Analysis of food security in Southeast Asia countries

N E Fauziyyah and J Duasa*
Department of Economics, Kulliyah of Economics and Management Science, International Islamic University Malaysia, Malaysia

*E-mail: jarita@iium.edu.my

Abstract. The present study aims to investigate the determinants of food security in nine developing and least-developed countries of Southeast Asia. By adopting fixed effects model of panel regression with interaction terms, using yearly data (2006-2016), the results showed that all explanatory variables are significant, except agriculture land and Foreign Direct Investment (FDI). Employment in agriculture, Consumer Price Index (CPI), and Real Gross Domestic Product (RGDP) positively affect food production. Meanwhile, CO₂ emission and gross fixed capital negatively related to food production. The study also found that employment in agriculture gives negative impact on food production when it interacts with CO₂ emission and agriculture land. When RGDP interacts with CPI, it also contributes negatively to food production. However, gross fixed capital has a positive and significant relationship with food production when it interacts with CO₂ emission. The findings postulate the importance of appropriate policies and innovative programs for agriculture sector to boost food production as well as to hamper food insecurity in Southeast Asia countries.

1. Introduction
The establishment of the food security concept had firstly been triggered by the deep recession that occurred before the 1980s that affected daily lives of millions of people around the world, mainly in developing and least-developed countries. Poverty, hunger, and malnutrition became severe problems since this recession. Food and Agriculture Organization (FAO) recorded that around 957.3 million people, globally, could not meet their dietary needs at the beginning of the 21st century [1]. The problems have been highlighted and become a major target of Millennium Development Goals (MDGs) as well as Sustainable Development Goals (SDGs). The Global Hunger Index (GHI) Score and Scale shows that most developing and least-developed countries in Southeast Asia are still considered as serious category by 2017. Those countries are Myanmar, Philippines, Indonesia, Cambodia, Lao PDR and Timor-Leste [2].

Due to the geographical location of Southeast Asia countries is in coastal and river deltas and the weather is tropic, the countries have a big risk from climate change problem that disrupts the agricultural sector’s performance. They encounter problems such as sea-level rise, unpredictable weather, drought, flood, erosion, gas emission and so on. In addition, demographics phenomena also worsen the issue of food insecurity. Number of population in Southeast Asia countries went up from 532.3 million in 2001 to 648.6 million in 2017, which increase 116.2 million people in sixteen years as reported by the World Bank. As a consequence, the countries need to ensure the availability of the staple food for all their citizens. Bhaskaran [3] asserted that based on the United Nations report, 49 per cent of the current urban population in Southeast Asia is projected to grow to 56 per cent by 2030. As many productive-age people leave the rural area due to potentially high income in the city, it directly diminishes rural workers. Since the rural area is mostly related to the agricultural sector, urbanisation
may decrease agriculture production and food availability in the market. Nonetheless, lack of capital in this sector hampers its productivity. Infrastructure is underdeveloped and farmers suffer difficulties to increase production due to insufficient money and infrequent credit. Insufficient credit to finance costs of seeds, fertilisers, and other physical input exacerbated with escalation of input prices.

Having said this, the present study aims to investigate these determinants of food security in developing and least-developed countries of Southeast Asia. The study on food security in these countries using panel regression model with macro level analysis has relatively not conducted yet to the knowledge of authors. Thus, this study attempts to fill the gap.

2. Literature Review

Based on the basic theory, where principal inputs influencing the output of production are land, labour, capital, entrepreneurship and also technology, this study derives the factors which affect ‘food production’. The study categorises the factors or inputs into three. They are agricultural determinants such as land and labour, macroeconomics determinants such as capital, Gross Domestic Product (GDP), Consumer Price Index (CPI) and environmental determinant such as CO₂ emission.

The land size will immediately contribute to food production as land is one of important resources in crop production. Dewati and Waluyati[4], Koirala et al.[5] and Shaikh et al.[6] examined that land area positively and significantly influences rice production, while Azwardi et al. [7] and Bashir and Yuliana [8] obtained similar positive relationship but insignificant. Labour is a crucial element of the production model [6]. Bashir and Yuliana [8] proved that labour has a positive and significant contribution in increasing rice production in Indonesia, where farmer is the most common type of occupation in Indonesia. Similarly, in Thailand, Tiwasing, Dawson, and Garrod [9] argued that family worker could escalate workers’ capacity and reduce hired labour costs. Thus, family workers have a positive and significant relationship with household food security. As labour, capital is also an important determinant in production. Its performance in facilitating labours is expected to elevate agriculture productivity. Shaikh et al. [6] found that the relationship between capital and agriculture output, particularly rice in Jaffarabad, Pakistan is positive and significant. A similar finding found by Amegnaglo [10] after examining the Cobb-Douglas production model for maize production in Benin. Capital may be derived from domestic or foreign allocation. Referring to O’Keef and Li [11], foreign investment may potentially assist the rural area in modernising infrastructure and fulfill various agricultural producers’ facilities, so, it will support the improvement of food security target. Unfortunately, in real condition, most Foreign Direct Investment (FDI) is allocated to the industrial sector that expected to increase more profit than the agricultural sector. Somehow, some studies pointed out the significant effect of FDI on food security [12, 13].

Besides, both GDP and CPI may also influence food production and food security. Some studies found adverse effects from GDP to food security in the short-run such as Applanaidu, Bakar, and Baharudin [14], Hanif et al. [12] and Widada, Masyhuri, and Mulyo [15], but its relationship is not significant. Hanif et al. [12] stated that an increase in GDP does not attract investment in the agricultural sector but in industrial sector. Thus, GDP does not contribute to increase food production. Meanwhile, others such as Aker and Lemtouni [16] and Hanif et al. [12] indicated a positive and significant relationship among them as high GDP, which reflects economic development and better infrastructure, is a catalyst of more agricultural production. Likewise, food production can also be determined by food prices. The fluctuation of price may directly affect the household as a consumer. Those who have low income are unlikely to pay for higher food price during inflation. They will potentially suffer from food insecurity. On the other hand, higher food price encourages producers to produce more due to the potential of high profit. Widada et al. [15] found that the CPI of food harms food security status in Indonesia, although it does not give a significant contribution. However, a study done by Imoh and Ikechukwu [17] showed different result in which CPI, as general, has a positive and significant influence on agriculture production. They argued that the movement of price had been responded positively by farmers.
The sensitivity of the agricultural sector toward climate change is a highlighted issue in the current situation. The extreme climate condition can threat the agriculture production and later cause food insecurity. CO₂ emission, as one of the proxies for climate change, contributes a negative impact to agriculture productivity [17] as well as food security [18]. Huong, Bo, and Fahad [19] insisted that the negative impact appears when CO₂ emission pass over the limit level, yet it will enhance productivity if only reach optimal value. Hence, it is consistent with Xiong et al. [20] that showed an excellent contribution of CO₂ fertilisation to agriculture production. With CO₂ fertilisation, the projected range of temperature has no adverse effect on food production. In the long run condition, a negative and significant relationship occurred between CO₂ emission and food production index, as stated by Hanif et al. [12].

3. Data and Methodology

3.1. Data and variables
Data used in this research is panel data which combines the cross-section and time-series data. For cross-section, the study examines only nine developing and least-developed countries in Southeast Asia consisted of Indonesia, Malaysia, Thailand, Philippines, Lao PDR, Vietnam, Cambodia, Myanmar, and Timor-Leste. The data span from 2006 until 2016 (eleven years) resulting to 99 observations in total. The categorisation of under developing and least-developed criteria is done based on the World Bank’s definition. According to the World Bank, Singapore and Brunei Darussalam are categorised as a high income’s economies. Thus, both are considered as developed countries and automatically excluded from the analysis. The selected variables employed in the model follows a standard production theory which is Cobb-Douglass Production function. The variables are Food Production Index (FPI) as proxy of food security, agriculture land (AGRI_LAND), employment in agriculture (EMPLY_AGRI), CO₂ emission (CO₂_EM), gross fixed capital formation (FIX_CAP), Foreign Direct Investment (FDI_IN), Consumer Price Index (CPI) and Real Gross Domestic Product per capita (RGDPPC). Thus, the sample size of the research is data of 8 variables in 9 countries of Southeast Asia from 2006 to 2016.

3.2. Method
Panel regression model is conducted in this study. Following Asteriou and Hall [21], three methods are adopted, which are common effects, fixed effects and random effect method. The model for panel regression is as follows:

\[
\text{logFPI}_it = \beta_0 + \beta_1 \text{logAGRI_LAND}_it + \beta_2 \text{logEMPLY_AGRI}_it + \beta_3 \text{logCO}_2\_EM_it + \beta_4 \text{logFIX_CAP}_it + \\
\beta_5 \text{logFDI_IN}_it + \beta_6 \text{logCPI}_it + \beta_7 \text{logRGDPPC}_it + u_{it} \tag{1}
\]

where coefficients (betas) all variables are expected to be positive except CO₂ emission that could be negative based on previous literatures. At initial stage, to test whether all the variables are stationary or not stationary, the study employs Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests. Besides, the interaction term is used to get robustness of the regression and avoid specification error. Interaction term is the term where two variables are multiplied to be a product term. The advantage of including the product term is that it can avoid conditional monotone of relationship between independent variables and dependent variables. The relationship between dependent and independent variable might depend on the change of another independent variable. The model with the interaction effect term is as following:

\[
\text{logFPI}_it = \beta_0 + \beta_1 \text{logAGRI_LAND}_it + \beta_2 \text{logEMPLY_AGRI}_it + \beta_3 \text{logCO}_2\_EM_it + \beta_4 \text{logFIX_CAP}_it + \\
\beta_5 \text{logFDI_IN}_it + \beta_6 \text{logCPI}_it + \beta_7 \text{logRGDPPC}_it + \beta_8 \text{logFIX}_\_EM_it + \beta_9 \text{logCO}_2\_EM_it + \beta_{10} \text{logEMPLY}_\_AGRI_it + \beta_{11} \text{logAGRI}_\_LAND_it + u_{it} \tag{2}
\]
As mentioned above, there are three methods of panel regression model that are developed in which only one optimal model is to be chosen. In order to choose whether the best model is common effect or fixed effect, Redundant Fixed Effects – Likelihood Ratio or Chow test is employed. If the probability of $F$-statistic is less than 0.05, it means the test rejects the null hypothesis of common effects method and therefore, fixed effect is the best model. Further, to ensure the result, Correlated Random Effect or Hausman test is used to test whether the best model is random effect or fixed effect. If the null hypothesis of random effect is rejected, the fixed effect model will be chosen. When the result suggests the random effect is the appropriate model, Lagrange Multiplier (LM) test should be conducted to test whether random effect or common effect is the best model. In addition, two diagnostic tests are employed to ensure the residuals of the model satisfy the standard. There are heteroscedasticity and auto-correlation tests. Both tests are required in panel regression since panel data consists of cross-section and time-series data where the statistical problems may occur in the estimation. The common problem in cross-sectional data is heteroscedasticity, while in time-series, is auto-correlation. Thus, both problems must be traced and corrected. Glesjer test is utilized for heteroscedastic and Durbin Watson (DW) and AR (1) serial correlation tests for auto-correlation.

### 4. Findings and Discussion

The present study utilises fixed effect model of panel regression estimation to investigate the relationship between variables. This model is taken after employing the tests to choose the best model in panel regression. Table 1 shows that only one variable significantly affects the dependent variable of Food Production Index. It is gross domestic capital formation (DLFIX_CAP) which has a probability of 0.0815 (< 10 per cent). The positive sign of gross domestic capital formation supports some previous finding on the importance of capital to boost food production in the countries of study.

| Variables       | Coefficient | Standard Error | t-statistic | Probability |
|-----------------|-------------|----------------|-------------|-------------|
| DLAGRI_LAND     | 0.510612    | 0.314930       | 1.621351    | 0.1106      |
| DLEMPLOY_AGRI   | 0.030563    | 0.046494       | 0.657348    | 0.5136      |
| DLCO2_EM        | -0.010713   | 0.070846       | -0.151209   | 0.8804      |
| DLFIX_CAP       | 0.073978*   | 0.041695       | 1.774281    | 0.0815      |
| DLFDI_IN        | 6.79E-05    | 0.005920       | 0.011477    | 0.9909      |
| DLCPI           | 0.202076    | 0.144005       | 1.403253    | 0.1661      |
| DLRGDPPC        | -0.067561   | 0.108125       | -0.624841   | 0.5346      |
| C               | 0.005641    | 0.010616       | 0.531396    | 0.5972      |
| $R^2$-squared   | 0.197655    |                |             |             |
| $F$-statistic   | 1.061183    |                |             |             |
| Probability ($F$-Stat) | 0.410239 |          |             |             |

Notes: ***, **, * denote rejection of null hypothesis at 1%, 5%, and 10% level of significance.

The study attempts further analysis using possible interaction term in the model. It is expected that this term can fit the model well and give robust results. In the second model, the study added some interaction terms. Those are employment in agriculture (DLEMPLOY_AGRI) with CO$_2$ emission (DLCO$_2$_EM), fixed capital (DLFIX_CAP) with CO$_2$ emission, employment in agriculture with agriculture land (DLAGRI_LAND) and RGDP (DLRGDPPC) with CPI (DLCPI). The results are more robust compare to previous result where almost all variables are significant in this model. While checking for the unbiased and inefficient results by employing heteroscedasticity and auto-correlation tests, the model however suffers heteroscedasticity and auto-correlation problems which need to be
corrected. One way to correct the problems is by using robust standard error. Thus, the White Period in coefficient covariant is selected. The choice may deal with the errors that suffer from heteroscedasticity and serially correlated. This method adjusts the value of standard error of the explanatory variables. The results are shown on Table 2.

### Table 2. Result of fixed effects model with interaction terms and employing robust standard error method.

| Variables                                      | Coefficient | Standard error | t-statistic | Probability |
|------------------------------------------------|-------------|----------------|-------------|-------------|
| Dependent Variable: DLFPI                      |             |                |             |             |
| DLAGRI_LAND                                    | 0.164073    | 0.212064       | 0.773695    | 0.4426      |
| DLEMPLOY_AGRI                                  | 0.259518*** | 0.074682       | 3.474984    | 0.0010      |
| DLCO2_EM                                       | -0.167424***| 0.040936       | -4.089949   | 0.0002      |
| DLFIX_CAP                                      | -0.137218***| 0.015776       | -8.697808   | 0.0000      |
| DLFDI_IN                                       | 0.000233    | 0.001737       | 0.134029    | 0.8939      |
| DLEMPLY_AGRI*DLCO2_EM                         | -1.979854***| 0.635497       | -3.115444   | 0.0030      |
| DLFIX_CAP*DLCO2_EM                             | 2.333466*** | 0.352381       | 6.622000    | 0.0000      |
| DLEMPLY_AGRI*DLAGRI_LAND                      | -5.123796*  | 2.575852       | -1.989166   | 0.0520      |
| DLRGDPCC*DLCP                                 | -11.44664***| 2.815752       | -4.065216   | 0.0002      |
| C                                              | 0.017572*** | 0.002049       | 8.574238    | 0.0000      |
| R-square                                       | 0.528813    |                |             |             |
| F-statistic                                    | 3.432918*** |                |             |             |
| Probability (F-stat)                           | 0.000312    |                |             |             |

Notes: ***, **, * denote rejection of null hypothesis at 1%, 5%, and 10% level of significance.

Most of the coefficients are significant except for agriculture land and FDI (DLFDI_IN). This result is similar to studies done by Azwardi et al. [7], Bashir and Yuliana [8] and Iqbal, Khan, Suhail, and Zaman [22], where land size does not significantly affect food production. For the FDI, the probability which is more than 5 per cent (0.8939) reveals that FDI does not contribute significantly to food production. This result is in contrast to findings of some previous studies discovering significant effect from FDI to agriculture production such as Hanif et al. [12] and Slimane et al. [13]. The finding is makes sense because FDI inflows for agricultural sector is hardly occur in Southeast Asia countries for the last few years. For instance, in 2017, the share of FDI for agricultural sector in Southeast Asia region remained at 3 per cent only, which was at low level [23]. CO2 emission as environmental factor significantly influences food production. As expected, this study finds that CO2 emission negatively and significantly affects food production. The uncontrolled emission will affect climate changes such as high temperature, precipitation, unpredictable rainfall etc. Further implication, for instances infertility of the cultivation area and even the decreasing health of the farmers will appear which result to low crop production. Geographical location and weather condition of Southeast Asia countries will also increase this risk. The present finding is consistent with previous studies of Edoja et al. [18], Hanif et al. [12] and Imoh and Ikehuchukwu [17]. Other significant variables are employment in agriculture, gross fixed capital formation, CPI and RGDP. From the results, employment significantly and positively affects food production. This result is consistent to theory where the role of workers is crucial in the agricultural sector due to its labour-intensive in nature requiring a large number of labours. Studies by Amegnaglo [10], Bashir and Yuliana [8], Shaikh et al. [6] and Tiwasing et al. [9] supported this result. When employment variable interacts with agriculture land and CO2 emission, the relationships however change from positive sign to negative sign. It can be said that although one country has abundant of labour in the agricultural sector, due to the limitation of land and also the
impact of CO$_2$ emission, production might be declined. Carbon dioxide or pollution could affect health condition of workers which negatively affect food production. In the case of gross fixed capital formation, positive sign is identified when the variable interacts with CO$_2$ emission. The obtained sign reflects that food production increases due to increase in fixed capital in the present of CO$_2$ emission. However, the individual relationship shows that fixed capital negatively and significantly affects food production. This could be explained from a study by Afiat [24] that concluded that increase infrastructure by government positively impact on the industrial sector but not on agricultural sector.

In addition, CPI and RGDP per capita are positive and significant influencing food production in Southeast Asia countries. Rationally, higher price, particularly for food, tends to encourage producers to produce more food. The finding is consistent to studies by Applanaidu et al. [14] and Imoh and Ikechukwu [17]. The studies found a positive relationship between price and agriculture or food production in Malaysia and Nigeria, respectively. RGDP or income per capita may also enhance food production due to the additional demand from the consumers. Aker and Lemtouni [16] and Hanif et al. [12] found similar findings as income has been considered as a factor enables consumers to access food. Since price also influences demand side of food market, increasing consumer price will also be impactful to food production. Hence, when RGDP interacts with CPI, the sign of RGDP coefficient changes from positive to negative. It is expected that when the price of food in Southeast Asia countries increases, people will tend to choose import foods rather than domestic foods due to relatively lower price although their income increases. Hence, domestic food production will also fall as a result of less demand. Nonetheless, when GDP escalates, there are more opportunities to increase investment in the industrial sector rather than the agricultural sector [12] with high price. As a result, food production might be reduced due to lack of capital.

5. Conclusion
The study attempts to examine the relationship between food security and several key variables in the Southeast Asia region from 2006 until 2016. Agriculture land and FDI is not significant in the result, while others significantly affect food production. Based on the findings, we could conclude that prominent issues arose in the developing and least developing countries of Southeast Asia are shortage of agriculture land, lack of investment in the agricultural sector and unfinished tasks to tackle problem of climate change. The government of each Southeast Asia countries needs to take necessary actions and develops innovative programs to boost food security in these countries. The Philippines and Thailand’s government support on an organic farming by mandating in the Act is one example in which the government in other Southeast Asia countries is recommended to replicate. FAO’s recent proposed concept of Climate-Smart Agriculture (CSA) which guides and supports agriculture within changing of climate to maintain development and ensure food security is another model can be adopted. Besides, each country of Southeast Asia is recommended to participate in international negotiations addressing climate change and food security issue, such as Kyoto Protocol that has been extended to Doha Amendment.

Acknowledgment
This study is funded by the Fundamental Research Grant Scheme (FRGS), FRGS/1/2019/SS08/UIAM/01/1, Ministry of Higher Education, Malaysia. The authors would like to thank the Ministry for generously funding the research.

References
[1] FAO, IFAD and WFP 2013 The State of Food Insecurity in the World. The multiple dimensions of food security 2013 (Rome: Food and Agriculture Organization of the United Nation)
[2] Grebmer K von, Bernstein J and Patterson F 2018 Global Hunger Index. Force Migration and Hunger
[3] Bhaskaran M 2018 From shifting demographics to climate change, Southeast Asia confronts a host of challenges. Retrieved October 10, 2019, from
https://www.imf.org/external/pubs/ft/fandd/2018/09/future-of-southeast-asia-bhaskaran.htm

[4] Dewati R and Waluyati L R 2018 Production risk of rice in Kebonsari, Madiun Regency Agr. Ekon. 29 161–72

[5] Koirala K H, Mishra A K and Mohanty S 2014 Determinants of Rice Productivity and Technical Efficiency in the Philippines. Selected Paper for Presentation at Southern Agricultural Economics Association (SAEA) Annual Meeting, 2014 (Dallas Texas: USA)

[6] Shaikh S A, Hongbing O, Khan K and Ahmed M 2016 Determinants of Rice Productivity: An Analysis of Jaffarabad District – Balochistan (Pakistan) Europ. Sci. J. 12 41–50

[7] Azwardi Bashir A, Adam M and Marwa T 2016 The effect of subsidy policy on food security of rice in Indonesia IJABER 14 9009–22

[8] Bashir A and Yuliana S 2018 Identifying factors influencing rice production and consumption in Indonesia J. Eko. Pembangunan: Kajian Masalah Ekonomi Dan Pembangunan 19 172–185

[9] Tiwasing P, Dawson P and Garrod G 2018 Food security of rice-farming households in Thailand: A Logit Analysis The J. of Dev. Areas 52 85–98

[10] Amegnaglo C J 2018 Determinants of maize farmers’ performance in Benin, West Africa Kasetsart J. of Soc. Sci 1–7

[11] O’Keef A M and Li Q 2011 Modernization vs dependency revisited: effects of foreign direct investment on food security in less developed countries l. Int. Stud. Quar. 55 71–93

[12] Hanif N, Nisa M and Yaseen M R 2019 Relationship between food security, macroeconomic variables and environment: evidences from developing countries J. Appl. Econ. Business Res. 9 27–37

[13] Slimane M Ben, Huchet-Bourdon M and Zitouna H 2015 The role of sectoral fdi in promoting agricultural production and improving food security Int. Econ. 145(C) 50–65

[14] Applanaidu S D, Bakar N A A and Baharudin A H 2014 An econometric analysis of food security and related macroeconomic variables in Malaysia: a vector autoregressive approach (VAR) UMK Procedia 193 93–102

[15] Widada A W, Masyhuri and Mulyo J H 2017 Determinant factors of food security in Indonesia Agro Ekon. 28 205–19

[16] Aker J and Lemtouni A 1999 A framework for assessing food security in face of globalization: the case of Morocco Agroalimentaria 8 13–26

[17] Imoh E U and Ikechukwu O M 2015 Climate change and agricultural productivity in nigeria: an econometric analysis 1–11

[18] Edoja P E, Aye G C and Abu O 2016 Dynamic relationship among CO₂ emission, agricultural productivity and food security in Nigeria Cogent Economics & Finance 3 0–13

[19] Huong N T L, Bo Y S and Fahad S 2018 Economic impact of climate change on agriculture using ricardian approach: a case of Northwest Vietnam J. Saudi Society Agri. Sci. 18 DOI: 10.1016/j.jssas.2018.02.006

[20] Xiong W, Lin E, Ju H and Xu Y 2007 Climate change and critical thresholds in China’s food security Climatic Change 81 205–21

[21] Asteriou D and Hall S G 2011 Applied Econometrics(United Kingdom: PALGRAVE MACMILLAN)

[22] Iqbal M, Khan M F, Suhail M and Zaman Q 2017 Determinants of various factors for wheat production J. Agri 55 379–85

[23] ASEAN 2018 ASEAN Key Figures 2018 (Jakarta: ASEAN Secretariat)

[24] Afiat M N 2015 Analisis pengaruh pengeluaran pemerintah terhadap perubahan struktur ekonomi di propinsi Sulawesi Tenggara J. Ekonomi Pembangunan XVI (8) 20–26