The Empirical Econometrics and Quantitative Economics Letters
Volume 4, Number 2, (June 2015): pp. 17 – 30.
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Analysis of rice production and contributions to Cambodian economic growth

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ABSTRACT

This study uses ARDL model to analyze time series data over the period of 50 years (1961 - 2010) in order to examine the factors that could affect rice production in Cambodia. We find that seeds, fertilizer, machinery, irrigation area and harvested area have a significant and positive impact on rice production in Cambodia. It also uses ARDL model to analyze time series data over the period of 15 years (1996 - 2011) to investigate the rice export contributions to Cambodian GDP growth. The results indicate that rice export has a significant and negative effect on Cambodian GDP growth. The study also employs ARIMA model to analyze time series data over the period of (1960 - 2013) to examine the best ARIMA model that can be used to forecast rice production in Cambodia from 1960 to 2013. We find that the ARIMA (1, 1, 1) is the best model for forecasting rice production. This may suggest that Cambodian government should design a strategy that assists credit on machinery, seeds and fertilizers to farmers in order to increase rice production and promote rice export. Government also needs to pay close attention to make an investment strategy that stimulate rice production in Cambodia.

Keywords: GDP growth, Rice Production, ARIMA model, ARDL model, Cambodia
JEL Classification: Q12, C22, O41

1. Introduction

Rice, which contributes the staple food for nearly one-half of the world's population, is important to the economy of many developing countries. In 2012, 85 percent of Cambodia's cultivated land was contributed to rice production (MAFF, 2012). Agricultural is the second largest sector of the Cambodian economy, accounting for 36 percent of real gross domestic product (GDP), the industry sector has contributed 24 percent and service sector 40 percent of real GDP in 2013 (World Bank, 2013). Rice is the most significant crop in term of production. It also employs the population in remote area and provides the major source of income in remote areas (Thomas, 2013). Approximately 80 percent of the Cambodian population relies on agriculture, especially rice production for their livelihoods and unsurprisingly the huge majority of those are living on less than $1.25 a day (Thomas, 2013).

Cambodia is seen as a low income country, rice is the staple food for households and the most important crop, considering food security. FAO (1994) estimates that rice represents 75 percent of nutrition intake on average, with per capita consumption needs estimated at 151 kg of white rice or 250 kg of paddy, or 1.4 tonnes per average household annually (MAFF, 1996). Rice is planted in both the wet and dry seasons in Cambodia. Wet-season rice is planted in July or August and harvested in December or January and contribute for 86 percent of the total rice area in 2007 (MAFF, 2013). According to (Young et al., (2001), the area under early wet season is estimated to be approximately 2,241,114 hectares in 2007. Dry season rice is planted under conditions mainly during January or February to May or June (Dawe, 2009). However, these planting periods are not clearly limited due to diversity of farmer practice of staggered planning (Javier, 1997). In 2007, rice area in the dry season was approximately 344,791 hectares or about 14 percent of the total rice area (MAFF, 2009). The yield of dry season rice in 2007 was 3.96 tonnes per hectare or 64 percent higher than that of wet season rice (2.41 tonnes per hectare) (Dawe, 2009).

The Cambodian government is targeting to increase rice exports to 1 million tons by 2015, and is investing in rice processing facilities and providing credit to farmers. Such measures to help rice exports in 2012 that were hurt due to lack of buying by traditional buyer Vietnam in the face of increased supply of rice in the international market (Yang, 2013). Domestic consumption for rice per capita was about 143 kg/year and demand per annum was about 2.11 million tons with the population growth per annum was about 1.5% and surplus paddy rice was about 4.34 million tons in 2012 (Yang, 2013). Moreover, Cambodian government has considered agricultural sector as the main economic strategies to reduce rural poverty and increase farmer incomes. Farmer and government have to work together in order to raise food production and also to help increase the income of farmers.

After civil war for two decades, the Cambodian economy has grown at an average rate of 7.8 percent per year from 1994 to 2010 (Annual development review, 2012). Cambodian economy has been driven by four sectors which are garments and footwear, hotels and restaurants, construction, and agriculture. Agricultural sector is known as the lowest growth among those four sectors, at an average 5 percent per year. Agricultural growth has mainly been based on the expanded use of inputs as against intensive improvement in productivity (Chandararot and Liv, 2013). Agriculture is a key to reduce poverty and eradicating hunger in Cambodia (FAO, 2013). Cambodia is rich in natural resources including land and water, favorable climatic conditions and geographic position, which represent potential comparative advantages for increased agricultural production and livelihood improvements (FAO, 2013).

Despite agricultural sector plays a crucial role in developing Cambodian economy, the country encounters with many challenges and constraints that can be an obstacle of taking full advantage of the new opportunity. The difficulties of Cambodian farmer include the lack of access inputs (e.g., labors, fertilizers, machineries, and seeds) and credit, deficiency of public services in marketing, less support from the government in term of investment and infrastructure in rural area. The huge majority of poor rice farmers is lack of capital. Due to insufficiency of capital or access to affordable line of credit, poor rice farmers could not find it virtually impossible to move beyond subsistence to producing a marketable surplus (Thomas, 2013).

This study will analyze how the Cambodian rice production can contribute to economic growth, forecast rice production for farmers and government planning, and increase rice output in responding to high prices in order to boost the income and well-being of farmers.

2. Literature review

Many academic studies have investigated the factors that impacted on rice product and economic growth as well as forecasting the rice production in the period of time by using a variety of both classical multivariate regression and advanced modern econometric approaches, such as VAR model, ARMAX model, autoregressive distributed lag model, co-integration test, error correction model, advanced time-series models (seasonal ARIMA and conditional volatility models), time-series fussy, and stochastic frontier model (methods of efficiency measurement and data envelopment analysis).

The Cobb-Douglas function form of production is widely used to represent the relationship of an output to inputs. It was proposed by Knut Wicksell (1851 - 1926) and tested against statistical evidence by Charles Cobb and Paul Douglas in 1928 (Coelli, Rao and Battese, 1997). For instance, Yu and Fan (2009) has studied on rice production responses in Cambodia and Prasanna, Kumar and Singh (2009) have conducted research in the topic of rice production in India – implication of land inequity and market imperfections. At the same time, Fatoba, Omotesho and Adewumi (2009) have studied in the topic of economic of wetland rice production technology in the Guinea Savannah of Nigeria. Sachchamarga and Williams (2004) have also studied on economic factors affecting rice production in Thailand. Hussain et al. (1999) have conducted research on rice and wheat production in Pakistan with effective Microorganisms and Fulginiti and Perrin (1998) have studied on agricultural productivity in developing countries. Similarly, Frisvold and Ingran (1994) has conducted a research in sources of agricultural productivity growth and stagnation in Sub-Saharan Africa.

In addition, the contribution of agricultural exports to economic growth model is used to analyze the impact of agricultural export on economic growth. For example, Cao and Birchenall (2013) have conducted research in agricultural productivity, structural change, and economic growth in post-reform China and Anthony (2010) has studied on agricultural credit and economic growth in Nigeria: an empirical analysis. Gilbert, Linyong and Divine (2013) have examined on the impact of agricultural export on economic growth in Cameroon: Case of Banana, Coffee and Cocoa. Sanjuang Lopez and Dawson (2010) have conducted research in contribution of agricultural exports to economic growth in developing countries. Dawson (2005) has studied on the contribution of agricultural export to economic growth in less developed countries. Aurangzeb (2006) has employed the economic growth model on the relationship between economic growth and exports in Pakistan.

The Autoregressive Integrated Moving Average Model (ARIMA) was developed by Box and Jenkins. ARIMA is the most general class of models for forecasting a time series. For instance, Aliet. al (2013) have employed ARIMA model in forecasting production of food grain using ARIMA Model and its requirement in Bangladesh. Biswas and Bhattacharyya (2013) has also conducted research using ARIMA model to forecast area and production of rice in West Bengal and Akter (2013) conducted research in forecasting of rice production in Bangladesh. Iqbal, et al. (2005) has studied on the way of using the ARIMA Model for forecasting wheat area and production in Pakistan. Sivapathasundaram and Bogahawatte (2012) have employed the ARIMA Model for forecasting of paddy production in Sri Lanka: a time series analysis. Badmus and Ariya (2011) have also conducted a research using ARIMA Model for forecasting cultivated area and production of maize in Nigerian. Awal and Siddique (2011) has employed ARIMA Model to study on rice Production in Bangladesh.

3. Methodology

In this study, a typical Cobb-Douglas functional form is used to estimate the rice production function in Cambodia. The contribution of agricultural exports to economic growth model mainly based on Cobb-Douglas production is used to analyze the impact of agricultural export on economic growth. Autoregressive Integrated Moving Average (ARIMA) (p, d, q) method is employed to forecast annually rice production in Cambodia during the time periods 2014-2019.

More specifically, the Cobb-Douglas production function is used to represent the rice production for Cambodian farmers can be written as:

$$Y = a_0 HA^{\alpha 1} SE^{\alpha 2} MA^{\alpha 3} FE^{\alpha 4} IR^{\alpha 5}$$

Taking natural logarithm,

$$LnY_t = a_0 + a_1 LnHA_t + a_2 LnSE_t + a_3 LnMA_t + a_4 LnFE_t + a_5 LnIR_t + U_t$$

Where, Y_t is rice production output; HA_t rice harvested area; SE_t is seed use; MA_t is machinery use (tractors); FE_t is fertilizer use; IR_t is irrigated agricultural area. Irrigated agricultural area is proxy to be rice irrigated area.

In order to achieve research objectives, this work obtained inspiration from the model used by Muhammad Zahir Faridi (2010). He established an econometric model based on a generalized Cobb Douglas production function. The study develops the same theoretical model based on the contribution of rice export to economic growth in Cambodia with the case in point being rice export.

$$Y_t = A_t (EXP_t^{\alpha} LAB_t^{\beta} GFC_t^{\lambda})$$

Taking natural logarithm,

$$LnRGDP_t = LnA_t + aLnEXP_t + \beta LnLAB_t + \lambda LnGFC_t + U_t$$

where α, β and λ are parameters to be estimated.

To estimate the effect of rice export on economic growth in Cambodia, the study specifies the following model which is just a slight modification of equation

$$LnRGDP_t = \beta_0 + \beta_1 LnEXP_t + \beta_2 LnLAB_t + \beta_3 LnGFC_t + U_t$$

In this study, Autoregressive Distributed Lag (ARDL) was proposed by Pesaran (Pesaran and shin, 1995), is introduced to examine rice production and rice export contributions to economic growth in Cambodia. Many current studies have demonstrated that the ARDL approach to co-integration is mostly used to estimate long-run and also short run relationship. Since all variables are confirmed to be stationary, ARDL is used to estimate the long-run and short run relationship. The ARDL model can be written as:

$$\Delta Y_{t,j}^{P} = \alpha_0 + \Sigma_{i=1}^{n_1}\alpha_{1i,j}\Delta Y_{t-i,j} + \Sigma_{i=0}^{n_2}\alpha_{2i,j}\Delta HV_{t-i,j} + \Sigma_{i=0}^{n_3}\alpha_{3i,j}\Delta SD_{t-i,j} + \Sigma_{i=0}^{n_4}\alpha_{4i,j}\Delta MA_{t-i,j}$$
$$+ \Sigma_{i=0}^{n_5}\alpha_{5i,j}\Delta FE_{t-i,j} + \Sigma_{i=0}^{n_6}\alpha_{6i,j}\Delta IR_{t-i,j} + \alpha_7 Y_{t-1,j} + \alpha_8 HV_{t-1,j} + \alpha_9 SD_{t-1,j} + \alpha_{10} MA_{t-1,j}$$
$$+ \alpha_{11} FE_{t-1,j} + \alpha_{12} IR_{t-1,j} + U_t$$

where, time t is during 1961-2010; i is number of lag; j is rice as commodity.

$$\Delta Y_{t,j}^{G} = \alpha_0 + \Sigma_{i=1}^{n_1}\alpha_{1i,j}\Delta Y_{t-i,j} + \Sigma_{i=0}^{n_2}\alpha_{2i,j}\Delta EXP_{t-i,j} + \Sigma_{i=0}^{n_3}\alpha_{3i,j}\Delta LAB_{t-i,j}$$
$$+ \Sigma_{i=0}^{n_4}\alpha_{4i,j}\Delta GFC_{t-i,j} + \alpha_5 Y_{t-1,j} + \alpha_6 EXP_{t-1,j} + \alpha_7 LAB_{t-1,j} + \alpha_8 GFC_{t-1,j} + U_t$$

where, time t is during 1996-2011; i is number of lag; j is rice as commodity.

In order to analyze the outcomes, F-test is used to test the existence of long-run relationship for all variables between dependent variable and independent variables. To test whether there is any existence of long-run relationship, two step tests need to be calculated. The first step consist of estimating the equation in level form I(0), while the second step consists of testing the stationarity of the residual I(1). The hypothesis can be written as:

H_0 : has not the long run relationship or co-integration among the variables

H_1 : has the long-run relationship or co-integration among the variables

In order to determine the results whether there is reject or accept null hypothesis, there conclusion can be derived from F-test results. If the calculated F-statistics is statistically significant, mean null hypothesis is rejected. There is a long-run relationship among the variables. However, the result is inclusive when the value of computed F-test falls between the lower and upper bound critical values.

Once the variables accept the existence of co-integration, then the conventional Vector Error Correction Model (VECM) is applied using OLS, in order to confirm the short run relationship effect speed of adjustment between dependent variable and independent variables within bounds testing approach. Therefore the VECM method can be written as:

$$\Delta Y_{t,j}^{P} = \beta_0 + \Sigma_{i=1}^{k_1}\beta_{1i,j}\Delta Y_{t-i,j} + \Sigma_{i=0}^{k_2}\beta_{2i,j}\Delta HV_{t-i,j} + \Sigma_{i=0}^{k_3}\beta_{3i,j}\Delta SD_{t-i,j} + \Sigma_{i=0}^{k_4}\beta_{4i,j}\Delta MA_{t-1,j}$$
$$+ \Sigma_{i=0}^{k_5}\beta_{5i,j}\Delta FE_{t-i,j} + \Sigma_{i=0}^{k_6}\beta_{6i,j}\Delta IR_{t-i,j} + \lambda EC_{t-1,j} + \mu_t$$

$$\Delta Y_{t,j}^{G} = \beta_0 + \Sigma_{i=1}^{k_1}\beta_{1i,j}\Delta Y_{t-i,j} + \Sigma_{i=0}^{k_2}\beta_{2i,j}\Delta HV_{t-i,j} + \Sigma_{i=0}^{k_3}\beta_{3i,j}\Delta SD_{t-i,j} + \Sigma_{i=0}^{k_4}\beta_{4i,j}\Delta MA_{t-1,j}$$
$$+ \Sigma_{i=0}^{k_5}\beta_{5i,j}\Delta FE_{t-i,j} + \Sigma_{i=0}^{k_6}\beta_{6i,j}\Delta IR_{t-i,j} + \lambda EC_{t-1,j} + \mu_t$$

The speed of adjustment is determined by estimating the value of λ. It is known as coefficient of adjustment and usually statistically negative sign. It can explain the economic adjustment to be recovered in the short run period if any shock would be occurred. It also provides vital information about economic recovery to long-run as equilibrium and the steady state.

Autoregressive Integrated Moving Average (ARIMA) (p, d, q) method is employed to forecast annually rice production in Cambodia during the time periods 2014-2018. The Box-Jenkins (1976) can be used for a non-seasonal series in order to forecast rice production based on time series in Cambodia. According to (Box and Jenkins, 1970), the Box-Jenkins approaches consist of three steps, identification, estimation, and diagnostic checking. These steps can be explained in detail as the following:

Identification of the model for ARIMA (p,d,q) is based on the concept of using the techniques for determining the value of p, d and q. These values are defined by using autocorrelation function (ACF) and partial autocorrelation function (PACF) (Biswas and Bhattacharyya, 2013). In order to determine whether the series is stationary or not we could be considered the graph of ACF. If a graph of ACF cuts of falling quickly, then the time series value could be considered stationary. Here is p represents the order of the autoregressive part, d represents the amount average of difference and q represents the order of the moving average part. If the original series is stationary, d=0 and the ARIMA models become to the ARMA models (Badmus and Ariyo, 2011).

The difference linear operator (Δ), can be written as:

$$\Delta Y_t = Y_t - Y_{t-1} = Y_t = BY_t = (1-B)Y_t$$

The stationary series:

$$W_t = \Delta^d Y_t = (1-B)^d Y_t = \mu + \theta_q(B)\varepsilon_t$$

Estimation of the appropriate values of p, d and q in the model and their statistical significance can be determined by t-distribution. A model has minimum values of Root Mean squared error (RMSE), Minimum Absolute Percentage Error (MAPE), Akaike's information criterion (AIC), Schwarz's Bayesian Information criterion (BIC), Mean Absolute error (MAE), Mean squared error (MSE) Q-statistics and high R-square, can be considered as the best model forecasting (Biswas and Bhattacharyya, 2013). The test statistics Q is given in equation:

$$Q_m = n(n+2)\sum_{k-1}^{n} \frac{r_k^2(e)}{n-k} \chi_{m-r}^2$$

where, r_k (e) is the residual autocorrelation at lag k; n is the number of residuals; m is the number of time lags includes in the test.

This step is to check whether the selected model appropriates the data based on ARIMA (p,d,q) model in order to find out if they are white noise. If the residuals are white noise the ACF of residuals and the Ljung and Box (1978) statistic will be applied. These may be determined by Ljung-Box statistic under null hypothesis that autocorrelation co-efficient is equivalent to zero. The best appropriate model for selecting when two or more competing models passing the diagnostic checking can be considered as the following criteria multiple R^2, Adjusted R^2, Root mean squared error (RMSE), Akaike's Information Criterion (AIC), Schwarz's Bayesian Information (BIC), Mean absolute error (MAE) and Mean absolute proportion percent error (MAPPE) (Biswas and Bhattacharyya, 2013).

4. Data

Due to data limitation, data used for this study is secondary data for the period of 1961 to 2010 as most of the variables analyzed were available in the International Rice Research Institute (IRRI), World Food Programme (WFP), Food and Agriculture Organization of the United Nations (FAO), United States Department of Agriculture (USDA), World Trade Organization (WTO), Asian Development Bank (ADB), ASEAN food security information system (AFSIS), CEIC database, Cambodian Development and Research Institute (CDRI) and government reports. Dependent variable is rice output in Cambodia. This variable will be used to achieve three significant purpose of the study.

5. Results and Discussion

5.1 Porter's Diamond Model

Factor Condition: fertilizer is used by most of farmer households in Cambodia, as the report of Cambodia Socio-Economic Survey in 2004 and 2007 (CSES) stated that 77 to 78 percent of wet season and 87 to 94 percent of dry season rice obtained chemical fertilizer. According to CSES data, both average fertilizer price paid by farmers and the quantity of fertilizer used by farmers was low which about 72 percent and 105 kg/ha for wet and dry season rice in 2004, respectively. According to (Yu and Diao, 2012), farmer households on average used 332 kilograms of fertilizer in Vietnam and 135 kilograms in Thailand from 2004 to 2012, which similarly geographical and temperature conditions with Cambodia.

In 2004, irrigation was approximately 11.5 percent of wet season rice and 50 percent of dry season rice area based on CSES 2004 and 2009. Due to the price of fuel had increased and better weather condition caused the shares of irritated area use in total paddy field decreased to 8 percent for wet season rice and 36 percent for dry season rice. Irrigation coverage in Cambodia is lower than Thailand and Vietnam. According to FAO (2014), the irrigation share of total arable land on average of Cambodia, Thailand and Vietnam is approximately 9 percent, 41 percent and 70 percent respectively.

Demand Factor (Domestic Consumption): rice is a staple food in Cambodia, which provides calorie intake to Cambodian households approximately 65% in 2004 (FAO, 2009). According to International Rice Research Institute (2014), Cambodian needs calories intake from rice is higher than neighboring countries (Vietnam, Thailand) Rice provides the huge majority of calories for Cambodian households, Vietnamese households and Thai households on average 1504 Kilocalories per day, 1413 Kilocalories per day and 1190 Kilocalories per day from 2004 to 2009, respectively.

Firm Strategy, Structure and Rivalry: in Cambodia, central government is responsible for registering, designing policy implications to stimulate rice production, and manage companies in rice producing industry. The central government has designed various trade policy tools such as explore export opportunities in regional and global market, and enhance trade facilitation and reduce informal fees and eliminate illegal check points. Presently, Thailand is the world's largest exporter of rice. Thailand is the top among rice exporting countries in both value and volume, wherein rice exports are mainly long-grain and jasmine rice. Rice policies in Thailand have always been pushed domestic consumption and improved production for trade (Tobias, et al. 2012). Rice policies in Vietnam are a balance between maintaining domestic food security and promoting rice export.

Related and Supporting Industries: the local supporting industries in Cambodia remains insufficient, the factor that can facilitate rice industry is very limited. Sum (2008) stated that approximately 50 percent of the roads are made of crushed stone, gravel, or improved earth; and the remaining 30 percent are unimproved earth or little more than tracks. As comparing the situation in Cambodia with neighboring countries like Thailand and Vietnam, infrastructure access in Cambodia is very poor.

The electricity price in Cambodia is very high. As comparing, in Vietnam the rate is at 10 cents. High electricity cost force rice millers to use their own diesel generators, which cost them only 12.60 dollars or 2.2% per tonne of rice, compared to 23.38 dollars or 4.1% per tonne by using electricity.

Government: in order to achieve paddy rice surplus of more than 4 million tonnes and reach the goal of exporting milled rice at least 1 million tonnes in 2015, Cambodian government has launched the policy on paddy rice production and promotion of milled rice export.

Chance: agricultural productivity remain low, with the average rice yield 2.3 tonnes per hectare in Cambodia is about a half of that Vietnam with yield averaging barely 5 tonnes per hectare. Essentially, despite the lower yield and smaller rice area, rice production per capita 4.26 kg rough rice in Cambodia is not far different from Thailand and Vietnam. It means that a high level of rice production per capita has shown the potential for Cambodian rice export. Therefore, rice production in Cambodia has potential to growth depends on technology, better-quality seeds, expansion of dry-season rice, and irrigation system, and fertilizers.

5.2 Rice Production and Rice Export Contributions on Economic Growth in Cambodia

This study examines the order of integration of the variables by ADF-Test (1979) and if all variables are integrated of I(0) and (1) then ARDL would be applied to co-integration for the long run relationship between the dependent variable and the independent variables Pesaran et al. (2001). Since the variables had accepted the long run co-integration, then Error Correction Model (ECM) could be applied for estimating the short-run. F-statistics for testing the existence of the long run relationship among variables.

Table 5**:** F-statistics Bound Testing for Rice Production and Rice Export Contributions on economic growth in Cambodia.

Depend variable (intercept and no trend)	F-statistics	1% Critical value		The number of k
		I(0) Lower bound	I(1) Upper bond	
F_t ($LnPR_t$| $LnFE_t$, $LnHV_t$, $LnIR_t$, $LnMA_t$, $LnSD_t$)	13.165***	2.649	3.805	5
F_t ($LnRGDP_t$| $LnGCF_t$, $LnLAB_t$, $LnEXP_t$)	2.70*	2.649	3.805	3

Source: computed, *=Significant at 10%, **=Significant at 5%, ***=Significant at 1%

The empirical results of the long-run for Cambodian rice production are presented on the Table 6. All variables appeared with both the correct sign and incorrect sign. Precisely, fertilizers, irrigations, machinery (tractors), harvested area, and seed of Cambodia are influential in Cambodian rice production. Consequently, all variables were used in this study impact on the Cambodian rice production during 1961-2010. According to ARDL approach to co-integration, suggested that ln(SDt), ln(HVt), ln(FEt) and ln(MA) have negatively and positively impacted on Cambodian rice production based on the number of lags and ln(IRt) has positively impacted Cambodian rice production. The empirical results imply that in long-run when $\ln(IR_t)$ increases 1% then the Cambodian rice production increases 0.15% and when $\ln(SD_t)$ increases 1% and then the Cambodian rice production increases 1.35% at lag 1 and decreases 0.78% at lag 2. The empirical results also indicate that in long-run when ln(FE) increases 1% then the Cambodian rice production decreases 0.03% at lag 4 and then starts to increase 0.02% at lag 5. Similarly, when $\ln(HV_t)$ increases 1% then the Cambodian rice production decreases 0.38% at lag 1 and then starts to increase 0.29% at lag 2. Furthermore, when ln(MAt) increases 1% then cause Cambodian rice production increases 1.14% at lag 3 and then decreases 1.01 at lag 4.

Table 6: Estimated ARDL long run coefficients for rice production from Pesaran and Shin (2001).

Regressor	Coefficient	t-ratio (p-value)
$LnFE_{t-1}$	-0.008	-0.78
$LnFE_{t-2}$	0.011	1.06
$LnFE_{t-3}$	8.920	0.07
$LnFE_{t-4}$	-0.030	-2.55***
$LnFE_{t-5}$	0.026	2.71***
$LnHV_{t-1}$	-0.382	-1.72*
$LnHV_{t-2}$	0.297	2.36**
$LnIR_{t-1}$	0.152	1.79*
$LnMA_{t-1}$	-0.001	-0.14
$LnMA_{t-2}$	-0.246	-0.50
$LnMA_{t-3}$	1.143	1.73*
$LnMA_{t-4}$	-1.015	-2. 46**
$LnSD_{t-1}$	1.355	9.60***
$LnSD_{t-2}$	-0.781	3.22***

Source: computed, *=Significant at 10%, **=Significant at 5%, ***=Significant at 1%

The empirical results in the short-run revealed that seeds have positively impacted on Cambodian rice production. The results are presented demonstrated that in short-run when seeds increasing 1% then Cambodian rice production increasing 1.1701%. Otherwise, when irrigation increasing 1% then Cambodian rice production decreasing 0.6719% (see Table 7). The lagged error correction term EC_{t-1} is negative and significant at the 1% level. The coefficient of 0.5424 indicated a moderate rate of convergence to equilibrium. The value of adjusted R^2 of ECM model is more than 70%. The value of F-statistics indicated that Cambodian rice production ECM model is fit for a short-run by statistically significant at 1%.

Table 7: Estimated ARDL short run coefficients for rice production from Pesaran and Shin (2001).

Variables	Coefficient
C	0.0428 (0.5244)
$\Delta Ln(FE_t)$	0.0010 (0.1247)
$\Delta Ln(IR_t)$	-0.6719* [a] (-1.8812)
$\Delta Ln(MA_t)$	0.0017 (0.1644)
$\Delta Ln(SD_t)$	1.1701*** [a] (9.7139)

Variables	Coefficient
$\Delta Ln(HV_t)$	0.4554 (0.1673)
EC_{t-1}	-0.5424*** (-2.7743)
R^2	0.7561
$\overline{R}^2$	0.7123
DW.	1.7646
F-statistics	17.2720***

Source: computed, a=lag 1 period, * = Significant at 10%, ** = Significant at 5%, *** = Significant at 1%

Table 8: Estimated ARDL long run coefficients for rice export contributions on Cambodian economic growth from Pesaran and Shin (2001).

Regressor	Coefficient	t-ratio (p-value)
$LnRGDP_{t-1}$	0.966	32.21***
$LnGFC_{t-1}$	0.055	1.51*
$LnEXP_{t-1}$	-0.017	-1.56*
$LnLAB_{t-1}$	-0.006	-1.82*

Source: computed, *=Significant at 10%, **=Significant at 5%, ***=Significant at 1%

The empirical results of the long-run for Cambodian rice export contributions on economic growth are presented on the Table 8. All variables appeared with both the correct sign and incorrect sign. Precisely, gross fixed capital, rice export and agricultural labor force of Cambodia are influential in Cambodian economic growth. Consequently, all variables were used in this study impact on the Cambodian economic growth during 1995-2011. According to ARDL approach to co-integration, suggested that $\ln(LAB_t)$ and $\ln(EXP_t)$ have negatively impacted on Cambodian economic growth. On the other hand, $\ln(GFC_t)$ has positively impacted on economic growth. The empirical results imply that in long-run when $\ln(GFC_t)$ increases 1% then the Cambodian real GDP growth 0.05%. In contrast, when $\ln(EXP_t)$ and $\ln(LAB_t)$ increases 1% and then the Cambodian real GDP growth decreases 0.01% and 0.006% respectively.

Table 9: Estimated ARDL long run coefficients for rice export contributions on Cambodian economic growth from Pesaran and Shin (2001).

Variables	Coefficient
$\Delta Ln(EXP_t)$	-0.0204** [a] (-2.4976)
$\Delta Ln(GFC_t)$	0.0789 (1.1328)
$\Delta Ln(LAB_t)$	0.0006 (0.1690)
EC_{t-1}	-1.17*** [a] (-2.0372)
R^2	0.60
$\bar{R}^2$	0.40
DW.	2.3157

Source: computed, a=lag 1 period, * = Significant at 10%, ** = Significant at 5%, *** = Significant at 1%

The empirical results in the short-run revealed that rice export has positively impacted on Cambodian real GDP growth. The results demonstrated that in short-run when rice export increasing 1% then Cambodian real GDP growth decreases 0.02%. The lagged error correction term EC_{t-1} is negative and significant at the 1% level. The coefficient of 1.17% indicated a moderate rate of convergence to equilibrium.

5.3 Rice Production Forecasting

Four ARIMA models were used to select the best model which has the minimum AIC (Akaike's Information Criterion) and BIC (Bayesian Information Criterion) and maximum values of R^2 and $\bar{R}^2$. They are ARIMA (1, 1, 1), ARIMA (1, 1, 2), ARIMA (2, 1, 1), and ARIMA (2, 1, 2).

Table 10: Comparison of different ARIMA models with model fit statistics for rice production

Model	Value of selection criteria			
	AIC	BIC	R^2	$\bar{R}^2$
ARIMA (1, 1, 1)	**28.32**	**28.43**	**0.91**	**0.91**
ARIMA (1, 1, 2)	28.34	28.49	0.91	0.91
ARIMA (2, 1, 1)	28.36	28.51	0.91	0.91
ARIMA (2, 1, 2)	28.39	28.58	0.91	0.90

Source: computed.

Table 11**:** Estimated Results of Rice Production from ARIMA (1, 1, 1)

Variable	**Coefficient**	**SD**	**t-ratio (P-value)**
AR (1)	1.0421	0.0350	29.7139***
MA (1)	-0.2774	0.1434	-1.9159*
R^2	0.91		

Source: computed, * = Significant at 10%, ** = Significant at 5%, *** = Significant at 1%

Based on the results of time series of rice production, it is indicated that ARIMA (1, 1, 1) is the best fitted model. The estimated parameters of mathematical model can be written as follows:

$$Z_t = 1.042105 Z_{t-1} + \varepsilon_t - 0.274874 \varepsilon_{t-1}$$

6. Conclusions

The study aims to investigate the situation of rice production in Cambodia, estimate and forecast rice production in Cambodia and evaluate the contribution of rice production and export to economic growth. Rice industry in Cambodia is the major issue need to be debated. Rice is the staple food for Cambodian people and significant to the economic growth in Cambodia. In 2012, 85 percent of Cambodia's cultivated land was accounted for rice production. Presently, agricultural is considered to be the second largest sector of the Cambodian economy, accounting for 36 percent of real gross domestic product (GDP), the industry sector has contributed 24 percent and service sector 40 percent based on World Bank statistics. Rice is the most fundamental crop in term of production in Cambodia. It also creates job for population essentially who live in remote area and provides the major source of income. Therefore, it is clear that Cambodian government needs to work closely with farmer households in order to improve productivity of rice sector. As noticed throughout the study, rice yields growth rate of wet season rice and dry season rice remain slow, approximately 2.56 percent and 2.75 percent respectively. This is essentially crucial from the overview of poverty reduction. According to the results of the study on rice production, the enhancement of rice productivity clearly relies on the improvement of seed qualities and increased access to irrigation system. As a matter of fact, access to high quality seed and inputs are very limited among famer households, lack of research and development institutions to improve efficiency of rice production and markets' information in Cambodia become major constraints for farmers.

With the increase in per capita rice production over time, Cambodia had moved from rice deficit to surplus since 2001 and emerged as an exporter again in 2002. The private sector played an important role in promoting rice export, especially firms that have a well-recognized potential for pure, high quality of local fragrant rice such as Somaly and Neang Malis, and have improved the private means, through varietal selection, private extension service, and development of marketing strategy. The rise in rice production pushed economic growth and created new opportunities to become a fundamental exporting country.

ACKNOWLEDGMENT

We would like to thanks Associate Professor Dr. Prapatchon Jariyapan and Lecturer Dr. Nattamon Teerakul from the Faculty of Economics, Chiang Mai University from their valuable comments on this study.

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