



THE CAUSAL IMPACT OF GOVERNMENT SUPPORT ON THE SMALL STRATEGIC CROP INDUSTRY: MALAYSIA'S EXPERIENCE

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ABSTRACT

Rice is a staple food for countries particularly in Asia, including Malaysia, hence arise concern on its supply. Thus, this study aims to investigate the causal relationship between the incentives (fertiliser subsidy and minimum price guarantee) given and paddy production in Kedah, the rice bowl of Malaysia. A time-series data ranging from the 1996 main season to the main season in 2018 (1996H1 to 2018H1) employed. Using ARDL and Granger approaches, the result shows that any disequilibrium in paddy production is regulated to accomplish the convergence faster. In the short-run, fertiliser subsidy and paddy prices are not significant in the MADA regions. The results of the analysis show that there are various causes of the long-run in the production of rice with subsidized steel and rice prices related to rice yield. The outcome of this study demonstrates the presence of long-run causality between paddy production with fertiliser subsidy and paddy price with respect to paddy yield. Therefore, to boost the paddy yield, the government should increase the number of subsidies, and control the paddy price to prevent it from falling below the market price. Therefore, future research should investigate the causal relationship between fertiliser and paddy price subsidy to the different types of paddy seeds planted.

Contribution/ Originality

This study significantly contributes to the growing evidence of the relationship between government incentive schemes to paddy production in Malaysia. The research explored how fertiliser subsidy and minimum price guarantee contributed to paddy yield. The evidence provided in this study demonstrates that the presence of long-run causality between paddy production of fertiliser subsidy minimum price guarantee.

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1. INTRODUCTION

Paddy that is undoubtedly the principal crop in Malaysia represents the predominant source of the single Malaysians' staple food that is rice. Paddy planting areas cover almost 6% to 10% of the total agricultural areas in Malaysia (Economic Planning Unit, 2001, and 2006, Fatimah *et al.*, 2020). Although rice is a staple food for Malaysians, by 2015, more than 70% of the agricultural land was occupied by oil palm (Fatimah *et al.*, 2020).

Paddy cultivation is initiated on a small scale and the average field size is 1 to 2 hectares. There are two types of paddy crops, namely wetland paddy, and dryland paddy. The average production for the main and off seasons is around 3000 kilograms per hectare. Based on these facts, it seems that the Malaysian paddy yield is below the national paddy production target at a rate of 5% in 2010 (Food and Agriculture Organization, 2002; Othman, 2008; Department of Agriculture, Malaysia, 2011). The actual yield for rice production is between 44% to 68% and under the potential yield (Othman, 2008, Che *et al.*, 2019). This situation causes a shortage of paddy production around 125,552.15 metric tons per annum. The shortage of local paddy production also causes lower local rice supply. On average, rice consumption in Malaysia is roughly 120 kilograms per person every year. This is approximately 26% to 44% of the daily calorie needs (Suthida *et al.*, 2008; USDA, 2012, Che *et al.*, 2019). To solve these problems, the government has to import almost 30% of the rice from neighbouring countries such as Vietnam and Thailand. Therefore, to increase the rice self-sufficiency level (SSL), Malaysia has to increase its local paddy production. The tenth Malaysia plan aims to achieve a minimum self-sufficiency level of 70 percent food security (Saiful and Mohd, 2016). Thus, as to increase paddy production, farmers have to increase their level of productivity.

To increase Malaysian paddy production, the government has adopted various series of subsidy policies. The purpose of subsidy policies is basically to reduce the costs of production and to boost farmers' income. There are also subsidies given to reduce consumers' burden. Fundamentally, there are three instruments implemented under the subsidy policy, which are the fertiliser scheme, paddy price subsidy scheme, and rice price subsidy scheme. The fertiliser subsidy was introduced in the early 1950s. In the early stage, the government stopped the fertiliser subsidy when the price of fertilisers decreased. Nonetheless, in 1979, the government had to resume this policy when the price of fertilisers increased and until to date, fertilisers have become 100% subsidy. It was only given to the landowners and not to the operators. The average allocation of fertilisers for the years (2003-2007) was approximately USD 44.4 million. Meanwhile, the government introduced the paddy price subsidy scheme in 1980. The purpose of introducing this scheme was to increase the farmers' productivity and income (Tan, 1987; Tawang *et al.*, 1999, Fatimah, 2018). The scheme was stemmed from the realisation that the paddy farmers have recorded the highest poverty rates in Malaysia. On average, the paddy price subsidy has increased over the years except in 2006. However, the allocation gap between 2005 and 2006 had a minor difference of about 0.6%. This proves that the paddy price subsidy is the major instrument in boosting the farmers' income. Therefore, the purpose of this study is to analyse the fertiliser and paddy price subsidy schemes on paddy cultivation based on the estimated paddy production function.

2. LITERATURE REVIEW

Among the most important inputs in agricultural production is fertiliser. The correct measurement of the fertiliser application may help to increase production output. Generally, fertilisers are classified into two, namely organic fertilisers and chemical fertilisers. Fertilisers are additional nutrients supplied to the plant. They are very important, especially in increasing the level of productivity among paddy farmers. The right application of the fertilisers and the right fertiliser specification help increase the nutrients in the soil, such as nitrogen, phosphorus, potassium, and others. The effective use of fertilisers may increase the output by more than 20 %. Therefore, fertilisers are crucial in

increasing the fertility of the soil especially in unfertile paddy growing areas (Nurul *et al.*, 2012; Meena *et al.*, 2013).

Many of the researchers concluded that fertiliser inputs are complementary to the production of other inputs (Lori *et al.*, 2013; Lenis *et al.*, 2013; Adnan *et al.*, 2017). In other words, to increase the paddy production, farmers have to make sure that they use effective technology and the correct schedule of fertilisers.

In a preliminary study of paddy, Jayaraman (1983) found that fertiliser is an important input in the paddy production in Indonesia. Meanwhile, in 2010, Krishna *et al.* (2010) discovered that fertiliser is an extremely important factor for the family farms in Nepal. Chaudhry *et al.* (2009) and Oluwatosin (2013) also discovered that fertiliser is significant in agricultural production.

In the efficiency study conducted by Sherlund *et al.* (2002), it was discovered that labour can be substituted by the use of chemical fertilisers. Furthermore, Suresh and Ready (2006) found that the ratio of MPV / MFC land in the district of Kerala, India is high, which is approximately 3:04. This means that land is significant as a determinant factor in paddy production. However, the size of the cultivated areas is small. This causes a low average output. Therefore, to increase paddy production, Ready (2007) suggested that the farmers in Kerala employ fertilisers. Furthermore, the results of the study indicated that one rupee increase in the fertiliser expenditure increases the yield by about 2.83 rupees in the Kerala district of India. The literature above shows strong evidence in supporting that fertilisers are very important in increasing the paddy yield.

Similar to other sectors, the agricultural output price also affects the allocation of resources to aggregate production (Liyan and Richard, 1993). Mundlak (1988), in his article, stressed the importance of price as an input to determine the choice of technique used. Furthermore, the price also important in influencing the level of productivity (Mundlak, 1988). When the price of agricultural output is high, farmers are given the incentive to improve their earning and, indirectly, it can help to raise the supply of the agricultural product. Numerous research has shown that price and productivity are positively related. Several studies have shown that price and productivity are positively related to the research in South Asia (Bhavani *et al.*, 2019)

According to Timmer *et al.* (1983), two major roles played by price are, firstly, it shows the level of consumption especially among the poor. Secondly, the price also affects the supply through increased production as an incentive to producers. In reality, there are two different desires among consumers and agricultural producers. Consumers prefer lower prices of goods while farmers want a higher price of output. In the case of Malaysia, this difference is offset by the government through price subsidies for both consumers and agricultural producers.

3. MATERIALS AND METHODS

3.1. Co-integration test: the ARDL approach

The underlying regression for this section is based on the log-linear production model as follows:

$$Y = (N, K, L40, L41, F, P) \dots\dots\dots (1)$$

where Y is the paddy yield. Meanwhile, F and P represent fertiliser and paddy price subsidy schemes respectively. In the meantime, N, K, LL40, and LL41 are selected control variables for land, capital, young farmers, and old farmers. A natural log of both sides of equation 1 is taken and equation 2 will be obtained as follows:

$$\ln Y_t = \alpha_0 + \alpha_1 \ln(N_t) + \alpha_2 \ln(K_t) + \alpha_3 \ln(L40) + \alpha_4 \ln(L41) + \alpha_5 \ln(F_t) + \alpha_6 \ln(P_t) + \mu_t \dots (2)$$

where α represents the elasticity of paddy production with respect to each independent variable in VAR model. Subscript t represents time and μ represents the residual. Equation 2 is the underlying VAR that is used in the empirical analysis of all paddy production regions in MADA. The notation of α_0 is the intercept, μ_t is white-noise random error, and α_1 to α_6 are the coefficients for the long-run model.

The F-statistic of the bounds testing method (Pesaran and Pesaran, 1997; Pesaran *et al.*, 2001) is examined for the joint significance of the coefficients of the lagged levels of the variables. Every year has two main seasons. So all together 32 observations. This study employed the Narayan (2004) approach because critical values produced by Narayan is more suitable for small sample sizes. This study employs time-series data from the main season in 1996 (1996H1) to the main season in 2011 (2011H1). This study only focuses on the Muda Agricultural Development Authority (MADA) granary area.

The long-run equations which form the production functions model to be analysed in the present study can be portrayed as a general vector autoregressive model of order p in z_t as follows:

$$z_t = a_0 + \beta t + \sum_{i=1}^{p-1} \phi_i z_{t-i} + \varepsilon_t, t = 1, 2, 3, \dots, T \quad \dots\dots\dots (3)$$

where a_0 represents a $(k+1)$ vector containing intercepts and β is a $(k+1)$ vector of trend coefficients. Following this, a vector equilibrium error-correction model (VECM) is derived as shown below:

$$\Delta z_t = a_0 + \beta t + \Pi z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + \varepsilon_t \quad t = 1, 2, 3, \dots, T \quad \dots\dots\dots (4)$$

where the $(k+1) \times (k+1)$ matrices $\Pi = I_{k+1} + \sum_{i=1}^p \Psi_i$ and $\Gamma_i = -\sum_{j=i+1}^p \Psi_j$ with $i = 1, 2, \dots, p-1$ have

both the long-run multipliers and short-run dynamic coefficients of the VECM. z_t contains the vector of variables y_t and x_t . y_t is the dependent variable and x_t reflects the ‘forcing’ I (0) and I (1) variables. Assuming there is a unique long-run association between the parameters of interest, the VECM above can be written as:

$$\Delta y_t = a_{y_0} + \beta t + \delta_{yy} y_{t-1} + \delta_{yx} x_{t-1} + \sum_{i=1}^{p-1} \lambda_i \Delta y_{t-i} + \sum_{i=0}^{p-1} \xi_i \Delta x_{t-1} + \varepsilon_{y,t}, t = 1, 2, \dots, T \quad \dots\dots (5)$$

In equation (5) above, i refers to the paddy sub-sector, δ is the long-run multiplier, a is constant, and ε is the white-noise error.

Adapting the above specification to the variables in the present study, yield equations (6) and (7) below are for the production function model of paddy sub-sector:

$$\begin{aligned} \Delta \ln Y_t = & c_0 + \delta_1 \ln Y_{t-1} + \delta_2 \ln N_{t-1} + \delta_3 \ln K_{t-1} + \delta_4 \ln L40_{t-1} + \delta_5 \ln L41_{t-1} + \delta_6 \ln F_{t-1} + \\ & \delta_7 \ln P_{t-1} + \sum_{j=0}^{q1} \omega_j \Delta \ln N_{t-j} + \sum_{k=0}^{q2} \gamma_k \Delta \ln K_{t-k} + \sum_{l=0}^{q3} \phi_l \Delta \ln L40_{t-l} + \sum_{m=0}^{q4} \vartheta_m \Delta \ln L41_{t-m} + \\ & \sum_{n=0}^{q5} \mu_n \Delta \ln F_{t-n} + \sum_{o=0}^{q6} \tau_o \Delta \ln P_{t-o} + \varepsilon_t \quad \dots\dots\dots (6) \end{aligned}$$

$$\Delta \ln N_t = c_0 + \delta_1 \ln N_{t-1} + \delta_2 \ln Y_{t-1} + \delta_3 \ln K_{t-1} + \delta_4 \ln L40_{t-1} + \delta_5 \ln L41_{t-1} + \delta_6 \ln F_{t-1} + \delta_7 \ln P_{t-1} + \sum_{j=0}^{q1} \omega_j \Delta \ln N_{t-j} + \sum_{k=0}^{q2} \gamma_k \Delta \ln K_{t-k} + \sum_{l=0}^{q3} \phi_l \Delta \ln L40_{t-l} + \sum_{m=0}^{q4} \vartheta_m \Delta \ln L41_{t-m} + \sum_{n=0}^{q5} \mu_n \Delta \ln F_{t-n} + \sum_{o=0}^{q6} \tau_o \Delta \ln P_{t-o} + \varepsilon_t \dots \dots \dots (7)$$

The OLS technique is used to conduct the F-test for the above equation which tests the null hypothesis $H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ against the alternate hypothesis $H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$. The rejection of the null hypothesis shows that there exists a long-run relationship between the variables. Therefore, the variables in the model are co-integrated. The F-statistic obtained is a statistic in a generalised Dickey-Fuller type of regression that employed to test the significance of lagged level variables in a conditionally unrestricted equilibrium-correction model (Pesaran *et al.*, 2001). F-statistic is then compared with the two sets of critical values that create a band. The first value presumes all the variables are I (1) while another value presumes all the variables are I (0). Critical values for I (1) series are known as upper bound while the critical values for the I (0) series are known as lower bound.

If the computed F-statistic is beyond the upper-bound level, the null hypothesis can be rejected. This shows that there is a co-integration between the parameters or variables. However, if the F-statistic is below the lower-bound value, the null hypothesis cannot be rejected and this demonstrates no co-integration between variables. If the statistic falls between the upper and lower bounds, a conclusive inference cannot be made without knowing the order of integration of the independent variables (Narayan, 2004). If the variables are integrated I (1), then the upper bound is taken as the critical value. If the variables are integrated I (0), the lower bound becomes the critical value. In the meantime, there is also an alternative way to capture the existence of co-integration for the inclusive case. As mentioned by Kremers *et al.* (1992), the alternative way to capture the co-integration is by using the error-correction term (ECT). Additionally, the ECT value must be negative and significant. This condition indicates that there is a presence of adjustment towards the long-run equilibrium, therefore, the series are co-integrated.

The bounds table by Pesaran and Pesaran (1997) and Pesaran *et al.* (2001) has produced a sample size of 500 and 1,000 observations and 20,000 and 40,000 replications consecutively. However, the present study just employs 31 observations. Therefore, the F-statistic obtained compared by the critical values generated by Narayan (2004), which is more suitable for small sample sizes¹. After establishing the presence of co-integration, the long-run relationship between the variables is estimated via the following conditional ARDL (p, q1, q2, q3, q4, q5), a long-run model for paddy sub-sector production function in equations (8) and (9) below:

$$\Delta \ln Y_t = c_0 + \sum_{i=1}^p \delta_1 \Delta \ln N_{t-i} + \sum_{i=0}^{q1} \delta_2 \Delta \ln K_{t-i} + \sum_{i=0}^{q2} \delta_3 \Delta \ln L40_{t-i} + \sum_{i=0}^{q3} \delta_4 \Delta \ln L41_{t-i} + \sum_{i=0}^{q4} \delta_5 \Delta \ln F_{t-i} + \sum_{i=0}^{q5} \delta_6 \Delta \ln P_{t-i} + \varepsilon_t \dots \dots \dots (8)$$

$$\Delta \ln N_{i,t} = c_{i,0} + \sum_{j=1}^p \delta_1 \Delta \ln N_{i,t-j} + \sum_{l=0}^{q1} \delta_2 \Delta \ln K_{i,t-l} + \sum_{m=0}^{q2} \delta_3 \Delta \ln L40_{i,t-m} + \sum_{n=0}^{q3} \delta_4 \Delta \ln L41_{i,t-n} + \sum_{o=0}^{q4} \delta_5 \Delta \ln F_{i,t-o} + \sum_{p=0}^{q5} \delta_6 \Delta \ln P_{i,t-p} + \varepsilon_t \dots \dots \dots (9)$$

The optimal lag for each variable (p, q1, q2, q3, q4, q5) is selected based on Schwarz Bayesian Criterion (SBC) or Akaike Information Criterion (AIC).

After obtaining the long-run coefficient estimates, the short-run dynamic coefficients are estimated by OLS through the error-correction models associated with the long-run estimates. The error-

¹ Narayan (2004) generated a different set of critical values using the same GAUSS code as Pesaran *et al.* (2001) but tailored his study with 31 observations. These new critical values were calculated using stochastic simulations for T=31 and 40000 replications for the F-statistic.

correction models corresponding to paddy sub-sector production functions are presented in equations (10) and (11) below:

$$\Delta \ln Y_{i,t} = \beta_i + \sum_{j=1}^p \phi_1 \Delta \ln N_{i,t-j} + \sum_{l=0}^{q1} \omega_2 \Delta \ln K_{i,t-l} + \sum_{m=0}^{q2} \varphi_3 \Delta \ln L40_{i,t-m} + \sum_{n=0}^{q3} \gamma_4 \Delta \ln L41_{i,t-n} + \sum_{o=0}^{q4} \eta_5 \Delta \ln F_{i,t-o} + \sum_{p=0}^{q5} \eta_6 \Delta \ln P_{i,t-p} + \vartheta ect_{i,t-1} + \varepsilon_{i,t} \dots\dots\dots (10)$$

$$\Delta \ln N_{i,t} = \beta_i + \sum_{j=1}^p \phi_1 \Delta \ln N_{i,t-j} + \sum_{l=0}^{q1} \omega_2 \Delta \ln K_{i,t-l} + \sum_{m=0}^{q2} \varphi_3 \Delta \ln L40_{i,t-m} + \sum_{n=0}^{q3} \gamma_4 \Delta \ln L41_{i,t-n} + \sum_{o=0}^{q4} \eta_5 \Delta \ln F_{i,t-o} + \sum_{p=0}^{q5} \eta_6 \Delta \ln P_{i,t-p} + \vartheta ect_{i,t-1} + \varepsilon_{i,t} \dots\dots\dots (11)$$

In equations (10) and (11), the short-run coefficient estimates for the paddy sub-sector production function models are given by $\phi, \omega, \varphi, \gamma, \eta, \zeta$ each model converges to its long-run equilibrium. ϑ reflects how fast the equilibrium is achieved or how the speed of adjustment is.

3.2. Granger causality

If the co-integration test reveals that the variables are co-integrated, we employ the Vector Error-Correction (VEC) Model estimation as in equations 12 to 18y. The Error-Correction Model (ECM) is used to test for Granger-type causality. A benefit of using an ECM specification to test for causality is that it permits the testing of the short-run causality over the lagged different regressors. It also used to test the long-run causality over the lagged Error-Correction Term (ECT). A significant ECT confirms the presence of the long-run causality from the independent variables to the measured variable. Nevertheless, if the variables are not co-integrated, then Vector Autoregressive (VAR) Model is used in the first difference in the estimation given that both variables fertiliser and paddy price is I (1). Thus, ECM is used to examine the Granger causality between variables.

$$\Delta LY_t = \alpha_{0Y} + \sum_{i-1}^k \delta_{1Y} \Delta Y_{t-1} + \sum_{i-1}^k \delta_{2Y} \Delta N_{t-1} + \sum_{i-1}^k \delta_{3Y} \Delta K_{t-1} + \sum_{i-1}^k \delta_{4Y} \Delta LL40_{t-1} + \sum_{i-1}^k \delta_{5Y} \Delta LL41_{t-1} + \sum_{i-1}^k \delta_{6Y} \Delta LF_{t-1} + \sum_{i-1}^k \delta_{7Y} \Delta LP_{t-1} + \gamma_1 ECT_{t-1} + \varepsilon_t \dots\dots\dots (12)$$

$$\Delta LN_t = \alpha_{0N} + \sum_{i-1}^k \delta_{1N} \Delta N_{t-1} + \sum_{i-1}^k \delta_{2N} \Delta Y_{t-1} + \sum_{i-1}^k \delta_{3N} \Delta K_{t-1} + \sum_{i-1}^k \delta_{4N} \Delta LL40_{t-1} + \sum_{i-1}^k \delta_{5N} \Delta LL41_{t-1} + \sum_{i-1}^k \delta_{6N} \Delta LF_{t-1} + \sum_{i-1}^k \delta_{7N} \Delta LP_{t-1} + \gamma_2 ECT_{t-1} + \varepsilon_t \dots\dots\dots (13)$$

$$\Delta LK_t = \alpha_{0K} + \sum_{i-1}^k \delta_{1K} \Delta K_{t-1} + \sum_{i-1}^k \delta_{2K} \Delta K_{t-1} + \sum_{i-1}^k \delta_{3K} \Delta Y_{t-1} + \sum_{i-1}^k \delta_{4K} \Delta LL40_{t-1} + \sum_{i-1}^k \delta_{5K} \Delta LL41_{t-1} + \sum_{i-1}^k \delta_{6K} \Delta LF_{t-1} + \sum_{i-1}^k \delta_{7K} \Delta LP_{t-1} + \gamma_3 ECT_{t-1} + \varepsilon_t \dots\dots\dots (14)$$

$$\Delta LL40_t = \alpha_{0LL40} + \sum_{i-1}^k \delta_{1LL40} \Delta LL40_{t-1} + \sum_{i-1}^k \delta_{2LL40} \Delta Y_{t-1} + \sum_{i-1}^k \delta_{3LL40} \Delta N_{t-1} + \sum_{i-1}^k \delta_{4LL40} \Delta LK_{t-1} + \sum_{i-1}^k \delta_{5LL40} \Delta LL41_{t-1} + \sum_{i-1}^k \delta_{6LL40} \Delta LF_{t-1} + \sum_{i-1}^k \delta_{7LL40} \Delta LP_{t-1} + \gamma_4 ECT_{t-1} + \varepsilon_t \dots\dots\dots (15)$$

$$\Delta LL41_t = \alpha_{0LL41} + \sum_{i-1}^k \delta_{1LL41} \Delta LL41_{t-1} + \sum_{i-1}^k \delta_{2LL41} \Delta Y_{t-1} + \sum_{i-1}^k \delta_{3LL41} \Delta N_{t-1} + \sum_{i-1}^k \delta_{4LL41} \Delta LK_{t-1} + \sum_{i-1}^k \delta_{5LL41} \Delta LL40_{t-1} + \sum_{i-1}^k \delta_{6LL41} \Delta LF_{t-1} + \sum_{i-1}^k \delta_{7LL41} \Delta LP_{t-1} + \gamma_5 ECT_{t-1} + \varepsilon_t \dots\dots\dots (16)$$

$$\Delta LF_t = \alpha_{0LF} + \sum_{i-1}^k \delta_{1LF} \Delta LF_{t-1} + \sum_{i-1}^k \delta_{2LF} \Delta Y_{t-1} + \sum_{i-1}^k \delta_{3LF} \Delta N_{t-1} + \sum_{i-1}^k \delta_{4LF} \Delta LK_{t-1} + \sum_{i-1}^k \delta_{5LF} \Delta LL41_{t-1} + \sum_{i-1}^k \delta_{6LF} \Delta LL41_{t-1} + \sum_{i-1}^k \delta_{7LF} \Delta LP_{t-1} + \gamma_6 ECT_{t-1} + \varepsilon_t \dots\dots\dots (17)$$

$$\Delta LP_t = \alpha_{0LP} + \sum_{i-1}^k \delta_{1LP} \Delta LP_{t-1} + \sum_{i-1}^k \delta_{2LP} \Delta Y_{t-1} + \sum_{i-1}^k \delta_{3LP} \Delta N_{t-1} + \sum_{i-1}^k \delta_{4LP} \Delta LK_{t-1} + \sum_{i-1}^k \delta_{5LP} \Delta LL41_{t-1} + \sum_{i-1}^k \delta_{6LP} \Delta LL41_{t-1} + \sum_{i-1}^k \delta_{7LP} \Delta LF_{t-1} + \gamma_7 ECT_{t-1} + \varepsilon_t \dots\dots\dots (18)$$

Where ECT_{t-1} is the lagged error-correction term.

The Granger causality testing technique includes testing the significance of δ_{ij} s limited on the optimum lags. The ECM equations 12 to 18 are the alternative tests of causality. The γ_{ij} is zero,

which means that the variation in the dependent variable doesn't respond to the deviation in the long-run equilibrium in a period of $t - 1$. For example, equation 1, if γ_{ij} is zero and all δ_{ij} is zero, that can be implied that all the variables do not Granger-cause paddy production. The insignificance of t and F-statistic in the Wald test suggests that the variable is weakly exogenous.

If there is a presence of the co-integration between variables, we presume that at least one or all of the ECTs should be significantly non-zero. Granger causality between LY and other variables can be revealed by testing the following null hypothesis:

- a) Short-run Granger causality:
 $(H_0: \delta_{2Y} = 0, H_0: \delta_{2N} = 0, H_0: \delta_{2K} = 0, H_0: \delta_{2LL40} = 0, H_0: \delta_{2LL41} = 0, H_0: \delta_{2LF} = 0 \text{ and } H_0: \delta_{2LP} = 0,)$
- b) Long-run Granger causality:
 $(H_0: \gamma_1 = 0, H_0: \gamma_2 = 0, H_0: \gamma_3 = 0, H_0: \gamma_4 = 0, H_0: \gamma_5 = 0, H_0: \gamma_6 = 0 \text{ and } H_0: \gamma_7 = 0)$
- c) Joint Granger causality:
 $(H_0 = \delta_{2Y} = \gamma_1 = 0, H_0 = \delta_{2N} = \gamma_2 = 0, H_0 = \delta_{2K} = \gamma_3 = 0, H_0 = \delta_{2LL40} = \gamma_4 = 0, H_0 = \delta_{2LL41} = \gamma_5 = 0, H_0 = \delta_{2LF} = \gamma_6 = 0 \text{ and } H_0 = \delta_{2LP} = \gamma_7 = 0)$

4. EMPIRICAL RESULTS

Based on the results of the unit-root test, ARDL co-integration test, vector autoregressive (VAR) Granger-cause test in the framework of vector error-correction (VECM), response functions (IRFs), variance decomposition (VDS), and diagnostic tests shown in table 1 and 2. Table 1 displays the results of Augmented Dickey-Fuller (ADF) and Phillip Perron test (PP) to the paddy yield, land, capital, young farmers, old farmers, fertiliser, and paddy price to MADA paddy production areas. Based on these tests, at level, the absolute t-statistic obtained for all the time-series data fails to reject the null hypothesis of which the data are not stationary time series. This situation describes that, all factors not stationary at 1% and 5% significance level. This research proceeded with the first-difference stationarity test and found out that the t-calculate was larger than the t-critical value at 1% and 5%. This means that the integration of the variables is at the first difference or I(1).

Table 1: Unit-root analysis for MADA Regions

Variables	ADF Test		PP Test		Conclusion
	Constant	Without Trend	Constant	Without Trend	
LY		-1.696		-2.041	I(1)
Δ LY		-14.489*		-22.41**	
LN		-1.037		-1.455	I(1)
Δ LN		-7.489*		-7.537*	
LK		0.254		0.080	I(1)
Δ LK		-4.465*		-4.465**	
LL40		-2.273		-2.407	I(1)
Δ LL40		-6.125*		-6.108*	
LL41		-2.083		-2.198	I(1)
Δ LL41		-6.402*		-6.356*	
LF		-1.564		-1.565	I(1)
Δ LF		-6.779*		-6.611*	
LP		-0.115		-0.051	I(1)
Δ LP		-5.599**		-5.599**	

Notes: *, and** donated 1% and 5% significant levels respectively

To approve the existence of co-integration among the parameters, this study employed the bound test and the Autoregressive Distributed Lag (ARDL) method. The optimal lag length needs to be determined first before the ARDL co-integration test. Based on the AIC suggestion, the optimal lag

length is 2. Table 2 shows that F-statistic for the MADA area is 3.4337. This F-statistic value is between the lower (2.303) and upper (3.483) bound value at 5% and 10% significant levels. This indicates that the presence of co-integration between variables in the model could not be ascertained. Therefore, the test on the error correction term (ECT) by *Kremers et al. (1992)* is used to confirm the co-integration between variables. To test the ECT, the long-run equation for the MADA area needs to be generated first.

Table 2: Results of bounds test and critical values for case II

Case II (intercept and no trend)			
Level of Significance	Lower	Upper	
1% Significance	3.901	5.611	
5% Significance	2.780	4.084	
10% Significance	2.303	3.483	
Computed F-statistic			3.4337

Notes: The F-statistics are compared with the upper bound i.e. I(1) and lower bound i.e. I(0) critical values for zero restriction on the coefficient of the lagged level variables
N = 30

Based on Table 3, the coefficient estimation shows that land, old farmers, fertilisers, and paddy prices are significant in the long-run equation for MADA. The coefficient estimation of land, fertilisers, and paddy price show that paddy yield is elastic towards change in land, fertilisers, and paddy price. 1% increase in land size leads to an increase in output by 28%. Meanwhile, a 1% increase in fertilisers used triggers the increase in output by approximately 172%. This reflects that the use of fertilizers intensively and effectively increases paddy yield. On the other hand, old farmers and paddy prices are inelastic to the change in paddy yield. If there is a 1% increase in the number of old farmers, the output decreases by about 0.4%. Nonetheless, when the paddy price increases by 1%, the output decreases by 5%. Other variables are not significant to determine paddy yield in the long-run.

Table 3: Long-run coefficient estimations for the determinants of the paddy yield in MADA Area

Variables	LN	LK	L40	L41	LF	LP	C
Coefficient	28.29**	-0.06	0.12	-0.04**	172.35**	-5.07**	-1438.3**
t-statistic	2.86	-0.78	1.50	-2.17	2.83	-2.84	-3.31

Notes: *, ** indicates significance at 5% and 10% levels

From the information in Table 3, we then computed the error-correction term (ECT). The negative and significant value of the error-correction term (ECT) shows the presence of the long-run relationship among variables. The Output Error-Correction Terms (ECT) for MADA are shown as below: -

$$\Delta LY = 0.015 + 46.966\Delta LN^{**} + 0.449\Delta LK^{**} + 256.334\Delta LL40^{*} - 345.454\Delta LL41^{**} + 93.228\Delta LF - 2.851\Delta LP - 1.038ect^{*}$$

$$\begin{matrix} [1.445] & [4.083] & [2.986] & [6.522] & [-4.233] \\ [1.297] & [-1.288] & [-8.355] & & \end{matrix} \dots\dots\dots (19)$$

R²: 0.843; Adjusted R-squared: 0.793; AR(2): 0.970(0.396);
Heteroscedasticity (1): 0.891(0.559); RESET(2): 1.645(0.217);
Normality(2): 1.269(0.530); CUSUM: Stable; CUSUM-SQ: Stable

Notes: Brackets denote the t-statistics while p-values are in parentheses. Breusch-Godfrey, White, Ramsey RESET, and Jarque Bera tests are used to test for the presence of serial correlation, heteroscedasticity, model miss-specification, and residual non-normality in the model.

* and ** denote significant at 1% and 5% level respectively. SR is short-run

From the above ECT estimation, we found that the value of ECT is negative and significant. This shows that there exists a long-run relationship among variables. The lagged coefficient of the error-correction term (ECT) depicts the speed of adjustment of paddy yield to shock in the system. The speed of adjustment of paddy production is higher. From the short-run output, the speed of adjustment for MADA is 104%. The result suggested that any disequilibrium in paddy production is adjusted to achieve faster convergence. Additionally, it could be inferred from these results that paddy yield, land, capital, young and old farmers, fertilisers, and local paddy price are the long-run ‘forcing variables’ of paddy yield in MADA paddy production areas. From this result, we could make an initial assumption that at least there is a presence of one-way causality between variables in MADA paddy production areas.

The present study also found that in the short-run, the land is significant in the MADA areas. The degree of elasticity of paddy yield with respect to land is that it is elastic and has a positive sign. This means that 1% of the increase in paddy planting areas leads to approximately 46.97 % of the increase in paddy yield. This indicates that in the short-run, the increase in harvested areas may increase the paddy yield (Fatimah *et al.*, 2020). Besides, the present research also found that young and old farmers are also significant in influencing paddy production. The degree of elasticity of paddy yield concerning young and old farmers is elastic. However, both variables have a different sign. Young farmers have a positive effect on paddy yield; a 1% increase in young farmers, paddy yield increases roughly by 611%. The increase in old farmers reduces paddy production by about 611%. This indicates that young farmers are among the most vulnerable target to increases agricultural output (Balezentis *et al.*, 2020). If paddy cultivation is too dependent on old farmers, the productivity may reduce. Nonetheless, this research also found that capital is significant in the short-run. From the above result, the degree of elasticity is inelastic and has a positive sign. Based on the empirical finding, a 1% increase in capital results in the increase of paddy yield by about 0.45 %. This finding is smaller as compared to the study done by Oniah *et al.* (2008).

The diagnostic test was then employed to test the goodness of fit of the model. The goodness of fit of the model is adequate as roughly 84% of the differences in paddy yield clarified by dissimilarities in the regressors. Additionally, there is no autocorrelation, no residual non-normality, and no miss-specification problems associated with the MADA areas model. The present study also found that there is no heteroscedasticity in MADA. The CUSUM and CUSUM-Sq test in Figure 1 shows that the model parameters and residual variance are stable throughout the study.

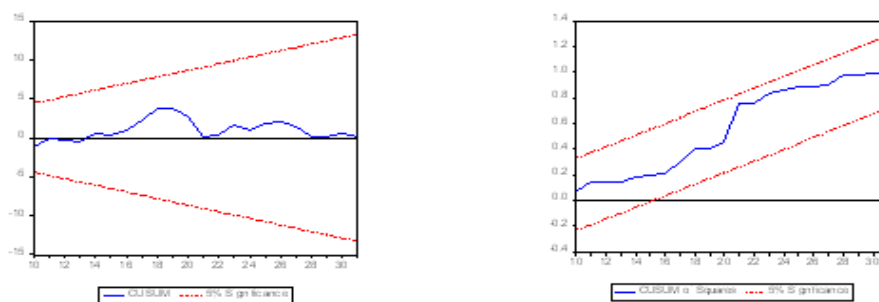


Figure 1: CUSUM and CUSUM-SQ Graphs for MADA paddy production

4.1. Causal relationship

The result from Table 4 shows that land and capital are significant at 5% and 1% levels respectively in the paddy yield equation but there are no other explanatory variables that are significant in the

short-run. Meanwhile, in the land and capital equation, paddy yield is significant at 5% and 1% levels. These clearly show that paddy yield and land, and paddy yield and capital both have a bidirectional Granger causality in the short-run. Furthermore, we also discovered that young farmers and capital, old farmers and capital, old farmers and young farmers, and paddy price and fertilisers also have the presence of bidirectional Granger causality.

Table 4: Short-run and long-run granger causality VEC Model

Variable s	MADA Short-run Causality							Long- run Causality ECT
	ΔLY_t	ΔLN_t	ΔLK_t	$\Delta LL40_t$	$\Delta LL41_t$	ΔLF_t	ΔLP_t	
Wald F-statistics								
ΔLY_t	-	5.96**	11.53*	0.89	0.20	1.38	1.39	1.03*
		[0.02]	[0.00]	[0.36]	[0.66]	[0.25]	[0.25]	(-7.85)
ΔLN_t	5.81**	-	0.50	0.93	1.37	0.39	0.35	0.009**
	[0.03]		[0.49]	[0.35]	[0.26]	[0.54]	[0.56]	(2.17)
ΔLK_t	24.99*	0.57	-	11.30*	6.00**	1.04	1.26	0.86*
	[0.00]	[0.46]		[0.00]	[0.02]	[0.32]	[0.27]	(4.10)
$\Delta LL40_t$	2.39	0.89	10.71*	-	101.66*	0.09	0.12	-0.0006
	[0.14]	[0.36]	[0.00]		[0.00]	[0.77]	[0.73]	(-1.58)
$\Delta LL41_t$	-0.71	1.29	6.05**	100.87*	-	2.68	2.48	0.0004
	[0.41]	[0.27]	[0.02]	[0.00]		[0.12]	[0.13]	(0.82)
ΔLF_t	2.13	0.38	0.82	0.09	2.63	-	5213*	0.001
	[0.16]	[0.55]	[0.37]	[0.76]	[0.12]		[0.00]	(1.53)
ΔLP_t	2.22	0.84	1.23	0.11	2.43	50.80*	-	-0.044
	[0.15]	[0.37]	[0.28]	[0.74]	[0.13]	[0.00]		(-1.43)

Notes: () is t-statistic, [] is p value. *, **, and *** shows 1%, 5%, and 10% level of significance respectively

Based on t-statistic, it could be seen that the coefficient of ECT is significant in the paddy yield, land, and capital equations. Meanwhile, ECT is found to be insignificant in fertilisers, young and old farmers, and paddy price equations. This implies that paddy yield, land, and capital carry out the short-run adjustment to the long-run equilibrium. Based on the paddy yield equation, the deviation of paddy yield from the long-run equilibrium, and all the seven variables interact ineffective way to restore the long-run equilibrium.

Joint Granger causality in Table 5 suggests that the presence of bidirectional causality in capital and land, young farmers and land, young farmers and capital, old farmers and capital, old farmers and young farmers, fertilisers and old farmers, fertilisers and young farmers, and paddy price and fertilisers have the presence of two-way short-run Granger causality. There are also a few variables having a one-way Granger causality such as young farmers Granger-cause paddy yield, old farmers Granger-cause paddy yield, fertilisers Granger-cause paddy yield, and paddy price Granger-cause paddy yield.

Table 5: Joint causality Granger causality VEC model

Variables	MADA Joint Causality						
	ECT ΔLY_t	ECT ΔLN_t	ECT ΔLK_t	ECT $\Delta LL40_t$	ECT $\Delta LL41_t$	ECT ΔLF_t	ECT ΔLP_t
Wald F-statistics							
ΔLY_t	-	32.22*	30.83*	31.95*	31.74*	30.82*	30.83*
		[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
ΔLN_t	2.91***	-	3.14***	4.98**	4.30**	2.36	2.36
	[0.08]		[0.07]	[0.02]	[0.03]	[0.12]	[0.12]
ΔLK_t	12.49*	9.47*	-	16.42*	14.09*	8.44*	8.49*
	[0.00]	[0.00]		[0.00]	[0.00]	[0.00]	[0.00]
$\Delta LL40_t$	1.29	3.02***	5.49**	-	63.23*	1.27	1.26
	[0.29]	[0.07]	[0.01]		[0.00]	[0.30]	[0.31]
$\Delta LL41_t$	0.36	1.64	3.58**	57.34*	-	2.75***	2.61**
	[0.69]	[0.22]	[0.05]	[0.00]		[0.08]	[0.09]
ΔLF_t	1.18	1.17	1.17	1.18	3.72**	-	2627*
	[0.33]	[0.33]	[0.33]	[0.33]	[0.04]		[0.00]
ΔLP_t	1.12	1.08	1.04	1.03	3.33***	2561*	-
	[0.35]	[0.36]	[0.37]	[0.38]	[0.06]	[0.00]	

Notes: () is t-statistic, [] is p value. *, **, and *** shows 1%, 5%, and 10% level of significance respectively

5. CONCLUSION

In the short-run, fertiliser subsidy and paddy prices are not significant in the MADA regions. This indicates that fertiliser subsidy and paddy prices do not give any significant effects to the local paddy production in the short run. Nonetheless, in the long-run, fertiliser subsidy and paddy prices have a positive relationship and are significant with respect to paddy yield. Although fertiliser subsidy and paddy prices are significant with paddy yield, the relationship between paddy price and paddy yield is negative. This means that when paddy price increases, paddy yield decreases. Poor soil fertility and the awful weather condition might be the cause of this negative relationship. The present research also discovered the presence of one-way short-run causality between fertilisers and paddy yield in the MADA regions. This clearly shows that any shock in fertilisers will increase paddy yield. Fertiliser is considered as one of the most important non-traditional inputs in paddy production. The evidence from the Granger causality analysis shows that fertilisers play an important role in causing the rise in paddy output in the MADA regions. Therefore, the government should provide information and knowledge related to the use of fertilisers to paddy farmers. The government should also reduce the price of fertilisers by increasing the number of subsidies. Also, paddy farmers themselves should have a better understanding of how to use the fertilisers efficiently. They should also follow the fertilising schedule provided by the government to raise the paddy yield. Therefore, researchers should expand the study further by investigating the causal relationship between fertiliser subsidy and paddy price subsidy to different types of paddy seeds planted.

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