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RESEARCH ARTICLE

AN ECONOMIC ANALYSIS OF ANTHROPOGENIC CLIMATE CHANGE ON RICE PRODUCTION IN MALAYSIA

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ABSTRACT

Rice is an important staple food in Malaysia and represents a substantial household expenditure. Malaysia, which imports about 35 percent of its rice, is the 13th largest importer of rice in the world. This makes Malaysia susceptible to global rice crisis, similar to the one in 2008. Climate change is crucial in affecting rice production in tropical countries especially Malaysia as climate projections have shown that climate change will affect countries in the tropics most negatively with increased temperature and flooding due to anthropogenic carbon dioxide emissions. This study analysed the effect of anthropogenic carbon dioxide emissions on rice production in Malaysia during the period 1970-2013. The analysis incorporated the following variables: total local rice production, carbon dioxide emissions, precipitation, land used for paddy farming, total rice imports, and global average crude oil prices. The results indicated that in the estimated model the level of carbon dioxide does not affect rice production in the short- run. However, increased carbon dioxide emissions can influence rice production indirectly by affecting the level of precipitation. Precipitation and area of irrigated land are significant variables in determining level of rice production. Policies for reducing carbon emissions is however crucial for ensuring long run sustainability in rice production.

KEYWORDS

rice production, climate change, temperature rise, precipitation, carbon dioxide emission.

1. INTRODUCTION

The agriculture sector is an important component in any country as it provides food and economic opportunities for the people. Due to its importance, various policies and budget allocation have been implemented to ensure its sustainability. Although this has been the case, it has been projected that in the coming two decades, developing countries would be affected by crop production problems following changes in global temperatures and weather (Mekonnen, 2018). These climate changes stemming from anthropogenic activities such as mass deforestation, urbanization and vehicle pollution would contribute to food and economic problems in the country. Anthropogenic climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and natural climate variability observed over comparable time periods" (Hulme, 2016).

Malaysia imported RM45 billion worth of food in year 2015, thus food security is an important problem to be given attention (Carvalho, 2016). Anthropogenic activities such as burning of forests for cultivation, land reclamation, carbon emission from industrial factories and housing development can cause the agriculture activities to decline. The decline in agricultural outputs may cause Malaysia to import even more food in the future especially rice from other nations such as Vietnam and Thailand. Rice is crucial to Malaysia as rice is a staple food in Malaysia accounting for some 25 percent of the food expenditure budget share (Sheng, 2008). Any reduction in rice production due to anthropogenic climate change will have serious impacts on the welfare of Malaysians. This study examines the impact of anthropogenic climate change by examining the data on rice production and the impact of climate change variables such as carbon dioxide emissions and the level of precipitation on rice production in Malaysia. We suggest some policy actions to manage the impact of anthropogenic activities in Malaysia that affects climate change.

2. RICE IN MALAYSIA

Rice is the major staple food in Malaysia, making up the largest portion in food expenditure in an average household (Ishida, 2003). Due to its

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importance, the Malaysian government allocates incentives and subsidies to local farmers to increase production. With these efforts, production has increased from 1,318,000 tonnes in the year 1980 to 1,820,000 tonnes in the year 2016 (Department, 2016). Although Malaysia has seen increase in rice production, demand has so far outweighed local output. In the year 2017, Malaysians demanded 2.75 million tonnes of rice whereas the domestic production was only 1.8 million tonnes (US Department, 2017). This puts local rice supply well below sufficiency to meet the populations' demand with a supply deficit of close to a million tonnes. To overcome this deficit in rice supply, the Malaysian government imported rice from neighbouring countries such as Thailand, Vietnam, Cambodia, Pakistan and India. Among these countries, Thailand and Vietnam are the top exporters of rice to Malaysia (US Department, 2017). Comparatively, Malaysia is also ranked thirteen in total import of rice globally with an import of 950,000 metric tonnes (US Department, 2017). Thus, rice is an important commodity for the Malaysian people, and the government relies heavily on imports to meet the high national demand.

The high dependency on rice imports has in the past, negatively affected Malaysia, such as in the case with the 2008 global rice and cereal crisis. The rice crisis, which was due to number of factors, namely constraints in trade by major exporters, the panic purchase of stock by importers, high crude oil prices, and a weakening dollar, caused rice prices to increase substantially (US Department, 2017). Together with a weak Malaysian currency, meeting the country's demand for rice proved costly for the Malaysian government, as rice was a controlled commodity in the country (Arandez, 2011). Realizing that Malaysia is over dependent on rice imports, the Malaysian Government then prompted to increase rice sufficiency level to 90 percent by the year 2010 but was later reduced to 70 percent in the Tenth Malaysian Plan (2011 to 2015). Thus, being overly dependent on food imports can be detrimental, as any regional food crisis would affect the country's food security.

3. Methodology

The framework of impacts of anthropogenic climate change on rice production is presented below.

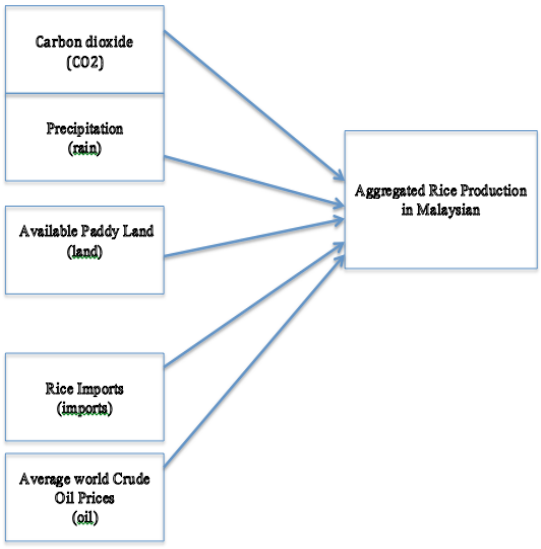

Figure 1: Determinants of Rice Production in Malaysia

The dependent variable is aggregated rice production in Malaysia. Independent variables on the other hand will include carbon dioxide emissions, precipitation levels, amount of available irrigated paddy land, amount of rice imports into the country, and average crude oil prices.

The model of rice production is as follow:

Rice = f (CO2, rain, land, imports, oil)

$$\Delta lnrice = \beta_0 + \beta_1 \Delta lnco2_{t-1} + \beta_2 \Delta lnrain_{t-1} + \beta_3 \Delta lnland_{t-1} +$$

$$\beta_4 \Delta lnimports_{t-1} + \beta_5 \Delta lnoil_{t-1} + \beta_6 ECT_{t-1} + \varepsilon_t \text{ ----------}$$

---------- (1)

Where:

Rice = total local rice production (tonnes)

CO2 = concentration of carbon dioxide the atmosphere (parts per million, ppm)

Rain = precipitation (millimetres)

Land = available paddy land (% of total land)
Imports = total rice imports in Malaysia (tonnes)

Oil = average world crude oil prices (USD per barrel)
ECT= Error Correction Term

ε_t = error term
t = time period

β_0 = intercept

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ = coefficient for the explanatory variables

The data collected covers a period from 1970 to year 2013. The data of rice production and area of land were obtained from Department of Statistics Malaysia. The data of precipitation was obtained from the World Bank, data of carbon dioxide from United Nations Statistics Division's World Energy Data Set and data of petroleum price from world Brent crude oil price. The Vector Error Correction Model was used to examine the effect of anthropogenic climate change on rice production in Malaysia.

4. Results and Discussions

The Table 1 below shows the results of Vector Error Correction Model of Rice Production.

Table 1: Model of Rice Production

Variables	Coefficient (p-values)
1. Carbon dioxide (lagged one year)	0.045 (0.398)
2. Carbon dioxide (lagged two years)	-0.035 (0.421)
3. Number of rainfall (lagged one year)	0.545 (0.002)***
4. Number of rainfall (lagged two years)	0.548 (0.0001)***
5. Area of irrigated paddy land (lagged one year)	-0.645 (0.296)
6. Area of irrigated paddy land (lagged two years)	3.00 (0.015)**
7. Imported rice (lagged one year)	-0.137 (0.014)**
8. Imported rice (lagged two years)	0.01 (0.410)
9. Average world crude oil prices (lagged one year)	-0.050 (0.162)
10. Average world crude oil prices (lagged two years)	-0.02 (0.299)
11. Error correction term	-0.106 (0.004)***

Note: The values in the brackets indicate the p-values for the regression results. * denote 10% significance level, ** denote 5 % significance level and *** denote 1% significance level.

From Table 1, it can be observed that only rain, irrigated paddy land, imports of rice, and the error correction term are deemed significant at the least 5% level of significance. Rain, area of irrigated paddy land and imports of rice all show significant impacts on rice production in Malaysia. From the regression results, every 1% increase in the change of rainfall in country during the previous year will result in a 0.55% increase in rice output within the country. This is considered to be an inelastic effect as the lagged one year rain variable's coefficient is less than one unit. An increase and well distributed rain-fall throughout the year is expected to increase

rice output as farmers are not required to fully rely on the countries' irrigation system (Van, 2011). Not being dependent on irrigation results in less strain for the rice crop. Thus, allowing the aforementioned system to water a larger area. Saseendran's results similarly found positive long-term effects of rain on rice production in the order of below unity.

From Table 1, besides the effect or rain, the p-value for the area of irrigated paddy land is proven to be significant at 5% level with a p-value of 0.014. Furthermore, analyzing the coefficient, available irrigated paddy land can be observed to have an elasticity value of 3.00. In other words, a 1% increase in area of available irrigated paddy land will result in a 3 percent increase in total rice output in the short-run. This can be interpreted as the demand for food increases, stress on the country's food producing sector will prompt the opening of additional agricultural land for paddy production (Saseendran, 2000). Increase in the opening of irrigated paddy land may result in the increase in rice production.

Increase droughts in the country will result in low yielding crop seasons. Lower yields will then prompt the need to increase food import to meet increasing demand. Increase in food imports will hinder and reduce the rice production in Malaysia as the country will rely on food import and put less focus on developing the country's rice production to ensure self-sufficiency. This is seen from the significant negative coefficient of 0.13 between the imported rice and Malaysian rice production.

Lastly, the utilization of the vector error correction model necessitates the analysing of the error correction term. This term allows the model's system to correct any disequilibrium that may potentially occur in the system and adds adjustments to bring the model back to equilibrium. In the model above, the estimated coefficient for the error correction term is significant at 5% level and thus points to the validity of the existence of a long-run relationship between the tested variables. With a coefficient of 0.106, the speed of adjustment during events of shock can be said to be slow. In other words, the system has a speed of adjustment of about 10.6% during shocks. The model is also expected to be stable as any corrections made to reach the long-run equilibrium during short-run disequilibrium will not cause the model to explode and increase exponentially as the coefficient possesses a value smaller than one (a<1). Besides that, the value for the coefficient of the error term is also negative, falling into the expected range of values that the error term should be, to keep the model stable. What this entails is that whenever the model encounters shocks, after a period of time, the model will shift back to equilibrium and not grow exponentially and break down. For example, crude oil spikes, droughts, and floods are a few commonly encountered shocks.

Comparing the effects of increase carbon dioxide with the other variables, it can be observed that the other variables are more significant. Carbon dioxide is found to be insignificant in affecting the rice production in Malaysia (Lambin, 2011; Garcia, 2008; Department, 2015). On the other hand, rain or precipitation has a significant impact on rice output within the country. The increase in carbon dioxide does not seem to have an impact on rice production. This could be due to the fact that in the case of Malaysia the increase in carbon dioxide emissions is not large enough to cause a drop in rice production. That is, the emission of carbon dioxide is still well below the threshold level to cause a reduction in production of rice. Due to this, it can be inferred that precipitation is still the major factor in affecting rice production and if emissions from carbon dioxide were to reduce precipitation than one can expect a reduction in rice production (United Nations, 2006; United Nations 2015). Thus, the impact of greenhouse gasses on precipitation would be more important in determining rice production. Besides that, land allocation for farming has also been found to be more significant than increase in carbon dioxide emissions. Thus it can be said that increase in agriculture intensification may be able to counteract the effects of increased greenhouse gasses in the atmosphere.

5. Conclusion

Various researchers have cautioned the existence of global warming from recent increases of greenhouse gases in the atmosphere. The rising temperature has been found to have detrimental negative effects on plants and various food crops around the world. Malaysia is expected to experience food production reductions in the near future. The results from this study however show that the impact of greenhouse gases is not significant in the case of rice production. However if the continued increase in greenhouse gases were to effect temperature and rainfall than there will be a reduction in rice production as rainfall is a significant variable in determining production of rice. Thus, policies for monitoring the level of greenhouse gas emissions and the control of its emissions should be put in place to reduce the impacts of anthropogenic climate change on rice production in Malaysia. Actions to reduce open burning, extensive forest clearing and land reclamation should be enforced to reduce future greenhouse gas emissions.

Although it has been shown that the effects of carbon dioxide are not as profound as compared to other factors, it is still important that efforts are taken to manage the country's carbon emissions. This is because without any intervention, carbon dioxide emission may reach levels that would cause severe temperature rise over the coming decades. Among policies that can be applied is the introduction of carbon taxes, providing bigger budgets for biofuel development, improving mass public transportation, better urbanization management, and reducing deforestation.

The results also show that the opening of new agricultural land on the other hand, would also be able to increase rice output within the country by means of enlarging the agricultural capacity of the country. Although it is a quick way to achieve the target of self-sufficiency, the cutting down of forest may exacerbate the effects of global warming with the release of more carbon dioxide and the loss of carbon sinks. Instead of the opening of new agriculture land, a bigger budget should be allocated to agriculture research and development, allowing for an increase in the yields from smaller paddy farms. Greater yield of rice production in Malaysia would reduce the food imports from other nations. Reducing food imports from other nations are crucial for the development of local rice producers and ensuring food security of the nation is sustained in the future.

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