year is negative, while the coefficient of dummy 2 is positive, indicating that productivity has increased during the observation period.

The result of the inefficiency model is shown in the lower part of Table 4. The dependent variable in this model is the

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inefficiency score, and the explanatory variables are farm characteristics and farming households' socio-economic status. The negative sign of the gender variable describes the outcome that male producer household heads are positively correlated to technical efficiency; it implies that increasing technical efficiency is possible if the principal rice producers are men.

Table 4. Determinants of Technical Efficiency of Rice Production in Java Island

Variable	Coefficient	Std. Error
General Model		
Constanta	7.9490***	0.2068
Intermediate input	0.1381***	0.0287
Labor	-0.0160	0.0167
Capital	0.0058	0.0097
Cultivated Area	0.8061***	0.0320
Province dummy 1	0.1356***	0.0313
Province dummy 2	-0.0201	0.0277
Year dummy 1	-0.0936**	0.0298
Year dummy 2	0.6190**	0.0278
Inefficiency Model		
Constanta	-3.1566	2.0958
Gender	-0.3413	0.2616
Age	0.0396	0.0750
Age2	-0.0003	0.0006
Land status	0.7718***	0.1661
Education	-0.0502**	0.0217
Ratio	0.6090**	0.2580
Crop intensity	0.0362	0.1364
Number of observation	525	
Log-Likelihood	-54.6274	
Wald chi^2 (8)	4173.43	
Prob>chi^2	0.000	
Average TE	0.8225	

Note: *Significant at 10% level; **Significant at 5% level; ***Significant at 1%level

The household head's age had a slightly positive effect on the inefficient. A farmer's age can be a proxy for his farming experiences; thus, the older household head is more experienced and capable of making an efficient rice farming decision [22]. In addition, the age square has been found to have a negative effect on inefficiency, but not significantly. This is partly because, as age increases, farming experiences and efficiency improve. However, it will have a negative effect on efficiency after a certain age interval because elderly farmers are thought to be more conservative in trying to implement modern technologies. This implies that the u-shaped relationship between age and efficiency has been inverted; in other words, efficiency increases with age up to a point and decreases with age increase. As a result, the elderly and younger farmers are not as efficient as the middle-aged farmers. Farming is like any other profession and requires accumulated knowledge, skill, and physical capability, the age of the farmer, is important in evaluating efficiency. Farmer's

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knowledge, skills, and physical capability will likely improve as they age. However, after a certain age, this tends to decrease. Elderly farmers will have the less physical capacity to carry out farming tasks efficiently. This finding is in accordance with [4] findings, which showed that aging the labor force exacerbates production efficiency.

The land ownership status significantly had a negative effect on efficiency. According to this finding, non-landholders are more technically efficient than landholders. This could be explained by self-selection in the land market and farmer behavior in the study area. Smallholder farmers who lease or sharecrop the land have the better managerial ability and good agricultural practices. Because the tenant farmers strive to manage production professionally and are receptive to new technology, allowing them to increase production and income. This finding is consistent with previous work by Fukui [23] in Central Java which stated that the production efficiency under tenancy land was equal with the landholders.

The education of the household head has been found to affect farm inefficiency. The findings suggest that farmers with a higher level of education can manage rice farming more efficiently. It is because education can improve their ability to acquire information, allowing them to make better decisions. Moreover, it will help them adopt modern agricultural technologies and produce more output while using existing resources more efficiently. In the studies of Rice farming in Eastern India [24] education was found to improve technical efficiency significantly. It explained that acquiring agricultural knowledge through education and training could increase production capacity and improve a farm's technical efficiency.

The ratio of family labor variable had a positive effect on the inefficiency. The presence of a positive coefficient indicates that family farmers are less efficient than hired labor. This interpretation contrasts with the previous work [25], arguing that family farmers had efficiency advantages over non-farm household producers or hired laborers. Family labor might be efficient and effective because they are more motivated as a residual claimant on farm revenues. In addition, they require fewer operational costs to operate their farm. However, this inconsistency may be due to family labor's lack of entrepreneurial spirit and other specialized skills, such as managerial abilities. The involvement of family labor might be a solution for family members to find work because of a lack of alternative job opportunities in rural Java Island and/or low opportunity costs, as well as to preserve family traditions and values. This may result in underemployment, a decrease in the marginal product of labor used, and a decrease in farm efficiency [26].

4. Conclusion

The following conclusions can be drawn from research and discussion on the competitiveness, profitability, and efficiency of rice farming in West Java, Central Java, and East Java

1. Rice farming is profitable in the three provinces at private and social prices. It is evident in the private and social benefits, which are both positive and increasing over time.
2. Rice farming in the three provinces remains competitive, even though the level of economic feasibility is decreasing. The indicators of comparative advantage and competitive advantage (DRC<1; PCR<1) show the level of competitiveness of rice farming. West Java, East Java, and Central Java had the highest competitiveness from 2007 to 2020.
3. Government policies affecting the output (NPCO) include government purchase price (HPP) and import tariff policies. The NPCO policy has not been maximized in Central Java, as the NPCO < 1 indicates that the domestic output price is less than the efficiency price (world price).
4. Input-related government policies (NPCI) have failed to protect rice farming in West Java, as evidenced by NPCI >1, indicating that the price of tradable inputs in the domestic market is higher than the price of efficiency (world prices).
5. The level of protection for simultaneous input-output policies in 2007-2020 is ineffective in all provinces, as indicated by an EPC <1.
6. The average technical efficiency of the three provinces in Java is around 0.82.
7. Land and intermediate inputs were the factor inputs that significantly increased technical efficiency. The land variable proved to be the most responsive input variable that boosts production; thus, the government and stakeholders should consider land expansion as a first option in raising the output quantity of small-scale rice producers in Indonesia, either in Java Island or outside Java in Indonesia. Increases in intermediate input lead to increases in total output.
8. Lastly, the inefficiency factors that significantly increased technical efficiency were land status, education, and the ratio of family labor.

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Appendix 1: Examples of Input-Output Parity Price

(a) Input-Output Parity Price (Rice)

NO		2007	2010	2016	2020
1	F.o.b Bangkok (Thailand) ($/Ton)	243	365	420	488
2	Freight and Insurance	24	37	42	49
3	C.i.f Indonesia (c/: Tanjung Perak Port, Jakarta)	267	402	462	537
4	Exchange Rate (Rp/$)	9.419	8.991	13.436	14.105
7	C.i.f in domestic currency (Rp/ton)	2.517.699	3.609.887	6.207.432	7.571.564
8	Weight conversion factor	1.000	1.000	1.000	1.000
10	Handling	126	180	310	379
11	Transportation and handling to merchant/ wholesaler (Rp/kg)	134	160	180	80
12	Marketing (Rp/kg)	6	10	10	6
13	Price before processing (grain → rice)	2.784	3.960	6.708	8.036
14	Processing Factor Conversion (grain → rice)	64%	64%	64%	64%
15	Cost of Rice Milling	334	330	182	100
16	Wholesaler-level Import Parity Price (Rp/kg grain)	1.781	2.535	4.293	5.143
17	Distribution costs to farmer (Rp/kg)	200	231	100	102
18	Farm-level Import Parity Price (Rp/kg grain)	2.315	3.096	4.575	4.941

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(b) Input-Output Parity Price (urea and sp-36)

		Urea	SP-36
1	F.o.b Yuzhny ($/Ton)		
	➢ F.o.b Yuzhny ($/Ton)	200	-
	➢ F.o.b Tunisian ($/Ton)	-	284
2	Freight and Insurance	88	37
3	C.i.f Indonesia (eg/:Tanjung Perak Port, Jakarta)	288	402
4	Exchange Rate (Rp/$)	13.436	13.436
7	C.i.f in Indonesia currency (Rp/ton)	3.857.472	5.062.932
8	Weight conversion factor	1.000	1.000
10	Handling	54	54
11	Transportation and handling to merchant/ wholesaler (Rp/kg)	115	115
12	Marketing (Rp/kg)	6	10
13	Price before processing	3.911,47	5.116,93
14	Processing Factor Conversion	100%	100%
15	Wholesaler-level Import Parity Price (Rp/kg)	4.026,47	5.2231,93
16	Distribution costs to farmer (Rp/kg)	30	30
17	Farm-level Import Parity Price (Rp/kg)	4.056,47	5.261,93

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