An Analysis of Food Security in Malaysia: Does Fertility Rate Matters?

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Abstract. Throughout history, human societies have strived to ensure that every individual has access to sufficient food, promoting an active and healthy life. Having access to enough food persists as a pressing issue at the intersection of nature, society, and technology although there is a significant worldwide endeavour in this era. Food security can be defined as a condition that all individuals can access enough, nutritious and safe food physically, socially and economically. This paper contributes to the literature by examining the potential factors that affects the food security in Malaysia from 1990 to 2019. The factors included are Carbon Dioxide Emission, Gross Domestic Product, and Fertility Rate. Besides, fertility rate is mainly highlighted in the study as there are only limited studies that explored on these effects. Neo Malthusian Theory, Anthropogenic Global Warming Theory and Keynesian Theory were used to support the variables and several tests such as ADF Test, ARDL Bounds Test, ECM Test, ARCH Test, LM Test, CUSUM Test, and VIF Test have been used to estimate and validate the model. The findings show that, all factors have significant relationship on food security in the long run. Overall, the fertility rate captured in this study provides great effects to food security in Malaysia during the period of 1990 to 2019.

Keyword: Food Security, Malaysia, Carbon Dioxide Emission, Gross Domestic Product, Fertility Rate

1 Introduction

Following air and water, food ranks as the second most vital necessity for human survival. After the world food crisis between 2007 and 2008, every country took account of food security issues, as goal 2 of sustainable development goals is titled "Zero Hunger". According to FAO [1], food security can be defined as a condition that all individuals are capable of accessing enough nutritious and safe food physically, socially, and economically. Malaysia has remained a net importer of food for the past forty years. According to the Import Dependency Ratio (IDR), Malaysia's food import bill in the year 2020 was RM55.5 billion [2]. In this paper, 3 determinants will be included which are carbon dioxide emission (CO2), gross domestic product (GDP), and fertility rate (FR).

According to Nair [3], Barjoyai said that Malaysia was not a country with a secure supply of food. This is because Malaysia could not satisfy the demand of local residents. For instance, the rice production in Malaysia could support only 70% of its demand from local residents. In other words, this means that Malaysia is still suffering from a

Y. O. Choong et al. (eds.), *Proceedings of the 11th International Conference on Business, Accounting, Finance and Economics (BAFE 2023)*, Advances in Economics, Business and Management Research 272,
https://doi.org/10.2991/978-94-6463-342-9_4

lack of 30%. In addition to the rice shortage, during times of heightened food supply instability in Malaysia, like in 2019, the country's self-sufficiency rates for various food categories were as follows: vegetables at 46%, beef at 25%, mutton at 11%, fruits at 61% and dairy at 5%. This precarious situation puts millions of people in the most vulnerable communities at risk of losing their lives due to the global food crisis, especially in countries where hunger-related deaths, malnutrition, and poverty are increasing. The factors that focused on this study have also brought few negative impacts to the country's food security.

Firstly, due to rapid industrialization that releases unchecked carbon dioxide and other greenhouse gasses over the past few decades, Malaysian agriculture is experiencing a reduction in productivity as the climate around the world warms. Based on a 40-year dataset spanning from 1969 to 2009, it was observed that Malaysia's average surface temperature increased at a rate ranging from 0.6°C to 1.2°C every 50 years [4]. Siwar et al. [5] stated that the growth of industrial crops like oil palm, rubber, and cocoa is projected to diminish by 10% to 30% due to the detrimental impacts of climate volatility. According to Pek et al. [6], the Malaysian Agricultural Research and Development Institute (MARDI) predicted that a 1°C increment in daily average temperature would result in a 10% reduction in rice yield.

Secondly, the focus of Malaysia's economy was on the agriculture sector before the industrial revolution period. But its contribution to GDP has been decreasing since 1975 due to the conversion of agricultural lands into houses and industries and thus lead to decreased food crops. In the COVID-19 epidemic, Russia-Ukraine War and the ringgit's decline are also all to blame that lead to the food price increase which will then exacerbate the condition of food insecurity in Malaysia [7]. It is said that food insecurity will lead to the situation of famine among citizens and the condition of malnutrition. Consequently, this will directly affect Malaysia's gross domestic product (GDP) because the poor development of the citizen's physical and cognitive ability will cause an individual's productivity to become low. Upon research, we found that the major culprit of slowing economic growth of Malaysia is due to the dilemma. Based on the Global Food Security Index (GFSI), Malaysia's score is 68.1 and was ranked 40th out of 113 countries in 2018. Malaysia was performing significantly worse than wealthy nations like Singapore, the United Kingdom, Denmark, and Japan.

Lastly, it is stated that if the fertility rate keeps growing, it may affect food security to decrease; while if the fertility rate keeps declining, it may increase food security [8]. However, research shows a decline in total fertility rates in Malaysia from 4.9 newborns in 1970 to 1.8 babies in 2018. The nation's average number of births per woman is insufficient to produce the necessary number of offspring to replace her and her spouse in the population. Nevertheless, Murray [9] has stated that a reduced fertility rate will hinder economic expansion and place pressure on government finances because the children of today are the future workforce and contributors to tax revenue. The effect of the diminishing fertility rate is very vital in testing the stability of food security in Malaysia. Hence, the effect of the diminishing fertility rate is very vital in testing the stability of food security in Malaysia.

There are several contributions of this study provided to different audiences. First of all, food security issues have been a global trend among the world in recent years. Malaysia has been chosen in this study as its high dependence on imports, especially rice, to sustain its food supply in the recent years will jeopardize their future. Malaysia's insufficient development of its agricultural potential also remains a concern in terms of its approach to securing food supplies. Hence, it is believed that this country is worthwhile to be conducted in this study. Next, this study is to help future researchers better understand how the factors (CO2, GDP and fertility rate) influence food security in Malaysia. Based on the past studies, there is a mix result on the effect of fertility rate towards food security in Malaysia. Due to the limited research on this variable, it has become the main contribution in this study to determine its actual effect.

Lastly, this study is to provide a clear picture to policymakers and analysts in comprehending the food security issue in Malaysia. It aims to deliver beneficial advice to let those policymakers and government make an effective decision in improving our country's food security. The research gap in this study is the fertility rate. There are few studies on Malaysia contexts about how the fertility rates affects the food security in Malaysia compared to countries like United States, Tanzania, and Bangladesh. The changes in fertility rate will affect the demand for food in Malaysia. Therefore, it is simpler to capture the public's and the government's attention when the issue is narrowly focused.

To conclude, this study aims to investigate the factors that affects the food security in Malaysia based on the yearly data from 1990 to 2019. As a net food importer, it should place more emphasis on food self-dependency and strategic managements in order to deal with the difficulties with food security. In addition, this study will enable governments to make a more effective and advantageous planning and resource distribution within a certain region.

2 Literature Review

2.1 Theoretical Review

According to Malthus, Neo Malthusian Theory implies an increased population due to rising fertility rate moves in a quicker manner compared to food security, eventually outpacing it [10]. As per Malthus, the Law of Diminishing Yields suggests that the per capita food supply typically decreases with a growing population [11]. The increase of fertility will place shortage of land that led to an absolute shortage restriction on food security in particular and imposed falling rates of return on all other variables of production [12]. Next, based on the proponents of the Anthropogenic Global Warming Theory, the 0.7°C warming during the previous 150 years and the 0.5°C warming over the last 30 years are primarily or entirely due to the greenhouse gases produced by humans [13]. Water availability, food quality, and security will all suffer due to the changes in temperature, precipitation, and sea level. Rapid climate change threatens plant growth and productivity while also changing the type and quantity of nutrients available to plants [14].

Lastly, in the Keynesian view, the level of aggregate demand or total spending is affected by production, employment, and inflation in the country. The level of aggregate demand, or overall economic spending, alone determines the GDP and employment [15]. Government should take accurate fiscal policy actions while the central bank should take appropriate monetary policy actions to stabilize economic output, inflation, and unemployment over the business cycle [16].

2.2 Empirical Reviews

According to Sabo et al. [17], there is a direct correlation between GDP and food security in Nigeria. The agricultural sector plays a significant role in Nigeria's GDP, with crops contributing 80%, livestock 13%, forestry 3% and fisheries 4%. In the meantime, it provides 70% of employment to its citizens. Next, a study conducted by Yaseen [18] suggests that GDP has a positive effect on food security. By using the method of ARDL estimation, the research reveals that a 1% increase in GDP in developing countries leads to an average increase of 0.054 units in food security. Pawlak and Kołodziejczak [19] found that there is a positive connection between the GDP in agriculture and food security in developing countries. Their comparative analysis, which involved 100 developing countries, concludes that investing in farming technologies and adopting them plays a crucial role in improving national food security and enhancing food accessibility. Lastly, in the research of Matkovski et al. [20], it is discovered that a low GDP in agriculture has a negative effect on food security in developed countries. This happens because developed nations typically focus on manufacturing, mining, and services sectors instead of agricultural sectors.

Duasa and Mohd-Radzman [21] mentioned that carbon dioxide emissions have a minimal short-term impact on rice yield while the research by Edoja et al. [22] found that there exists an adverse connection between $CO2$ and agricultural productivity, which will, in turn, have an indirect impact on food security in Nigeria. Next, Kwakwa et al. [23] has investigated that carbon dioxide emissions from industrial, transportation and other sectors greatly slow down the agricultural development in the long run of Ghana by using regression analysis. Amponsah et al., [24] had also examined that a 1% increase in $CO2$ will result in a 54.67% drop in cereal yields in the long run; while a 1% of increment in $CO2$ will reduce approximately 31.03% of cereal crops in short run. An increase in emission of carbon dioxide will lead to climate variability and thus causing the agricultural system to become susceptible and crop productivity to diminish. According to another study, the present paddy yield decreases by 3.44% for every 1% increase in temperature [25, 26].

In the study of DiClemente et al. [27], women who have a high preference for fertility or who have many young children tend to experience lower levels of food security and vice versa. Similarly, Thomson et al. [29] find a negative relationship between increasing fertility rates and food security on Idjwi Island. This island has the highest fertility rate globally, with an average of over 8 live births per woman. However, the high population has resulted in severe environmental degradation and increased food insecurity on the island. The studies by Szabo [30] and Rosegrant and Cline [31] discovered that increase in fertility rates will cause food security problem to arise due to limited food accessibility. According to Hossain et al. [28], an increasing fertility rate in Bangladesh causes itself to struggle with limited land resources, low food grain productivity and inadequate food accessibility. Nonetheless, numerous scholarly articles have pointed out a favorable connection between the fertility rate and food security. In research from Merrick [32], food security will decrease as fertility rate decreases. This is because the proportion of older adults who no longer work will gradually increase. As a result, the productivity of the country will decline as a result of the decline in the working population. Additionally, Maharjan and Joshi [33] also asserted that a favorable connection exists between the fertility rate and food security. A high fertility rate could help increase the number of active workforce and thereby contribute to improving the food security of a given country. A rise in the fertility rate signifies a growth in the population, leading to an expanded agricultural labor force and enhanced food security [34].

It was found out that there is a mixed relationship of the variables based on past studies. Besides, this study will fill the gap by exploring more on the fertility rate effects on food security. Given the scarcity of previous research on fertility rates, this study is anticipated to make a valuable addition to the existing body of knowledge.

3 Research Methodology

Time series data has been employed to examine the connection between the dependent variable and independent variables from 1990 to 2019. Food security (food production index, 2014-2016=100) serves as dependent variable, whereas CO_2 (kg per PPP $ of GDP), GDP (GDP Growth-Annual %), and the fertility rate (births per woman) are the independent variables. The data has been obtained from World Development Indicators (WDI). Additionally, this study utilized an Autoregressive Distributed Lag Model (ARDL) Bounds Cointegration Test to assess the long-term relationship among the variables. It is a preferable choice when dealing with variables that have different orders of integration, whether I(0), I(1), or a combination of both. The ARDL bounds cointegration test is also a dependable method, especially when dealing with small sample sizes and a single long-term relationship among the underlying variables [35]. In the ARDL bounds test approach, regression variables can withstand varying optimal lags due to the diverse techniques connected with cointegrating demands the variables included in the regression linked with lag as another [36].

In the ARDL Bounds Test, the null hypothesis (H0) is rejected if the F-statistic exceeds the upper critical value for I(1), indicating that the variables are indeed cointegrated. Otherwise, H0 is not being rejected. The ARDL equation for the base model is as follows:

$$lnFOOD_t = \propto + \sum_{i=1}^{P} \beta_0 \, lnFOOD_{t-1} + \sum_{i=0}^{q} \beta_1 \, lnCO2_{t-i} + u_t \quad (1)$$

The ARDL equation for the extension model is as follows:

$$lnFOOD_t = \propto + \sum_{i=1}^{P} \beta_0 \, lnFOOD_{t-1} + \sum_{i=0}^{q} \beta_1 \, lnCO2_{t-i} + \sum_{i=0}^{r} \beta_2 \, lnGDP_{t-i} + \sum_{i=0}^{s} \beta_3 \, lnFR_{t-i} + u_t \quad (2)$$

Where,

lnFOOD=Food production index (2014-2016=100)
β0=Intercept of equation
β1lnCO2t= CO2 emissions (kg per PPP $ of GDP)
β2lnGDPt= GDP growth (Annual %)
β3lnFRt= Total fertility rate (births per woman)
ut=error term
t=1,2,3…..,T, time period

This paper has additionally employed the Error Correction Model (ECM) test to investigate the interplay of both long-term and short-term dynamics among variables in a time series dataset. The ECM model for base model is as follows:

$$\Delta lnFOOD_t = \beta_0 + \sum_{i=1}^{P} \beta_1 \, \Delta lnFOOD_{t-1} + \sum_{i=0}^{q} \beta_2 \, \Delta lnCO2_{t-i} + \lambda U_{t-1} + e_t \quad (1)$$

The ECM model for extension model is as follows:

$$\Delta lnFOOD_t = \beta_0 + \sum_{i=1}^{P} \beta_1 \, \Delta lnFOOD_{t-1} + \sum_{i=0}^{q} \beta_2 \, \Delta lnCO2_{t-i} + \sum_{i=0}^{r} \beta_3 \, \Delta lnGDP_{t-i} + \sum_{i=0}^{s} \beta_4 \, \Delta lnFR_{t-i} + \lambda U_{t-1} + e_t \quad (2)$$

where $\lambda Ut{-}1$ is the error correction term that is added into the equation to form ECM model.

4 Empirical Results

4.1 Unit Root Test

Table 1. Results of Augmented Dickey Fuller Test

Variables	Constant Level (p-value)	First Difference (p-value)	Constant Level (p-value)	First Difference (p-value)
	Intercept without trend		Intercept with trend	
ln Food	0.565 (0.9861)	-3.947** (0.0054)	-1.180 (0.8961)	-3.975** (0.0218)
ln CO2	0.494 (0.9835)	-6.322** (0.0000)	-1.554 (0.7859)	-6.330** (0.0001)
ln GDP	-3.934** (0.0056)	-7.980** (0.0000)	-4.054** (0.0183)	-7.873** (0.0000)

In FR	-3.359** (0.0219)	-1.744 (0.3984)	0.265 (0.9973)	-6.573** (0.0001)

Remarks: All variables were transformed into their natural logarithms, while (**) denotes that these variables exhibit statistical significance at the 5% level.

Referring to Table 1, GDP exhibited stationarity in both constant and first difference forms (intercept with trend and without trend). The Food Production Index and CO2 also demonstrated stationarity in their first difference forms, as evidenced by their p-values being less than alpha (intercept with trend and without trend). Lastly, FR is stationary in its level form (intercept without trend) and in its first difference form (intercept with trend). The null hypothesis is rejected when the p-value is less than the 5% significance level; otherwise, the null hypothesis is retained. To conclude, food production index, CO2, GDP, and FR are achieving stationary at different form of levels.

4.2 Model Estimation

ARDL Bounds Test Result

Table 2. Results of ARDL Bounds Test for Extension Model

Test statistics	Value	Significance level	I(0)	I(1)
f-statistic	7.7108**	1%	3.65	4.66
k	3	5%	2.79	3.67
	10%	2.37	3.2	10%
Conclusion		Cointegrated		

Table 3. Results of Long Run Coefficient for Extension Model

Variables	Coefficient	T-Statistic	P-Value
LN CO2	-0.7664	-3.9486	0.0055(0.1941)**
LN GDP	0.2159	4.2045	0.0040(0.0513)**
LN FR	-0.4912	-2.9821	0.0205(0.1647)**

Remarks: All variables were transformed into their natural logarithms, while (**) denotes that these variables exhibit statistical significance at the 5% level.

According to Table 2, the F-statistic holds a value of 7.7108, surpassing the upper critical values of 4.66, 3.67, and 3.2 at a 5% significance level. Therefore, we can conclude that the variables are cointegrated and the CO2, FR and GDP show long run effect on food security. Based on the Table 3, all the variables are significant at the significance level of 5%.

Error Correction Model

Table 4. Results of Error Correction Model for Extension Model

Variables	Coefficient
ECT Coefficient	CO2, GDP and Fertility Rate
P-Value	-1.7228
T-Statistics	0.0001**
Standard Error	-7.7836**

Remarks: All variables were transformed into their natural logarithms, while (**) denotes that these variables exhibit statistical significance at the 5% level.

Based on the Table 4, we can observe that there is a cointegration for the extension model as the p-value is statistically significant at the 5% of significance level. The ECT coefficient for the extension model is -1.7228 which has fallen out of the range of 0 and -1. It means that there is an overcorrection of 72% error in each time period of error correction process on Malaysia's food security [37].

Diagnostic Checking

Empirical tests such as Autoregressive Conditional Heteroscedasticity (ARCH) Test, Breusch-Godfrey Serial Correlation LM Test and Variance Inflation Factor (VIF) Test have been used.

Table 5. Results of ARCH Test, LM Test and VIF Test for Extension Model

Diagnostic Checking	Chi-Square/ P-value/VIF	Conclusion
Serial Correlation LM Test	0.1321**	No serial correlation
ARCH Test	0.1164**	No heteroskedasticity
VIF Test		
ln CO2	3.1983	No multicollinearity
ln GDP	1.1332	No multicollinearity
ln FR	3.4230	No multicollinearity

Remarks: All variables were transformed into their natural logarithms, while (**) denotes that these variables exhibit statistical significance at the 5% level.

The LM test yields a result of 0.1321, and the ARCH test produces a result of 0.1164, both exceeding the 5% significance level. Consequently, there are no issues of autocorrelation or heteroscedasticity present in the model. If the VIF (Variance Inflation Factor) falls within the range of 1 to 5, it indicates the absence of multicollinearity. Conversely, a VIF value exceeding 5 suggests the presence of multicollinearity. The findings presented in Table 5 reveal that all the VIF values in the extended model are nearly around 1, thus confirming the absence of multicollinearity in the model.

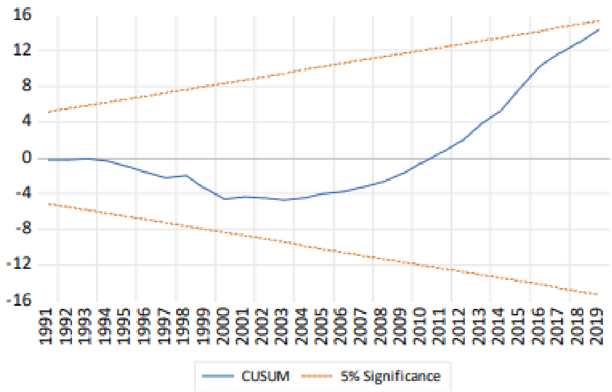

Fig 1: Result of Cumulative Sum of Recursive Residuals Test for Extension Model

The CUSUM test is to test the stability of the coefficient. Figure 1 illustrates that the CUSUM statistics remain within the range of the critical bounds at the 5% significance level. Consequently, the null hypothesis is retained, signifying the stability of the parameter.

5 Conclusion and Recommendations

The primary aim of this research paper is to ascertain the factors, including CO2 emissions, GDP, and fertility rate, that influence food security in Malaysia during the period spanning from 1990 to 2019. Firstly, the study indicates that CO2 is consistent with Anthropogenic Global Warming Theory. CO2 has a negative impact on food security in Malaysia due to climate change. It is predicted that the temperature in the Asia Pacific region will rise by 2℃ to 2.7 ℃ in the coming years, the agricultural productivity could decline by 10%-25% in 2080 [38]. Next, GDP is consistent with Keynesian Theory. GDP has a positive effect on food security in Malaysia. Productivity in agriculture is key to economic growth, which can boost average income, and living standards also leading to improved food security [39]. Lastly, the fertility rate is consistent with Neo-Malthusian Theory. The fertility rate has a negative relationship with food security in Malaysia. In the study of Molotoks et al. [40], it is found that the increasing fertility rate has an adverse impact on the food security on global food security.

In terms of limitations, this study is still limited to only one country and there are many potential factors that could bring the impact on food security from different context of the country's structure. Therefore, future research should include more emerging and developing countries to prove the significance of the factors towards food security and utilize more variables that relevant to issues that they are facing to gain in depth insights into the subject matter.

In addition, based on the findings of this study, three policies are recommended. Firstly, Baby Bonus Scheme is a component of a recurring set of family assistance programs that purport to aid private families with the costs of raising children while encouraging a rise in the country's fertility rate. This policy will be stop adopting if Malaysia's fertility rate reaches replacement level as the findings shows that the higher fertility rate will harm country's food security in the long run.

Next, Policy Reform and Land Tenure Security is a policy where government can reform the country policy to boost GDP by reducing the trade barriers through some actions such as lower tax imposition, reduce import quotas and encourage international trade. Besides that, the government should provide land tenure security to farmers to boost agricultural productivity. Lastly, Carbon Tax Policy is a policy that imposes tax on the CO2 emissions produced. The purpose of this policy is to encourage a healthy environment and the development of innovative technical techniques. Hence, all these recommendations could serve a platform for Malaysia to sustain the food security in future.

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