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# An Econometric Analysis of Food Security Determinants in Malaysia: A Vector Error Correction Model Approach (VECM)

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**Abstract**

Food security issue is getting more attention by world today. Although, Malaysia is a middle income country able to produce her own food, but there is still lack of food supply for domestic needs. This paper thus analyse the factors that affect the food security model in Malaysia during the period of 1982-2011. The analysis in this paper include food production index as food security proxy while the other variables include food prices, Malaysian population, foreign workers and $CO_2$ emission as important determinants of food security. The assessment of the impact of these factors is achieved using the Vector Error Correction Model approach (VECM). The series on the food prices, Malaysian population, foreign workers, $CO_2$ emission and palm-based biodiesel production are co-integrated. While in the short run only foreign worker is an important determinant of food security. Hence, the results of error correction term (Ect) from VECM shows that there is a long run causality between dependent variables and explanatory variables. This model is useful quantitative tool to assess food security especially to determine specific variables that explain the highest effect to food security at the national level.

**Keywords:** determinants, econometric analysis, food security, short run, VECM

## 1. Introduction

Since the World Food Conference in 1974, food security concept was introduced due to food crises and major famines in the world. This concept was evolved, developed, and diversified by the academic community and politics. The definition of food security was defined in many ways by researchers and international organization without changing the basic concept. As defined by FAO (2002), "food security exist when all people, at all time, have physical and economic access to sufficient, safe and nutritious food that meet their dietary needs and food preferences for an active and healthy lifestyle". When the supply of food in the country is able to cover the food demand of its population then this situation is known as food security. While, when people do not have adequate physical, social or economic access to food thus food insecurity exists

Food security comprised of four components; food availability, accessibility, utilization and stability. The supply side of food security and is determined by the level of food production, stocks levels, net food trade (exports minus imports) and food aid transfers is known as food availability. Food access is defined as ease of access by individuals to adequate resources (entitlements) for acquiring appropriate food for a nutritious diet. While, entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources). Utilization is usage of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security. The concept of stability can therefore refer to both the availability and accessibility dimensions of food security. The components of availability, accessibility, utilization and stability all interact to determine a country's or household's state of food security.

Food security issue is getting more attention by world today. Although Malaysia is able to produce food, but still there is lack of food supply for domestic needs. Where, Malaysia still has to import some food commodities including rice (Malaysian staple food) to fulfill the demand of food. The increasing deficit between domestic demand and local production is expected to continue. It will cause threat to food security to the country. There are many factors that affect food security in Malaysia.

The rising in food price due to the global food price crisis in year 2008 has been the main factor. Soaring food prices will cause food insecurity which will threaten individual's survival, especially the poor rural populations. It will give an impact to their purchasing power and expenses. To ensure sufficient levels of food, many poor families option to either spend less on other essentials, such as healthcare and education, or resort to stinting, which is the act of buying cheaper (and likely less nutritious) food products. High food price also raise the likelihood of increased rural-urban migration, as many gather to the cities in hope of better livelihood opportunities.

Malaysian population increased 265% from 8.2 million in 1960 to 30.0 million in 2013 (DOS, 2013). The increase of population has resulted in the rise of demand for food. Therefore, the Malaysian food supply deals with the capacity of the production to meet the demand for population. Lack of food production could cause a threat to people's life and safety. Adding with the increase in Malaysia population an increase in foreign worker is another factor influencing Malaysia's food security. The gap of unemployment in Malaysia is filled by foreign worker resulted in an increase in foreign workers in Malaysia. Their existence will cause an increase in food demanded in Malaysia.

Another factor is $CO_2$ emission that cause by the accumulation of Green House Gases (GHG) that will cause the increase of earth temperature. The warmer global climate will decline the agriculture production as well as food production. This factor should be a great concern since it threatens the basic elements of human life.

Since food security is increasingly become a critical issue in Malaysia and the ASEAN countries, all the problems that influence food security should be noted. This will help to develop more effective policies and strategies in order to improve food security level in the country. Although food security defined to be a relatively simple concept, the actual determinants of food security are far more difficult to determine. Thus the objective of this study is to identify the factors effecting food security in Malaysia by using a Vector Error Correction Model (VECM) approach.

## 2. Literature Reviews

There are ample of literature describing food security issues at the national and household level. Since this study focuses on the determinants of food security model at the national level, so only the relevant literature related to food security variables at the national level has been chosen. Aker and Lemtouni (1999) presented a framework for assessing food security at the national level in Morocco. This framework explains that food security affected by the integration of domestic and global market. The demand and supply theory of food has been applied with the introduction of Guttman Scale. Guttman Scale provides more quantitative means of assessing food security. There are many factors effects food security model in Morocco namely domestic food production, rainfall, world food prices, Gini coefficient of income distribution, export, female illiteracy rate and local health environment.

In terms of Malaysian studies, there are only a number of studies focusing on the factors to model a food security function. Arshad and Hameed (2010) examined the factors that increase the price in food commodities and the implication to food security in Malaysia. There are two aspects that contribute to food price increase; fundamentals and systemic. Fundamentals factors include decline in growth of agricultural production, hence supply, decline in global cereal stocks and strengthening food demand from emerging economies. The systemic factors include underinvestment, uneven policy in agriculture at the expense of food, increase in biofuel demand and technical factors respectively. As a net food importer, all these factors affected Malaysian in terms of first, higher food import bill where in 2008, Malaysia food deficit increased to RM10.9 billion compared with RM4.9 billion in year 2000. Secondly, increase in consumer price index affected by the recent global price change. Third implication is short spell of "social unrest" in the midst of the crisis.

Besides the variables listed in the previous studies there are also studies that highlighted population as one of the factors that give impact on food security. Household size are among the important determinants of food security at the household level and the results from the empirical studies shows that household size are significant and have negative relationship to food security (Mensah, James, Robert, & Thomas, 2013; Mitiku, Fufa, & Tadese, 2012; Faridi & Wadood, 2010; Omotesho, Adewumi, Muhammad-Lawal, & Ayinde, 2006; Gebre, 2012; Bashir, Schilizzi, & Pandit, 2012). There is a study shows that household size for food insecurity at household level gives significant result and positively related (Gebre, 2012). On the other hand, Amaza, Adejobi and Fregrene (2008) found that household size significant but have negative impact on food insecurity in rural household in Borno State of Nigeria.

In addition to whole population in a country, foreign workers need to be considered as a part of the population.

According to Mohamed, Ramendran and Yacob (2012), foreign worker is not a citizen and known as a person who employed in a country on a temporary basis. These workers act as a supplement to the existing workforce of the country for a limited term. While, according to Kanapathy (2006) stated that "migration has positive, negative or neutral effect". There are less empirical studies on the impact of migrant workers on the Malaysia economy. This may due to the lack of accurate data on contract migrant workers. However, several casual observations have been made according to the high incidence of irregular migrations and the visible socio-political and security problems. Nonetheless these observations are tends to highlight the negative impact of migrant workers on the economy.

Climate change is an important variable to be included in the food security model. Alam, Siwar, Murad and Toriman (2011) empirically investigated about the issue of the impact of climate change phenomena such as natural disaster, drought, flood, pest attack, plant disease and changing the time of crop cycle to the productivity in agriculture, choice of crop and food security in Malaysia. The chosen crops are paddy production (main staple food), fruits vegetables, fish product, beef, muttons, pork, chicken, duck, egg, and dairy product in the First National Agriculture Plan 1984. They found that the climate change have negative impact on self-sufficiency and long term food security in Malaysia. Edame, Ekpenyong, Fonta and Duru (2011) examined the impact of climate change on major components of food security such as availability, accessibility, affordability, preference, utilization, and nutritional value and food system stability. It is expected that the viability of current world agro ecosystem and future food availability have long term implication. This has been evidenced by the increased intensity and frequency of storms, altered hydrological cycles, and precipitation variance as much as 20% of decrease in agriculture activity in Africa, Asia and Latin America. Climate change, tend to reduce agriculture productivity, production stability and income in some areas that already have high food security.

In the context of Malaysia, Khee, Mee and Keong (2011) have estimated the economic impact of climate change on food security. This study reveals the demand side of Malaysians food security and use the willingness-to-pay (WTP). Contingent Valuation Method (CVM) has been applied to elicit the respondent's WTP in a way to avoid future damage on food security due to climate change. CVM questionnaire has been included with questions about the adaptation projects like dam construction, monitoring weather extremes, developing disaster preparation strategies and communal capacities buildings. To estimate the WTP function, Tobit Model are used and compared with the Ordinary Least Square (OLS) Model. The determinants of WTP that significant in this study are scale concern on the nation's food security is at risk, membership of environmental, gender and educational level. The result shows that climate change mitigation programs are important to ensure food security and willingness of the public to pay extra rice price for the mitigation programs. According to Arshad (2010), besides other structural and technical factors, unpleasant weather situation in the producing countries cause the policy response to the 2008 food security crisis. Food security crisis found to affect the low income net-food countries (Bangladesh, Egypt, Indonesia, Nigeria and Philippines) as 80% of their income were spent on food.

## 3. Data and Methodology

### *3.1 Data*

The variables of food security used in this study are:

i. Food production index (2004-2006=100) which is proxy of food security. This index covers food crops that are considered edible and that contain nutrients where coffee and tea are excluded because, although edible, they have no nutritive value.

ii. Food price index (P) for based year 2002-2004=100.

iii. Malaysia population (POP) in million.

iv. Percent of total foreign worker (FW) in Malaysia.

v. Carbon dioxide emissions ($CO_2$) in kilotonnes (kt) include carbon dioxide produced during consumption of solid, liquid, gas fuels and gas flaring.

All these variables are expressed in log terms. Those data are obtained from Food and Agriculture Organization (FAO), World Bank and Department of Statistic (DOS).

### *3.2 Model Specification*

Food security is defined in four components which are food availability, food access, food utilizations and food stability (FAO, 2006). Total food available is known as food for individual consumption, food production, stocks, import or food aid. According to Jones et al. (2013), usually food security measures developed for use at the country level often emphasize food availability. Tools for measuring food availability, such as food balance sheets, for example total amount of food produced and imported and utilization, for example the quantity of food exported, fed to livestock, used for seed, processed for food and non-food uses, and lost during storage and transportation. These data are used to create FAO's core food security measure. Food production indicates that food available for population which produced by a country through food domestic production alone or beyond food domestic production or both (Aker & Lemtouni, 1999). Domestic food production is the most important quantitative component in national food security for almost all countries (FAO, 1996). Lack of food supplies will cause hunger and starvation in a country. Therefore, empirical outline will be used food production as proxy for food security.

Based on the discussion on the potential determinants of food security, the model can be written as:

$$Q = fs\ (FP,\ POP,\ CO2,\ FW) \quad (1)$$

$$\log Q_t = \beta_0 + \beta_1 \log FP_t + \beta_2 \log POP_t + \beta_3 \log FW_t + \beta_4 \log CO2_t + \varepsilon_t \quad (2)$$

where,

Q = food production index (2004-2006 = 100)

FP = real food prices index

POP = Malaysia population

CO2 = Carbon dioxide emissions (kt)

FW = foreign worker (percentage)

$\varepsilon$ = error term

t = time series period

$\beta_0$ = the intercept

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

In order to evaluate the impact of the variables in percentage terms, the model is modified by transforming the equation into a log form (Equation 2).

In analyzing the time series data, the unit root test, co-integration test, and error correction model (ECM) techniques have been used. The unit root test is called the Augmented Dickey-Fuller (ADF) test. The results show that food security and all the explanatory variables are stationary in the first difference value

Next, Johansen test is conducted to examine the long run relationship between the dependent variable and the explanatory variables. Johansen test using the trace and Max-Eigen statistics test shows that exist a long run relationship among the variables in this study. This fulfill the second objective of the thesis which to examine the long run relationship between food security and its determinants. The normalized co-integrating equation shows that all the variables are significant in the long run.

Further, the data were analyzed using the Vector Error Correction Model (VECM) to determine how much the short run deviated from the long run. The coefficient in error correction term (ECT) is the speed of adjustment factor. There exists one error correction term in this analysis. The result shows the value of ECT is negative and significant indicated that there are long run causality between food security and its determinants.

Lastly, the diagnostic tests were conducted. These tests consist of the Lagrange Multiplier test. In the Breusch-Godfrey Serial Correlation LM Test, we conclude that there is no evidence of autocorrelation problem in the model. While, in the Autoregressive Conditional Heteroscedasticity (ARCH) test shows that we failed to reject $H_0$: Homoscedasticity (variance u is constant) and we conclude that there is no evidence of heteroscedasticity problem in the model.

*3.3 Unit Root Test*

All the variables in the equation are tested for stationarity using unit root test. Testing of the stationarity of the time series ensures that the variables used in the analysis are not subjected to spurious correlation should be done before the estimation of the econometric model. The time series properties of the variables used in this study are the standard Augmented Dickey-Fuller (ADF) test. An extensive overview on unit root test is provided by Maddala and Kim (1998). Parametric tests of Dickey and Fuller (1979) and non-parametric test of Phillips and Perron (1988) was the most cited in applied works. For various unit root data generating process (DGP) assumes identical distributed and independent error terms (iid) derived by Dickey and Fuller (1979) and it's known as Dickey Fuller (DF) distribution. On the other hand, Phillips and Perron (1988) proposed a nonparametric correction of the DF test to account the error term which are not iid (PP test). The extension of DF test by allowing a higher order of autoregressive process is known as ADF unit root test. Since the original DF does not take into account possible autocorrelation in the error process, $e_t$; this is the drawback of DF.

The ADF test is given by:

$$Y_t = \beta_1 + \beta_2 Y_{t-1} + \mu_t \qquad t = 1,2\ldots\ldots, \tag{3}$$

Where,

$Y_t$ = variable y at time t

$Y_{t-1}$ = variable Y at lagged 1

For convenient unit root testing, the equation is subtracted by $Y_{t-1}$ and we have equation (4):

$$\Delta Y_t = \alpha_1 + \alpha_2\, \Delta Y_{t-1} + e_t \quad \text{and } \alpha_2 = \rho\text{-}1 \tag{4}$$

The hypothesis for unit root test is as following:

$H_0$: $\alpha_2 = 0$ ($Y_t$ is non-stationary)

$H_1$: $\alpha_2 < 0$ ($Y_t$ is stationary)

*3.4 Johansen Co-integration Test and Long Run Equilibrium*

Johansen test is the procedure to test for co-integration in time series data. This test is based on the Vector Autoregressive (VAR) Model approach. The purpose of this test is to examine the long run relationship between the dependent variable and explanatory variables in the food security model. In this study, the focus is to determine the long run relationship between food security and the determinants. This test is carried out since all of the variables appeared to be co-integrated at the same order.

The Johansen tests are likelihood-ratio tests. There are two tests; (i) the maximum eigenvalue test, and (ii) the trace test. For both test statistics, the initial Johansen test is a test of the null hypothesis of no co-integration against the alternative of co-integration. The test differs in terms of the alternative. The null hypothesis for the eigenvalue test is r = equals the number of co-integration vectors in the model, while the null hypothesis for trace test is r ≤ the number of co-integration vectors in the model. Similar to the unit root test, the number of co-integration vectors could be constant or include a trend term or both. This approach will later be used to examine the long run impact of the explanatory variables on food security.

*3.5 Vector Error Correction Model (VECM)*

When the variables in the Vector Autoregressive Models (VAR) are co integrated, the Vector Error Correction Model (VECM) technique is used. Granger Representation theorem defined that when variables are co-integrated, there must also be an error correction term (ECT) that describes the short run dynamics or adjustments of the co-integrated variables towards their equilibrium values. One period lagged co-integrating equation and the lagged first differences of the endogenous variables ECT consists in ECT. One can estimate ECT by using the restricted Vector Autorgession (VAR) method. In particular, the error correction model (ECM) can be constructed by expressing changes in the dependant variables as a function of the level of disequilibrium in the co-integrating relationship (captured by the ECT) as well as changes in other explanatory variables. The regression analysis shows that the coefficients for the explanatory variables are able to interpret and the signs are able to detect. This approach will show the speed of adjustment of the model in short run. Equation (5) shows the error correction model is developed:

$$\Delta \log Q_t = \log\beta_0 + \beta_1 \Delta \log FP_t + \beta_2 \Delta \log POP_t + \beta_3 \Delta \log CO_{2t} + \beta_4 \Delta \log FW_t + \beta_5 ECT_{t-1} + v_t \tag{5}$$

Where $ECT_{t-1}$ is the error correction component and is the lagged estimated error series from Equation 3.2 while v are the random error terms.

## 4. Results and Discussions

The results of ADF unit root test shows that at level, t-statistic values for all the variables used in this study such as food production index (logQ), real food price index (logP), population (logPOP), carbon dioxide ($CO_2$) emissions ($\log CO_2$) and foreign labor (logFW) are not statistically significance. Then, null hypothesis of non-stationary cannot be rejected at any significant level indicates that all variables series are non-stationary at level and the series contain a unit root.

However, at first difference, t-statistic values are significant. So, the null hypothesis of non-stationary can be rejected indicates that all variables are stationary at first different. Therefore, the results means that all the series are integrated of order one, I(1). Since the variables in the model are I(1), the spurious regression problem occur.

Next, the co-integrations between the variables are tested.

Table 1. Unit root tests for Augmented Dickey Fuller (ADF)

| Variable | Level | | First Difference | | Results |
|---|---|---|---|---|---|
| | Intercept | Intercept & Trend | Intercept | Intercept & Trend | I(1) |
| logQ | -2.5534 [1]<br>(0.1144) | -3.0052 [4]<br>(0.1504) | -7.4367 [0]<br>(0.0000)*** | -8.2107 [0]<br>(0.0000)*** | I(1) |
| logP | 0.5746 [0]<br>(0.9864) | -3.2704 [7]<br>(0.1973) | -4.1870 [0]<br>(0.0030)*** | -4.4255 [0]<br>(0.0079)*** | I(1) |
| logPOP | -0.6239 [7]<br>(0.8459) | -2.9595 [7]<br>(0.1647) | -3.7565 [6]<br>(0.0103)** | -4.0668 [0]<br>(0.0178)** | I(1) |
| logFW | -1.2252 [0]<br>(0.6496) | -1.7106 [0]<br>(0.7206) | -4.9571 [0]<br>(0.0004)*** | -4.8734 [0]<br>(0.0028)*** | I(1) |
| logCO2 | -1.6782 [0]<br>(0.1413) | -1.0307 [0]<br>(0.9237) | -5.4325 [0]<br>(0.0001)*** | -5.5666 [0]<br>(0.0005)*** | I(1) |

*Note*. *** indicates the rejection of hypothesis null of non-stationary at 1 percent level of significant.

**indicates the rejection of hypothesis null of non-stationary at 5 percent level of significant.

[ ] indicates the lag specification.

( ) indicates t-statistic value.

Since the variables in the model are I(1), the spurious regression problems occur. Thus, the following sections discuss the results of co-integration analysis. The discussion starts with the determination of the optimal lag length obtained based on the VAR lag order selection criteria. The results in the Table 2 clearly show that the optimal lag length for co-integration is 1.

Table 2. VAR lag order selection criteria

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 216.0849 | NA | 3.28e-13 | -14.55758 | -14.32184 | -14.48375 |
| 1 | 426.1525 | 333.2107* | 9.67e-19* | -27.32086* | -25.90642* | -26.87787* |

*Notes*. * indicates lag order selected by the criterion at five level of significant.

LR: Sequential modified LR test statistic.

FPE: Final prediction error.

AIC: Akaike information criterion.

SC: Schwarz information criterion.

HQ: Hannan-Quinn information criterion.

Table 3. Results for co-integration test

| Hypothesized No. of CE(s) | Trace | | Max-Eigen | |
|---|---|---|---|---|
| | Statistic | 0.05 Critical Value | Statistic | 0.05 Critical Value |
| None | 142.0823*** | 69.81889 | 59.50393*** | 33.87687 |
| At most 1 | 82.57842*** | 47.85613 | 36.02549*** | 27.58434 |
| At most 2 | 46.55293*** | 29.79707 | 27.59047*** | 21.13162 |
| At most 3 | 18.96246** | 15.49471 | 17.34538** | 14.26460 |
| At most 4 | 1.617078 | 3.841466 | 1.617078 | 3.841466 |

*Note*. *** indicates the rejection of hypothesis null of non-stationary at 1 percent level of significant.

**indicates the rejection of hypothesis null of non-stationary at 1 percent level of significant.

It, is then, followed by the Johansen co-integration test conducted since unit root test showed that all the variables are I(1) and stationary at same order. Johansen test is purposely used to see the long run relationship between two or more variables in the model. There are two co-integration tests conducted such as trace test and Max-eigenvalue test and both tests used linear deterministic trend with restriction the result is shows in Table 3.

The co-integration test results both based on Trace statistic and Max-eigenvalue indicates 4 co-integrating equations at the 5% level. Both results indicates that the variables are co-integrated each other and there is a long run relationship between food security and explanatory variables.

Thus, it would be inappropriate to estimate a VAR model when the variables are co-integrated and expressed in first differences (Baffoe-Bonnie & Gyapong, 2012) because first differencing would leads to the loss of a significant portion of information related to the co-movement in the data. Rather than a VAR model, an error correction model is the appropriate model if the variables are co-integrated in first differences (Eagle & Granger, 1987). According to Engle and Granger (1987), the co-integration relationship must have an ECM representation. The ECM essentially estimates the short run dynamics between the variables. The results of short run Error Correction Model for food security is presented in Table 4.

Table 4. Results for estimated vector error correction model (VECM)

| Variables | Coefficient | t-statistic |
|---|---|---|
| C | -0.068389 | -1.095511 |
| $\Delta logQ_{t-1}$ | -0.060015 | -0.279115 |
| $\Delta logFP_{t-1}$ | 0.097518 | 1.479993 |
| $\Delta logPOP_{t-1}$ | 8.415742 | 1.450691 |
| $\Delta logFW_{t-1}$ | 0.147794 | 2.571362** |
| $\Delta logCO2_{t-1}$ | -0.007271 | -0.085955 |
| $ECT_{t-1}$ | -0.722071 | -2.337230** |

*Note*. ** indicates the rejection of hypothesis null of non-stationary at 5 percent level of significant.

The result shows that foreign worker is the only variable that significant in the short run. Changes in foreign worker effect positively the changes in Q indicating that this independent variables are positively affecting food security. A 1 per cent increase in $\Delta logFP_{t-1}$ will lead to expansion of $\Delta logQ_{t-1}$ by 0.0975 per cent. In terms of significant level, $\Delta logFW_{t-1}$ is statistically significant at 5 per cent level of confident. While the others variables such as food price, population and $CO_2$ emissions are not significant and not important in explaining Malaysia food security in the short run.

Based on the VECM result, there is an error correction term exist in this analysis. Since the coefficient value of this error correction term more than one ($ECT_{t-1}> 1$), it indicates that the short run deviation goes on rapid paths to equilibrium in the long run. Otherwise, if the coefficient value in this error correction term less than one ($ECT_{t-1}< 1$), it indicates that the error correction term slowly adjust back to equilibrium in the long run. The results presented show that the $ECT_{t-1}$ coefficient is negative and significant at 1 percent significant level implying that the series cannot drift too far apart and convergence is achieved in the long run. The estimated coefficient of the error correction term was 0.722071 indicates that the speed of adjustment is around 72 percent at 1 percent significant level. It is means that the adjustment process of the disequilibrium is about 72 percent in one year (annually data).

## 5. Conclusions and Policy Recommendations

### *5.1 Conclusions*

The purpose of this study is to determine the influence of selected variables on Malaysia's food security model. There are many variables which can be used to determine food security in the country. The variables selected for the analyses were food price (FP), Malaysia population (POP), foreign workers (FW) and carbon dioxide emissions ($CO_2$). These four independent variables have been tested to determine their effect on Malaysia food security model. This study employs time series data from 1982 to 2011.

The result shows that foreign worker is the only variable that significant in the short run. While the others variables such as food price, population and $CO_2$ emissions are not significant and not important in explaining

Malaysia food security in the short run.

The result also shows that the $ECT_{t-1}$ coefficient is negative and significant at 1 percent level implying that the series cannot drift too far apart and convergence is achieved in the long run. The estimated coefficient of the error correction term was 0.722071 indicates that the speed of adjustment is around 72 percent at 1 percent significant level. It means that the adjustment process of the disequilibrium is about 72 percent in one year.

*5.2 Policy Recommendations*

Based on the results of the study, several recommendations can be taken and performed to increase food security in Malaysia. These suggestions also allow the food security level to be better through improvements on the determinants that have significant effect on food security. Policymakers have a choice of long run and short run policies or a combination of both in promoting food security in Malaysia. The results shows that only foreign workers would affect food security in both long run and short run while the other determinants such as food price, population and carbon dioxide emissions affects food security in the long run. Therefore the policymakers should manipulate the significant variables to achieve the long run and short run goals.

Base from the results it is clearly shows that foreign workers is an important factor contributing to food security in Malaysia, both in long and short run. The results also show that it is positively significant then government may want to revise the policy regarding the foreign workers entry to Malaysia since currently, the government is trying to restrict the entry of foreign worker in the country.

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**Appendix A**

Table A1. Lag order selection criteria

VAR Lag Order Selection Criteria
Endogenous variables: LOGQ LOGPOP LOGP LOGFL LOGCO2
Exogenous variables: C
Sample: 1982 2011
Included observations: 29

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 216.0849 | NA | 3.28e-13 | -14.55758 | -14.32184 | -14.48375 |
| 1 | 426.1525 | 333.2107* | 9.67e-19* | -27.32086* | -25.90642* | -26.87787* |

* indicates lag order selected by the criterion.

LR: sequential modified LR test statistic (each test at 5% level).

FPE: Final prediction error.

AIC: Akaike information criterion.

SC: Schwarz information criterion.

HQ: Hannan-Quinn information criterion.

Table A2. Johansen co-integration test

Sample (adjusted): 1984 2011

Included observations: 28 after adjustments

Trend assumption: Linear deterministic trend

Series: LOGQ LOGPOP LOGP LOGFL LOGCO2

Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.880584 | 142.0823 | 69.81889 | 0.0000 |
| At most 1* | 0.723799 | 82.57842 | 47.85613 | 0.0000 |
| At most 2* | 0.626700 | 46.55293 | 29.79707 | 0.0003 |
| At most 3* | 0.461775 | 18.96246 | 15.49471 | 0.0144 |
| At most 4 | 0.056117 | 1.617078 | 3.841466 | 0.2035 |

Trace test indicates 4 co-integrating eqn(s) at the 0.05 level.

* denotes rejection of the hypothesis at the 0.05 level.

**MacKinnon-Haug-Michelis (1999) p-values.

Table A3. Unrestricted co-integration rank test (maximum eigenvalue)

| Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.880584 | 59.50393 | 33.87687 | 0.0000 |
| At most 1 * | 0.723799 | 36.02549 | 27.58434 | 0.0033 |
| At most 2 * | 0.626700 | 27.59047 | 21.13162 | 0.0054 |
| At most 3 * | 0.461775 | 17.34538 | 14.26460 | 0.0158 |
| At most 4 | 0.056117 | 1.617078 | 3.841466 | 0.2035 |

Max-eigenvalue test indicates 4 co-integratingeqn(s) at the 0.05 level.

* denotes rejection of the hypothesis at the 0.05 level.

**MacKinnon-Haug-Michelis (1999) p-values.

Table A4. Normalized co-integrating equation

Co-integrating Equation(s): Log likelihood 451.5899

Normalized co-integrating coefficients (standard error in parentheses)

| LOGQ | LOGPOP | LOGP | LOGFL | LOGCO2 |
|---|---|---|---|---|
| 1.000000 | 4.289889 | -0.310007 | 0.423932 | -1.825612 |
| | (0.58835) | (0.13662) | (0.13200) | (0.21220) |

Table A5. Vector error correction model (VECM)

Dependent Variable: D(LOGQ)
Method: Least Squares
Sample (adjusted): 1984 2011
Included observations: 28 after adjustments
D(LOGQ) = C(1)*( LOGQ(-1) + 0.0653694222874*LOGCO2(-1)-
2.15275403403 ) + C(2)*( LOGPOP(-1) - 0.0722808287479*LOGCO2(
-1) - 6.96512011308 ) + C(3)*( LOGP(-1) + 2.4627003911*LOGCO2(-1)
- 14.3178984743 ) + C(4)*( LOGFL(-1) - 1.92825856559*LOGCO2(-1)
+ 8.7820541109 ) + C(5)*D(LOGQ(-1)) + C(6)*D(LOGPOP(-1)) + C(7)
*D(LOGP(-1)) + C(8)*D(LOGFL(-1)) + C(9)*D(LOGCO2(-1)) + C(10)

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | -0.722071 | 0.308943 | -2.337230 | 0.0312 |
| C(2) | 1.935981 | 0.665465 | 2.909216 | 0.0094 |
| C(3) | -0.034864 | 0.027286 | -1.277763 | 0.2176 |
| C(4) | -0.116718 | 0.072199 | -1.616623 | 0.1234 |
| C(5) | -0.060015 | 0.215018 | -0.279115 | 0.7833 |
| C(6) | 8.415742 | 5.801195 | 1.450691 | 0.1641 |
| C(7) | 0.097518 | 0.065891 | 1.479993 | 0.1562 |
| C(8) | 0.147794 | 0.057477 | 2.571362 | 0.0192 |
| C(9) | -0.007271 | 0.084588 | -0.085955 | 0.9325 |
| C(10) | -0.068389 | 0.062426 | -1.095511 | 0.2877 |
| R-squared | 0.679931 | Mean dependent var | | 0.021876 |
| Adjusted R-squared | 0.519897 | S.D. dependent var | | 0.018070 |
| S.E. of regression | 0.012521 | Akaike info criterion | | -5.650434 |
| Sum squared resid | 0.002822 | Schwarz criterion | | -5.174647 |
| Log likelihood | 89.10608 | Hannan-Quinn criter. | | -5.504981 |
| F-statistic | 4.248656 | Durbin-Watson stat | | 2.333585 |
| Prob(F-statistic) | 0.004382 | | | |