The effect of COVID-19 outbreak on the competitive and comparative advantages of rice production in West Java, Indonesia

J F Sinuraya and A Setiyanto
Indonesian Center for Agricultural Socio Economics and Policy Studies, Jln. Tentara Pelajar No. 3B, Bogor, West Java, Indonesia

* juliaforcinasinuraya@gmail.com

Abstract. Food security is one of the keys to success in overcoming problems arising impact of the COVID-19 outbreak. Attention to the paddy production in West Java is imperative. This paper aimed to discuss the effect of the COVID-19 pandemic on the competitiveness of rice production in West Java by using two indicators of Policy Analysis Matrix (PAM), namely Private Cost Ratio (PCR) and Domestic Resource Cost Ratio (DRC). The data used is from the National Panel of Farmers (PATANAS) survey data for wetland rice agro-ecosystem in West Java, with 144 households of rice farmer respondents. The results show that the COVID-19 outbreak harms the competitiveness of rice production, and it takes three years for recovery to be a competitive advantage and more than five years for comparative advantage. At the private and social prices of GKP at the farm level equal to the GPP 2020, rice production in West Java will lose its competitive advantage starting in 2022, while the comparative advantage of rice production in West Java continues to decline until 2024. This study has three policy implications: the first eliminating disruption of the distributions of agricultural inputs and outputs. The second is striving to increase the use of machinery and equipment to secure the risk of yield loss during cultivation, harvest time, and post-harvest handling at the farm level. The third is selecting the farmers who have high capability in competitive and comparative advantages as a model for fostering competitiveness improvement for farmers with lower abilities.

1. Introduction
Rice is the most staple food for Indonesia. Rice consumed by 95% of Indonesia's population [1] and employed more than 38% of total agricultural households [2]. Attention to this commodity becomes very important. The rice economy is closely related to the industrial, trade, hotel and restaurant, services, and others. As the COVID-19 outbreak continues to spread, it is imperative to study the impact it has and may have on the rice economy in specific and food agriculture in general. Food security is one of the keys to success in overcoming the problems caused due to the COVID-19 pandemic that began to occur in Indonesia in early March 2020.

Lockdown policies disrupt supply and distribution flows, as well as food commodity prices as well as food production input prices. The COVID-19 pandemic has the potential to cause changes in the production, supply, and distribution of commodities from producers in production centers which are agricultural commodity areas to consumer areas, both fresh and processed, and affect the demand and supply of commodities that will occur permanently [3]. In addition to anticipating the increasingly widespread spread of the COVID-19 disease, the provision of basic food needs is the most important
thing. The choice is to import or produce domestically. Domestic Resource Cost ratio (DRC) as an indicator of comparative advantage is used to measure whether a commodity is more profitable when it is produced domestically or imported. Meanwhile, Private Cost Ratio (PCR) as an indicator of competitive advantage can be used as an indicator of whether the commodity has a competitive advantage when produced domestically [4,5].

The situation during COVID-19 pandemic may have an impact on the competitiveness of rice production in Indonesia, but there is no study about the effect of COVID-19 outbreak on rice competitiveness. Changes many factors both internal and external, may also have an effect on the performance of the rice competitiveness Indonesia. These factors could be input and output prices, productivity, cost of production, government policy, and market structure that has definitely changed due to the COVID-19 pandemic [6–10].

West Java Province is the third-largest producer of rice or rice in Indonesia. Giving attention to rice production in West Java Province is very important. Rice production influencing the dynamics of rice consumption in the region and national level. This paper aims to discuss the impact of the COVID-19 pandemic on the competitiveness of rice production in West Java Province. The results of the analyses are expected important for policy recommendations to increase farmers' production and income in anticipation of the impact of the COVID-19 pandemic.

2. Materials and methods

2.1. Materials

The data consists of primary and secondary data. The primary data were generated from interviews using the Indonesian Center for Agricultural Socio Economic and Policy Studies (ICASEPS) PATANAS of Rice questionnaire. Secondary data were from various agricultural institutions and the Central Bureau of Statistics (CBS), province, sample districts, and various other sources, either through direct visits or from websites and publications from each institution. The location survey is Karawang, Subang, and Indramayu Districts in the ICASEPS PATANAS of rice village in September–October 2019 and May–June 2020. The number of the respondents and research locations was intentionally according to the ICASEPS PATANAS of rice respondents in 2007, 2011, and 2016. The total number of respondents is 144 rice farming households. Data collection in May–June 2020 for the first planting season (PS I) 2020 data was carried out via telephone communication and limited to respondents who successfully contacted via long-distance communication (81.25%). For the 15.97% unsuccessfully contact respondents, was confirmed to the head of the farmer group and Field Agricultural Extension or PPL (2.78%). Data for the second planting season 2020 (PS II) and 2021 to 2025 are prediction results using econometric time series analysis.

2.2. Methods

The data were analyzed by two methods, namely the measurement of competitiveness using the Policy Analysis Matrix (PAM) and the distribution of kernel density for the results of the competitiveness measurement. Analysis was performed using Excel software for PAM and STATA 12 for kernel density distributions analysis. The PAM analysis used to assess DRC and PCR [4,11]:

\[
DRC = \sum_{j=k+1}^{n} \frac{aijW_j^S}{(P_i^S - \sum_{j=1}^{k} aijP_j^S)} \tag{1}
\]

\[
PCR = \sum_{j=k+1}^{n} \frac{aijW_j^D}{(P_i^D - \sum_{j=1}^{k} aijP_j^D)} \tag{2}
\]

The subscript i refers to outputs and the subscript j refers to inputs; ai for j= 1 to k, are technical coefficients for the traded inputs in the production of i; ai for j=k+1 ton are technical coefficients for the domestic inputs in the production of j; \(P_i^*\) is the price of output i, evaluated privately (*=D) or socially (*=S); \(P_j^*\) is the price of traded input j, evaluated privately (*=D) or socially (*=S); \(W_j^*\) is the price of domestic input j, evaluated privately (*=D) or socially (*=S). Following the method developed [6–8], the analysis considers the performance of farmer households before and after the COVID-19 pandemic occurred. Following Von Cramon-Taubadel and Nivyevskyi [12], this study is to estimate the...
proportion of rice farms that produce competitively and the proportion of the total rice production that is produced competitively. Measurement results before and after the comparison of the pandemic are used to see the impact of the COVID-19 outbreak. The adaptive kernel density estimate used in this study is as shown in equation (3) [13]:

\[
\hat{f}(x) = \frac{1}{\sum_{i=1}^{n} w_i} \sum_{i=1}^{n} w_i \frac{K\left(\frac{x-x_i}{h_i}\right)}{h_i} \]

where the \( x_i \)'s are the data points (associated with weights \( w_i \)), \( K \) is a kernel function, and \( h_i = h \times \lambda_i \). Equation (3) shows that the local bandwidth factors are proportional to the square root of the underlying density functions at the sample points [13]:

\[
\lambda_i = \lambda (x_i) = \left( \frac{G}{\hat{f}(x_i)} \right)^{0.5}
\]

where \( G \) is the geometric mean value of all \( i \) over the estimate of pilot density \( f^\prime (x) \). The estimate of pilot density is a standard fixed bandwidth kernel density estimate obtained with \( h \) as bandwidth. The variability bands are based on the following expression for the variance of \( \hat{f}(x) \) [14]:

\[
V \left( \hat{f}(x) \right) = \left( \sum_{i=1}^{n} \frac{w_i^2}{n} \right) \left( \frac{f(x)}{h \lambda (x)} \right) \int_{-\infty}^{\infty} K^2(s) ds
\]

where \( s \) is standard error. The \( h \) parameter that controls the number of standard errors to add around \( \hat{f}(x) \) to construct the variability bands is specified by the user [14].

A simulation analysis was conducted to determine the minimum yield (BEY) and minimum price (BEP) needed to maintain West Java, Indonesia's comparative and competitive advantage in producing rice. The BEY and BEP in simulation analysis are assuming other factors are not changed - ceteris paribus, the minimum level of yield needed to maintain the comparative and competitive advantages [15]. The BEY of comparative and competitive advantages was calculated using the following formulas:

\[
BEY^S (DRC = 1) = TC^S/P^S
\]

\[
BEY^D (PCR = 1) = TC^D/P^D
\]

where \( BEY^S \) is break even yield to maintain comparative advantage (kg/ha); \( TC^S \) is total cost in social value (IDR/ha); \( P^S \) is Social price of rice (IDR/kg); \( BEY^D \) is break even yield to maintain competitive advantage (kg/ha); \( TC^D \) is total cost in private value (IDR/ha); \( P^D \) is private price of rice (IDR/kg).

Equation (6) implies that even though the rice productivity is declining, Indonesia remains to have a comparative advantage if rice yield is not lower than \( BEY^S \). When the rice yield is lower than \( BEY^S \), West Java will no longer have the comparative advantage to produce rice. Under this condition, it is more beneficial for Indonesia to import rice than to produce it domestically. Equation (7) implies that rice farm still has a competitive advantage or is profitable for the farmers when its yield is not lower than \( BEY^D \).

The BEP in simulation analysis, the minimum level of rice price needed to maintain the comparative and competitive advantages in rice production. The \( BEP^S \) of comparative and competitive advantages were calculated using the following formulas:

\[
BEP^S (DRC = 1) = TC^S/Y
\]

\[
BEP^D (PCR = 1) = TC^D/Y
\]

Where \( BEP^S = \text{Break Even Price to maintain comparative advantage (IDR/kg)} \); \( BEP^D \) is break even price to maintain competitive advantage (IDR/kg); \( Y \) is rice yield (kg/ha).

Equation (8) and (9) expresses that West Java remains to have a comparative advantage in producing rice even though the price in the world market tends to go down as long as it is not lower than \( BEP^S \) and if the rice price at the farm gate is not lower than \( BEP^D \). When the rice price falls below \( BEP^S \) for comparative advantage and below \( BEP^D \) for competitive advantage, West Java will no longer have the comparative advantage and competitive advantage to produce rice. The simulation analysis is complemented by a competitiveness analysis if the price of rice at the private and social levels of farmers is the same as the Government Procurement Price (GPP). DRC and PCR analysis, as well as the proportion of rice farming businesses that are able to produce competitiveness and the proportion of total rice production that is produced competitively, were also carried out.
3. Result and discussion

3.1. The competitiveness of farmers' household rice farming in West Java during the COVID-19 pandemic

Competitive advantage (PCR) and comparative advantage (DRC) of farming businesses have shown a decline due to the COVID-19 pandemic. Table 1 shows that during the COVID-19 pandemic, the competitive advantage of rice farming decreased from 0.797 in 2019 to 0.828, 0.867, and 0.838 in 2020, 2021, and 2022, respectively. Rice farmer households that are able to manage their farms with a competitive advantage decreased from 84.03% in 2019 to 78.47%, 73.61%, and 75.69% in 2020, 2021, and 2022 respectively. Meanwhile, the volume of rice production that can be produced with a competitive advantage decreased from 82.09% in 2019 to 76.17%, 71.15%, and 73.99% in 2020, 2021, and 2022 respectively. Compared to the study results by Setiyanto and Pabuayon [7] and Pearson et al. [16] the competitive advantage, the number of rice farmer that able to manage their farm and the volume production that can be produced with a competitive advantage in the same location and time of span of analysis is lower. This is due to the distribution of inputs and outputs is hampered during the COVID-19 pandemic, resulting in a decrease in the amount of production, an increase in input prices, and a decrease in output prices. There was an increase in production costs during the COVID-19 pandemic.

Table 1. Average PCR and DRC values in 2019 and estimates for 2020–2025, 144 respondents of PATANAS rice farmers in West Java, 2019–2025

| Year | Private Cost Ratio (PCR) |  | Domestic Resources Cost (DRC) |  |
|------|--------------------------|--------------------------|-----------------------------|--------------------------|
|      | Average                  | Advantage (PCR < 1)     | Disadvantage (PCR >1)       | Average                  | Disadvantage (DRC < 1) | Disadvantage (DRC >1) |
|      | Percentage of farmers (%)|                         |                            | Percentage of farmers (%)|                         |                            |
| 2019 | 0.797                    | 84.03                   | 15.97                       | 0.829                    | 77.08                   | 22.92                      |
| 2020 | 0.828                    | 78.47                   | 21.53                       | 0.944                    | 61.81                   | 38.19                      |
| 2021 | 0.867                    | 73.61                   | 26.39                       | 0.965                    | 59.72                   | 40.28                      |
| 2022 | 0.838                    | 75.69                   | 24.31                       | 0.937                    | 63.19                   | 36.81                      |
| 2023 | 0.799                    | 83.33                   | 16.67                       | 0.887                    | 69.44                   | 30.56                      |
| 2024 | 0.779                    | 86.11                   | 13.89                       | 0.867                    | 74.31                   | 25.69                      |
| 2025 | 0.753                    | 89.58                   | 10.42                       | 0.822                    | 75.00                   | 25.00                      |

| Year | Percentage of farmer production (%) |  | Percentage of farmer production (%) |
|------|-------------------------------------|--------------------------|-------------------------------------|
| 2019 | 0.797                               | 82.09                   | 17.91                               | 0.829                    | 74.51                   | 25.49                      |
| 2020 | 0.828                               | 76.17                   | 23.83                               | 0.944                    | 59.11                   | 40.89                      |
| 2021 | 0.867                               | 71.55                   | 28.45                               | 0.965                    | 56.99                   | 43.01                      |
| 2022 | 0.838                               | 73.99                   | 26.01                               | 0.937                    | 60.48                   | 39.52                      |
| 2023 | 0.799                               | 81.23                   | 18.77                               | 0.887                    | 66.65                   | 33.35                      |
| 2024 | 0.779                               | 83.28                   | 16.72                               | 0.867                    | 70.87                   | 29.13                      |
| 2025 | 0.753                               | 88.72                   | 11.28                               | 0.822                    | 71.55                   | 28.45                      |

As in competitive advantage, the comparative advantage also shows a decline from 0.829 in 2019 to 0.944, 0.965, and 0.937 in 2020, 2021, and 2022 respectively. Rice farming households have a comparative advantage in rice farming are 77.08% in 2019 and show a decline to 71.15%, 61.81%, and 63.19% in 2020, 2021, and 2022, respectively. The volume of rice production produced by comparative advantage in 2019 was 74.51% and became 59.11%, 56.99%, and 60.48% in 2020, 2021, and 2022 consecutively. This results also lower compared to other studies [6,8]. The results of other studies show that during the pandemic there were problems selling agricultural products due to disrupted distribution access. This has an impact on the decline in output prices [11]. The decline in output prices causes farmers’ income to decrease. Farmers reduced farm production cost by reduce the use of fertilizers which
can cause a decrease in production. Lower prices and lower production can affect competitive and comparative advantage.

Even though it has a condition where the heaviest impact will occur in 2021, but unlike competitive advantage, comparative advantage requires a longer recovery time. Competitive advantage is starting to show recovery to the conditions before the pandemic or 2019 in 2023. However, a new comparative advantage shows recovery that leads to conditions before the pandemic in 2025. Due to the COVID-19 pandemic, even though it has the same impact period of 3 years, recovery of comparative advantage takes longer than the recovery of competitive advantage.

3.2. Production levels and minimum farmers prices to maintain the competitiveness of rice farming in West Java during the COVID-19 pandemic

Table 2 shows that in 2019, competitive losses will occur if the average rice production achieved by farmer households decreases by more than 18.50% of the production achieved in 2019. In the 2020–2025 period, competitive losses will occur if production per farmer household decreases between 11.94% and 13.02% compared to the expected production in the period. In this period, comparative losses will occur if production per farmer household decreases on average in the range of 12.57% to 15.50% compared to production expected in this period. Compared to the results of study by Setiyanto [6] and Setiyanto et al. [8], the BEY and BEP are higher. Its mean that comparative and competitive advantage decline during COVID-19 outbreak.

Table 2. Average value of BEY and BEP in 2019 and forecasts for 2020–2025, 144 respondents of PATANAS paddy farmers in West Java, 2019–2025

| Year | Competitiveness indicator | Break Even Yield (BEY) | Break Even Price (BEP) |
|------|---------------------------|------------------------|------------------------|
|      |                           | Value (kg) | Percentage (%) | Value (IDR/kg) | Percentage (%) |
| 2019 | Competitive (PCR = 1)    | 6,824.70   | 81.50         | 3,636.44      | 80.20         |
|      | Comparative (DRC=1)      | 7,287.19   | 87.03         | 3,507.71      | 87.82         |
| 2020 | Competitive (PCR = 1)    | 7,380.24   | 88.06         | 4,358.32      | 88.72         |
|      | Comparative (DRC=1)      | 7,081.94   | 84.50         | 3,419.44      | 85.82         |
| 2021 | Competitive (PCR = 1)    | 7,373.32   | 86.97         | 4,444.11      | 88.43         |
|      | Comparative (DRC=1)      | 7,212.52   | 85.07         | 3,466.68      | 86.37         |
| 2022 | Competitive (PCR = 1)    | 7,496.05   | 87.08         | 4,590.98      | 88.53         |
|      | Comparative (DRC=1)      | 7,370.46   | 85.62         | 3,574.92      | 86.89         |
| 2023 | Competitive (PCR = 1)    | 7,612.91   | 87.17         | 4,695.12      | 87.74         |
|      | Comparative (DRC=1)      | 7,596.83   | 86.98         | 3,684.70      | 88.25         |
| 2024 | Competitive (PCR = 1)    | 7,706.14   | 87.22         | 4,847.80      | 87.79         |
|      | Comparative (DRC=1)      | 7,686.61   | 87.00         | 3,725.44      | 88.27         |
| 2025 | Competitive (PCR = 1)    | 7,435.80   | 86.74         | 4,905.47      | 86.09         |
|      | Comparative (DRC=1)      | 7,495.46   | 87.43         | 3,777.42      | 88.76         |

In terms of the price changed, in 2019, competitive advantage maintained if prices at the farmer level do not fall by more than 19.80% compared to prices that occurred in 2019. In the 2020–2025 period, the competitive advantages preserved if product prices at the farm level do not decrease by 11.28% (2020) to 13.91% (2025) compared to the estimated price during that period. Meanwhile, the comparative advantages in 2019 are maintained if the social product prices of rice at the farmer level (border price) do not fall by more than 12.28% compared to the price in 2019. In 2019–2020, the comparative advantages are maintained if the social product prices at the farmer level are 11.24% (2025) to 14.28% (2020) of the estimated product prices that occurred in that period. Both in production or product price changes at the farm level, the COVID-19 pandemic harms the form of an increased risk of losing competitiveness in rice farmers’ household farming. Even though the heaviest impact on competitive and comparative advantage is estimated to only occur for three years, the risk of losing competitive and comparative advantage will continue and tend to increase until 2025.
3.3. Farmers’ household rice farming competitiveness at prices at farmer level same as HPP 2020 at the time of the COVID-19 pandemic

The Ministry of Trade has issued Regulation of the Minister of Trade Number 24 of 2020 concerning Determination of Government Purchase Prices (GPP) for Unhulled or Rice on March 16, 2020, and comes into force on March 19, 2020. Based on this regulation, the GPP set for Gabah Kering Panen (GKP) at the farmer level is IDR 4,200.00 per kg. Table 3 shows the analysis of the results using the assumption that the 2020 HPP of IDR 4,200.00 applies to the private and social prices.

Table 3. Average PCR and DRC values at private and social prices levels at farmer level equal to GPP 2020 for 2019 and forecasts for 2020–2025, 144 respondents of PATANAS paddy farmers in West Java, 2019–2025

| Year | PCR Average | Advantage (PCR < 1) | Disadvantage (PCR >1) | DRC Average | Advantage (DRC < 1) | Disadvantage (DRC >1) |
|------|-------------|---------------------|----------------------|-------------|---------------------|----------------------|
|      | Percentage of farmers (%) | Percentage of farmers (%) | Percentage of farmers (%) | Percentage of farmers (%) | Percentage of farmers (%) | Percentage of farmers (%) |
| 2019 | 0.866       | 71.53               | 28.47                | 0.861       | 69.44               | 30.56                |
| 2020 | 0.938       | 61.81               | 38.19                | 0.881       | 68.75               | 31.25                |
| 2021 | 0.993       | 54.17               | 45.83                | 0.902       | 68.06               | 31.94                |
| 2022 | 0.996       | 55.56               | 44.44                | 0.920       | 64.58               | 35.42                |
| 2023 | 1.016       | 53.47               | 46.53                | 0.923       | 64.58               | 35.42                |
| 2024 | 1.051       | 48.61               | 51.39                | 0.934       | 63.89               | 36.11                |
| 2025 | 1.067       | 48.61               | 51.39                | 0.926       | 64.58               | 35.42                |

The results show that if the GPP 2020 applying in 2020–2025, the rice farmers’ household farms will lose their competitive advantage or experience competitive losses in 2023. Rice farmer households that farmed competitively decreased from 71.51% in 2019 to 61.81% in 2020 and continued to decline to only 48.61% in 2024 and 2025. Proportion of total rice production that is produced competitively decreased from 67.84% in 2019 to 57.49% in 2020 and continues to decline to 43.66% until 2025.

In terms of comparative advantage, if the social price of GKP at the farmer level is the same as the HPP 2020, farmer households will not experience a comparative advantages loss in the period 2020–2025. However, the value of comparative advantage has decreased from 0.861 in 2019 to 0.881 in 2020 and continues to decline to 0.934 in 2024. In 2025 it slightly improved, namely 0.926 compared to 2024. The rice farmers that competitive farming decreased from 69.44% in 2019 to 68.75% in 2020 and continue shows decline to 63.89% in 2024 and 64.58% in 2025. The proportion of the total rice production that is produced comparatively decreased from 66.83% in 2019 to 65.79% in 2020 and continues decreasing to 61.05% in 2024 and 61.57% in 2025.

4. Conclusions

The COVID-19 pandemic has harmed the competitiveness of rice production. However, the values of PCR and DRC for the period 2020–2025 show that rice production in West Java Province still has a
competitive advantage and is more profitable to produce rice when compared to importing from other countries.

The negative impact of the COVID-19 pandemic will last from 2020 to 2022, with the heaviest impactions in 2021. Even though it has the same impact period of three years, the recovery of comparative advantage will take longer than the recovery of competitive advantage. To maintain a competitive and comparative advantage, rice production per farmer household and GKP prices at the rice farmer level in West Java Province must increase from year to year. If the GKP in private and social products prices at the farmer level is equal to GPP 2020, rice production in West Java Province will lose its competitive advantage from 2022 until 2025 and even though on averages it does not experience a comparative loss, the comparative advantage of rice production in West Java Province continues to decline from 2020 to 2024, and a slight improvement in 2025 compared to 2024.

Based on the results of this study, the government recommended taking some policies, first is eliminating input and output distribution disturbances during the COVID-19 pandemic. Second, seek to increase productivity and secure the risk of yield loss during cultivation, harvest, and post-harvest handling at the farmer level. Third, seeking the increase the usage of agricultural machinery for land management, cultivation, harvest, and post-harvest to reduce labor costs and yield loss. Fourth, considering that GPP applies nationally, studies are needed that reach a national scale. The last is selecting the farmers who have high capability in competitive and comparative advantages as a model for fostering competitiveness improvement for farmers with lower abilities.

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