Paddy Production Analysis in Non-Granary Areas

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ABSTRACT

Currently, it has been shown that Malaysia has a low production of paddy. That is one of the reasons why Malaysia has been importing rice from other countries. To help Malaysia overcome the rice output shortage, this study has decided to determine whether there is an effect of planted area and paddy yield towards paddy production in a long-run scenario. This study focuses on analysing the paddy production of non-granary areas in Johor, Melaka, Negeri Sembilan, Pahang, Pulau Pinang, and Terengganu from 2011 until 2020. The paddy production that is being analysed is during the main season in Malaysia. In order to determine the presence of the long-run relationship, this study employed the Pedroni cointegration test. It was found that the majority of the statistical tests from the Pedroni cointegration test are significant at 5% level of significance. It can be concluded that there is a long-run relationship between planted area, paddy yield, and paddy production. Thus, it is recommended for future researchers to investigate in detail these effects to help maximise the paddy production, especially in the non-granary areas.

Keywords— cointegration test, paddy production, panel data, stationary tests

INTRODUCTION

The three most important food crops in the world are rice, wheat, and maize. When taken as a whole, rice makes up almost half of the calories consumed by people worldwide [9]. Besides, rice has also been one of the staple foods in many countries in the world. Countries located in the Association of Southeast Asian Nations (ASEAN), also known as the Southeast Asian region, have been categorised as the countries that consume the most rice. In 2023, a study found that Malaysia only consumes 106 kilograms of rice per person every year, which is lower than in some of the other Southeast Asian countries [14]. Table 1 shows the total consumption of rice in Malaysia from 2019 to 2024 [10].

Table I Total Consumption of Rice in Malaysia

Year	Rice Consumption(million metric tons)
2019	2.75
2020	2.85
2021	2.90
2022	2.90
2023**	2.91
2024**	2.91

** indicates the estimation of the rice consumption in the future

In 2021, Malaysia produced roughly 1.68 million metric tons of rice, which was 180 thousand metric tons more

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than the production in 2020 [11]. It can be seen that the production of rice does not align with the rice consumption, as the current production is still unable to meet the demands of the Malaysian market. Naturally, as the demand for rice increases, production should also rise to meet the demand. While Malaysia produced 67% of its own rice, the remaining amount is imported from Pakistan, Vietnam, and Thailand [12]. Thus, the Malaysian government is preparing to increase the local rice production by 2025 [11].

Essentially, Malaysia needs to produce more rice. To maximise production, Malaysia should focus on land and climate change. Malaysia has two seasons, which are the main season and the off-season, where the activities of paddy cultivation, from the preparation of land to harvesting, start [6]. Based on Table 2, it can be seen that the non-granary areas in Johor, Melaka, Perak, and Terengganu have decreasing productivity status. Meanwhile, Kedah, Negeri Sembilan, and Perlis have optimum productivity, while productivity in Kelantan and Pahang has an increasing pattern.

Table 2 Summary of Productivity Status

Non-Granary States	Productivity Status
Johor	Decreasing
Kedah	Optimum
Kelantan	Increasing
Melaka	Decreasing
Negeri Sembilan	Optimum
Pahang	Increasing
Perak	Decreasing
Perlis	Optimum
Terengganu	Decreasing

Researchers believe that many aspects should be considered when discussing the causes of paddy production. A study found that rice production can be affected by human capital, labour, wages, wetland, urban population, and rice prices [3]. However, technology has barely any effect on production. Next, it is also important to explore both short- and long-run factors that affect the paddy production. A study on rice production in Nepal revealed that in both short- and long-term, rice production is positively influenced by cultivated area, fertiliser consumption, and agricultural credit [5].

The average yield of cleaned paddy is the mean crop of paddy after the process of drying, cleaning, and when the moisture content is at exactly 14% [6]. Win et al. (2020) found that during the dry season, there is no significant difference in the yield regardless of the types of water management. On the contrary, the yield differs with the alternate wetting and drying system having a higher paddy yield than in continuous flooding [13]. Next, it was stated that the paddy plantation is divided into two parts [6]. The granary areas refer to the dominant irrigation schemes, which are about 4,000 hectares minimum, while the outside granary areas are referred to as the areas with minor or outside the irrigation system.

A study by Win et al. (2020) stated that he used both water management system, continuous flooding (CF) and alternate wetting and drying (AWD), to manage water in maintaining the rice production. He also found that during the wet season, CF needed more irrigation than AWD as CF irrigates 1,835 mm water while AWD irrigates 1,522 mm of water [13].

Nevertheless, the current paddy production is not enough to cover the population in Malaysia. Since the granary areas are likely to have optimum and increasing productivity of rice, this study attempts to focus on the non-granary areas during the main season to help increase the productivity. Hence, the study decides to determine whether there is a long-term relationship between planted area, paddy yield and paddy production.

METHODOLOGY

Source of Data

This study used data from the Paddy Production Survey Report 2020/2021 by the Department of Agriculture, Peninsular Malaysia. The data provided is categorised as panel data, which is a combination of cross-sectional data and time series data [15]. The annual data utilises the information from six states in Malaysia specifically to non-granary states from 2011 until 2020, with the total observation of 60, with 2 independent variables. The six non-granaries states are Johor, Melaka, Negeri Sembilan, Pahang, Pulau Pinang, and Terengganu, while the independent variables that are being investigated are the planted area and paddy yield. Table 3 shows the variable of interest in this study.

Table 3 List of Variables

Variable	Description	Measurement
Area	Planted area in hectare	Ratio
Yield	Average yield of cleaned paddy in kilogram/hectare	Ratio
Production	Wetland paddy production in metric ton	Ratio

Stationary Test

Since panel data is a combination of time-series and cross-sectional data, the study needs to test for model stationary using unit root test. The study decides to use the Hadri Lagrange Multiplier test proposed by Hadri in 2000. Hadri has a null hypothesis of stationary, while in contrast, the alternative hypothesis of at least one series has a unit root [7]. The components of the Hadri test are represented by Equation 1 [1].

$$y_{it} = z'_{it}\gamma + r_{it} + \varepsilon_{it} \quad (1)$$

Where z_{it} is the deterministic component while r_{it} is a random walk,

$$r_{it} = r_{it} + u_{it} \quad (2)$$

And ε_{it} is known as a stationary process while $u_{it} \sim iid(0, \sigma_u^2)$. The partial sum of the residuals, S_{it} is written as in Equation 3

$$S_{it} = \sum_{j=1}^{t} \hat{e}_{ij} \quad (3)$$

While the LM statistic is represented in Equation 4

$$LM = \frac{\frac{1}{n}\sum_{i=1}^{N}\frac{1}{T^2}\sum_{t=1}^{T} S_{it}^2}{\hat{\sigma}_{\varepsilon}^2} \quad (4)$$

Hadri (2000) believes that the standardized statistics are as in Equation 5 and 6 [7]:

$$Z_{\mu} = \frac{\sqrt{N}(LM_{\mu} - \xi_{\mu}}{\zeta_{\mu}} \Rightarrow N(0,1) \quad (5)$$

and

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$$Z_\tau = \frac{\sqrt{N}(LM_\tau - \xi_\tau}{\zeta_\tau} \Rightarrow N(0,1)$$	(6)

As T→∞ followed by N→∞.

Cointegration Test

To verify the stationary variables, unit root test is run [2]. It is a crucial step in determining whether the stationary first-difference variables, I(1), are cointegrated or not. The cointegration test also able to check whether a long-run relationship among the variables exist or not [4]. The study chooses to test the cointegration using Pedroni (1999) residual-based cointegration test. It is constructed based on Engle-Granger (1987) as the test statistic is from the residuals of the panel static regression [2].

The test statistics and p-values that will be generated by the Pedroni (1999) are panel and weighted panel of v-statistic, ρ-statistics, PP-statistic, and ADF-statistic. Besides, there are also group mean approach of ρ-statistics, PP-statistic, and ADF-statistic [8]. The panel and weighted panel statistics are from pooled data along the within-dimension while the group statistics are from pooled data along the between-dimension [2]. According to Barbieri, L., Pedroni had designed the following test statistics [2]:

1.	Panel v-statistic: $Z_{\hat{v}_{NT}} = \frac{1}{(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{2})}$	(7)
2.	Panel ρ-statistic: $Z_{\hat{v}_{NT}} = \frac{1}{(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{2})}$	(8)
3.	Panel t-statistic (non-parametric): $Z_{t_{NT}} = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,(\hat{e}_{it-1}\Delta\hat{e}_{it}-\hat{\lambda}_i)}{\sqrt{\tilde{\sigma}_{NT}^{2}(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{2})}}$	(9)
4.	Panel t-statistic (parametric): $Z_{t_{NT}}^{*} = \frac{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{*}\Delta\hat{e}_{it}^{*}}{\sqrt{\tilde{s}_{NT}^{*2}(\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{*2})}}$	(10)
5.	Group ρ-statistic: $\tilde{Z}_{\hat{\rho}_{NT-1}} = \sum_{i=1}^{N}\frac{\sum_{t=1}^{T}(\hat{e}_{it-1}\Delta\hat{e}_{it}-\hat{\lambda}_i)}{(\sum_{t=1}^{T}\hat{e}_{it-1}^{2})}$	(11)
6.	Group t-statistic (non-parametric): $\tilde{Z}_{\hat{\rho}_{NT-1}} = \sum_{i=1}^{N}\frac{\sum_{t=1}^{T}(\hat{e}_{it-1}\Delta\hat{e}_{it}-\hat{\lambda}_i)}{(\sum_{t=1}^{T}\hat{e}_{it-1}^{2})}$	(12)
7.	Group t-statistic (parametric): $Z_{t_{NT}}^{*} = \sum_{i=1}^{N}\frac{\sum_{t=1}^{T}\hat{e}_{it-1}^{*}\Delta\hat{e}_{it}^{*}}{\sqrt{\sum_{t=2}^{T}\hat{s}_i^{*2}\hat{e}_{it-1}^{*2}}}$	(13)

As mentioned before, the null hypothesis of the Pedroni residual cointegration test is that there is no cointegration relationship between the non-stationary variables. So, in order to estimate a model in a long-run relationship, the study must reject the null hypothesis. To reject the null hypothesis, the study must ensure that the majority of the test statistics and their p-values are significant. Only then can it be proven that there is a long-run relationship between planted area, paddy yield and paddy production.

RESULTS AND DISCUSSION

Stationary Test

Since panel data is a combination of cross-sectional data and time series data, the stationary assumption must be checked. This study uses the Hadri Lagrange Multiplier (LM) Stationary test as stated in Table 4.

Table 4 Hadri Lm Test

Variables	Level	First Difference
AREA	1.443e-03 *	0.5037
YIELD	1.203e-06 *	0.7009
PRODUCTION	1.035e-04 *	0.6687
* significant at 0.05.		

Based on Table 4, at the level, all p-values are significant at 5%. So, the study can conclude that area, yield, and production are not stationary at a level. Hence, the variables need to be tested again at the first difference level. Next, it is proven that area, yield, and production are stationary at first difference as the p-values are insignificant. It can be concluded that all variables are stationary at first difference and integrated at first order, I(1). Thus, the study can proceed to check the cointegration between the variables to determine the existence of a long-run relationship between them.

Cointegration Test

Since the study aims to determine the presence of a long-run relationship between planted areas, paddy yield, and paddy production, a cointegration test is performed. If cointegration exists, it can be proven that a long-run relationship exists.

Table 5 Pedroni Residual Cointegration Test

Test	Statistic	Probability.
Alternative hypothesis: common AR coefficients. (within-dimension)		
Panel v-statistic	-1.2141	0.8877
Panel rho-statistic	1.1603	0.8770
Panel PP-statistic	-1.7310	0.0417 *
Panel ADF-statistic	-1.7291	0.0419 *
Weighted Panel v-statistic	-1.5085	0.9343
Weighted Panel rho-statistic	0.7018	0.7586
Weighted Panel PP-statistic	-6.9495	0.0000 *
Weighted Panel ADF-statistic	-5.4273	0.0000 *
Alternative hypothesis: common AR coefficients. (between-dimension)		
Group rho-statistic	1.6467	0.9502
Group PP-statistic	-7.6406	0.0000 *
Group ADF-statistic	-4.8891	0.0000 *

* significant at 0.05.

Six out of eleven of the p-values from Table 5 are less than 0.05. Hence, it can be concluded that the variables are cointegrated with each other. Thus, the study can conclude that there is a long-run relationship between planted areas, paddy yield, and paddy production.

CONCLUSION AND RECOMMENDATION

Conclusion

Rice is the staple food in Malaysia. So, it is normal when the demand for rice is higher compared to other foods. So, when the demand for rice increases, the paddy production should increase by the same amount of rice produced. However, since the market demands in Malaysia are not met, then, the study decides to explore the possible factors that could improve the local paddy production. Hence, the study investigates the dataset of paddy production, planted area, and paddy yield during the main season from 2011 until 2020 for a few non-granary states in Malaysia. Next, the Hadri LM test is used to test the stationary, and it is found that planted area, paddy yield and paddy production are not stationary at the level but stationary at first difference. Hence, the Pedroni residual cointegration test is run. From the cointegration test, the study found that all the variables are cointegrated to each other. The study can conclude that there is a long-run relationship between planted area, paddy yield, and paddy production.

Recommendation

The findings confirm the existence of a long-run relationship between planted area, paddy yield, and paddy production. Future research should further explore the extent and mechanisms through which these factors influence production outcomes over time. It is also recommended that subsequent studies incorporate data covering both the main and off-seasons to provide a more comprehensive understanding of paddy production dynamics. Furthermore, translating these empirical insights into concrete policy interventions would enhance the study's applied significance and ensure practical benefits for Malaysian agriculture. Policymakers and agricultural agencies should consider developing optimised planting strategies tailored to regional soil and climatic conditions, implementing yield-enhancement initiatives such as the adoption of high-yield paddy varieties, improved irrigation management, and precision farming technologies. These evidence-based measures, supported by continuous farmer training and performance monitoring, could strengthen productivity in non-granary areas and contribute meaningfully toward Malaysia's long-term objective of achieving rice self-sufficiency and sustainable agricultural development.

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