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FORECASTING PRODUCTION AND EXPORT OF THAILAND'S DURIAN FRUIT: AN EMPIRICAL STUDY USING THE BOX–JENKINS APPROACH

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ABSTRACT

This research aims to forecast the production and export of Thailand's durian fruit using the Box–Jenkins procedure. The export of Thailand's durian focuses on the Chinese market and the world market. The monthly time series from January 2005 to June 2020 is modeled using a seasonal autoregressive integrated moving average (SARIMA). The empirical results revealed that the models of $SARIMA(2,1,1)(0,1,1)_{12}$, $SARIMA(2,1,1)(0,1,0)_{12}$, and $SARIMA(4,1,1)(0,1,0)_{12}$ were selected as the most suitable models to forecast the durian production of Thailand, durian export to the Chinese market, and durian export to the world market, respectively. The findings indicated that the durian production of Thailand will increase by 2.419% in the second half of 2020, and by 13.480% in 2021. This is in line with the forecasts for durian exports to the Chinese and world markets that predict growth in the second half of 2020 by 43.398% and 0.542%, respectively, and in 2021 by 31.299% and 6.023%, respectively.

Contribution/Originality: Thailand is a significant durian producer and exporter to the world market. This study is one of the very few studies that have investigated the seasonal forecasting of Thailand's durian production and export using the Box–Jenkins procedure, also known as SARIMA(p,d,q)(P,D,Q)s.

1. INTRODUCTION

The durian is a significant fruit crop in the Thai agricultural economy due to the fact that Thailand has a suitable climate and excellent soil for optimum durian growth. Thus, Thailand has become an important producer and exporter, and has established an industry valued at more than a hundred thousand million baht, which can be calculated as more than a million tons of the product in 2019. The most appropriate areas for planting durians are in the eastern and southern regions of Thailand, including Rayong, Chanthaburi, Chumphon, Surat Thani, Nakhon Si Thammarat. Currently, the durian planting areas have expanded in every region by a million rai (6.25 rai = 1 hectare), because durian is an economic cash crop greatly enhancing the income of farmers; moreover, the government and private sectors also have policies to promote and support durian planting together with favoring durian consumption, which is increasing in both the Thai and international markets. Its growing popularity has resulted in the increasing cost of durian in recent years; durian prices between 2010 and 2019 increased by an average of 14.565% per year. Meanwhile, the overall index of agricultural product prices during the period 2010 to 2019 decreased consistently by 1.715% per year (Office of Agricultural Economics, 2020a; Office of Agricultural Economics, 2020b). Therefore, farmers increasingly prefer to plant durian instead of crops that provide lower

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returns. Additionally, the durian prices at present are good and are predicted to increase continuously due to growing domestic and international demand, providing stability and sustainability of income generation to farmers who plant durian in Thailand. To develop competition in durian production for export, the Ministry of Agriculture and Cooperatives of Thailand has policies to promote durian plantations in suitable areas and promote a modern large scale farming project to meet good agricultural practice (GAP) standards in order to reduce production costs and to provide quality products that meet market demand. In addition, Thailand has strategies for durian development, such as production management, marketing, research and development, agricultural organization development, and database system development, along with driving the strategy for developing durian production with an emphasis on quality and safety. This has resulted in Thailand becoming a significant durian producer and exporter to the world market. China is a big importer of Thai durians, calculated at 57.248% of the total exports of durian from Thailand. According to the Office of Agricultural Economics Report for 2019, Thailand's durian exports to the world market were valued at 51,187 million baht, calculated as 655,362 tons of exported weight, and China is the primary importer of Thai exported durians valued at 26,345 million baht, calculated as 375,184 tons of exported weight. The most competitive countries in the durian market are Indonesia, Vietnam, Malaysia, the Philippines, and Australia (Office of Agricultural Economics, 2020a; Office of the Permanent Secretary, 2020).

Over the past century, international trade has played an important and significant role in the economic growth of Thailand. The value of the gross domestic product at market price in 2019 showed an increase of up to 89.212%. However, the Covid-19 pandemic affected all economic systems, especially international trade. During the first half of 2020, it was discovered that the value of exported goods and products from Thailand decreased, and the value of exported goods and products decreased from 3,884 billion baht in 2019 to 3,562 billion baht in 2020, calculated as a drop of 8.293%. Although the overall exported goods and products from Thailand reduced as a result of the pandemic, the value and the quantity of exported durian increased. According to a report by the Ministry of Commerce for the period January 2020 to June 2020, it was found that Thailand exported durians to the world market valued at 32,732 million baht, calculated as 202,542 tons of exported weight, which was an increase of 144.919% and 51.211% respectively when compared with the same period in previous years (Office of Agricultural Economics, 2020a; Office of the Permanent Secretary, 2020).

Durian exports have grown steadily over the past several years, caused by rising domestic and global demands, especially in the Chinese market. As a result, farmers in the country have changed their growing behavior to produce more durian than what had been grown in the past, as the durian was previously only planted in eastern and some parts of southern regions. Therefore, continuing to expand the durian plantation areas without properly studying the demand and supply of durian may cause a price slump caused by oversupply, as Thailand experienced in the case of para rubber. This research aims to forecast the quantity of production and export of Thailand by emphasizing Thai durian exports to the Chinese and world markets. Although durian is one of the most important agricultural export products in Thailand, no study has ever been able to forecast production and export of durian at the same time to show the trend of Thai durian demand and supply as a supported guideline for managing plans of durian production throughout the supply chain. The result of this research would be of benefit to farmers who plant the durians, the entrepreneurs who collect and export Thai durians, as well as the government and private sectors in order to plan durian production, to those who produce business plans for durian export, or to use as information to plan the policies promoting and supporting the development of durian production throughout the supply chain in Thailand. Furthermore, it also supports the needs for durian consumption in the domestic and international markets. The remainder of this research is organized as follows: section 2 presents the literature review, section 3 explains the research methodology used based on the econometric techniques consisting of a stationary test using the ADF unit root, and a forecasting model using the Box–Jenkins procedure, also known as an autoregressive integrated moving average (ARIMA). The empirical results for the data analysis are displayed in section 4, and the conclusion and policy-implications are explained in section 5.

2. LITERATURE REVIEW

Forecasting durian production and durian export quantities are significant to the administration of durian supply and demand in the country in order to provide a suitable equilibrium, however, from documentary studies, it was found that not many researchers have studied this issue. Pokterng and Kengpol (2010) have forecast the production of fresh Thai durians by using time series models, as well as artificial neural networks (ANNs); as a result, it was found that the forecast model using ANNs was the most suitable for highest forecasting when considering the statistics of mean absolute percentage error (MAPE), which has the lowest error level. Meanwhile, Udomsri, Kengpol, Ishii, and Shimada (2011) have forecast the durian export demand of four types of products: fresh durian, frozen durian, durian paste, and durian chips, by using the methods of time series models, regression analysis, and ANNs. The results found that this forecasting model was the most suitable for fresh durian, frozen durian, and durian paste, while the forecasting model using ANNs was the most suitable for durian chips when taking the MAPE statistics into consideration.

However, from the relevant literature and research, it was found that there are many researchers who have studied the forecast of production quantity and agricultural goods and products for export. To illustrate this, the study by Jatuporn and Sukprasert (2016) forecast the quantity of Thai rubber production and export by using a regression model with trend and seasonal dummies, exponential smoothing, and ARIMA; as a result, it was found that the forecasting model using a regression model with trend and seasonal dummies was the most suitable for forecasting the quantity of Thai rubber production and export when considering the statistics of root mean square error (RMSE). Furthermore, Jatuporn and Sukprasert (2016) have analyzed the performance of forecasting models comparing actual value and forecast value by using a correlation coefficient. Similarly, Pannakkong, Huynh, and Sriboonchitta (2016) have forecast the quantity of Thai cassava starch exports by using ARIMA and ANNs methods; as a result, it was discovered that the forecasting model using the ANNs method was the most suitable when considering the mean squared error (MSE), mean absolute error (MAE), and mean absolute percentage error (MAPE). According to the study by Co and Boosarawongse (2007), they have forecast the quantity of Thai rice exports by using an exponential smoothing technique, ARIMA, and ANNs; as a result, it was shown that the ANNs method was the most suitable for forecasting when considering the statistics of MAE, MAPE, MSE, and RMSE. The study by Masood, Raza, and Abid (2018) forecast wheat production in Pakistan by using the forecasting techniques of linear, quadratic, exponential, s-curve, double exponential smoothing, single exponential smoothing, moving average, and ARIMA; it was shown that the forecasting model using the ARIMA method was the most suitable for forecasting. Similar to Iqbal, Bakhsh, Maqbool, and Ahmad (2005), they also used the ARIMA model to forecast wheat production in Pakistan. In addition, a study by Nath, Dhakre, and Bhattacharya (2019) forecast annual wheat production in India from 2018 to 2027 using the ARIMA(1,1,0) method.

Like the forecasting techniques mentioned previously, the ARIMA procedure was considered to formulate the forecasting model in this empirical research, as several studies were found to have applied the ARIMA method in various fields, such as Wang, Li, Li, and Ma (2018) who forecast monthly shell gas production in the U.S. using a hybrid ARIMA and metabolic nonlinear grey methods. The findings of Wang et al. (2018) showed that the applied hybrid of MNGM–ARIMA model was the most appropriate to forecast shale gas and other fuel production in the U.S. using the criterion of the lowest MAPE. Mgaya (2019) predicted the demand for livestock product consumption in Tanzania, which included eggs, milk, chicken, and beef. The ARIMA model was employed consisting of model identification using autocorrection function (ACF) and partial autocorrelation function (PACF), parameter estimation using the least-squares (LS) approach, and model validation using the Schwarz information criterion (SIC) and the plot of ACF residuals. Sahinli (2020) has projected consumer price of the potato market in Turkey on a monthly basis using the Holt–Winters multiplicative, the Holt–Winters additive, and the ARIMA approach. The most fitting model selection showed that the Box–Jenkins technique of ARIMA(1,1,2) based on the lowest values of MAE, MAPE, and RMSE was the most appropriate forecasting method to project the Turkish

potato price from August 2019 to December 2019. Moreover, Lai and Dzombak (2020) employed the ARIMA model to forecast short-term regional temperature and precipitation, as well as Pakrooh and Pishbahar (2019) who forecast air pollution concentrations in Iran by applying the various hybrid ARIMA methods.

3. RESEARCH METHODOLOGY

3.1. Data and Variables

The data used in this research is a monthly time series from January 2005 to June 2020; 186 months in total. The defined variables are: the quantity of Thai durian production (unit = metric ton) or P_{TH} variable, using data from the Office of Agricultural Economics; the quantity of Thai durian exported to the Chinese market (unit = metric ton) or EX_{CN} variable, using data from the Ministry of Commerce; and the overall quantity of exported Thai durians (unit = metric ton) or EX_W variable, using data from the Ministry of Commerce.

3.2. Econometrics

In the first step, to analyze the data of the time series, the data stationarity must be tested in order to prevent spurious regression since it would cause an unreliable result (Granger & Newbold, 1974). The study carried out this test by using the Augmented Dickey–Fuller (ADF) unit root from Dickey and Fuller (1979); Dickey and Fuller (1981). If the test found the time series to be non-stationary, it would be added to the order of the first difference; after that, the stationarity test will start testing again until the particular time series actually displays stationarity. Moreover, when the time series contains stationarity at the stage level of the data, it presents that it is a process that I(d) is equivalent to I(0); however, if the difference is added in one order and the stationarity of the data is found, it could be said that it is a process in which I(d) is equivalent to I(1). The model of the stationarity test by using the ADF unit root method can be shown by the following:

$$\Delta Y_t = \beta_1 Y_{t-1} + \sum_{i=1}^{p} \beta_2 \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

$$\Delta Y_t = \alpha_0 + \beta_1 Y_{t-1} + \sum_{i=1}^{p} \beta_2 \Delta Y_{t-i} + \varepsilon_t \quad (2)$$

$$\Delta Y_t = \alpha_0 + \delta T + \beta_1 Y_{t-1} + \sum_{i=1}^{p} \beta_2 \Delta Y_{t-i} + \varepsilon_t \quad (3)$$

where

Δ = Difference in data.

Y = Time series.

α = Constant.

β = Coefficient of the variable.

T = Time trend.

t = Time period.

p = Optimal lag length of time series by considering them from the lowest level of Schwarz criterion statistics.

ε = Error.

The ADF unit root models are based on the conditions of the model without both the constant and time trend for equation 1, the model with only the constant for equation 2, and the model with both the constant and time trend for equation 3.

According to this forecast, the autoregressive integrated moving average, or ARIMA(p,d,q), model from Box–Jenkins (Box, Jenkins, & Reinsel, 1994) was used to forecast the quantities of production and export of Thai durians.

To explain the steps of the ARIMA(p,d,q) forecasting method, it includes four steps: identify the model of preliminary ARIMA(p,d,q), estimate the parameter by using the maximum likelihood (ML) estimator, verify the suitability of the ARIMA(p,d,q) model in order to prevent the problem of serial correlation by using Q_{LB} statistics, and forecast 18 months forward respectively (Gujarati & Porter, 2009). If there is more than one forecasting model, the most suitable one would be chosen, considered by ARIMA(p,d,q) models, which provide the lowest level of Akaike criterion (AC) and Schwarz criterion (SC). At the same time, to analyze the efficiency of an established forecasting model's precision, the correlation coefficient (r) would be used to compare actual value and forecast value. To clarify, the more the correlation coefficient is contained, the more effective the forecasting model is (see (Kulthatpong, Jatuporn, & Toyama, 2019; Lim, Chang, & McAleer, 2009).

However, agricultural products, especially durians, are influenced by the change of the seasons, which becomes a factor in the composition of data. Consequently, it is necessary to consider the effects of the season in the ARIMA(p,d,q) model, or Seasonal ARIMA by using the SARIMA(p,d,q)(P,D,Q)s method, shown below (Box et al., 1994; Makridakis, Wheelwright, & Hyndman, 1998),

$$\phi_p(B)\Phi_P(B^s)(1-B)^d(1-B^s)^D Y_t = \theta_q(B)\Theta_Q(B^s)\varepsilon_t \quad (4)$$

where,

ϕ and θ = Non-seasonal autoregressive (AR) and non-seasonal moving average (MA) parameters, respectively.

Φ and Θ = Seasonal AR (SAR) and seasonal MA (SMA) parameters, respectively.

p and q = Non-seasonal AR and non-seasonal MA lags, respectively.

P and Q = Seasonal AR and seasonal MA lags, respectively.

s = Number for season frequency, which is equivalent to 12.

B = Backward shift operator.

4. EMPIRICAL RESULTS

To forecast the time series data using the Box–Jenkins method, the first step is to identify the preliminary model of SARIMA(p,d,q)(P,D,Q)s, taking it from the stationarity of time series using the ADF unit root as well as the AR(p), MA(q), SAR(P), and SMA(Q) orders using the correlogram. Finally, the result of the time series' stationarity test from the method of the ADF unit root in Table 1 is under the following analytical conditions: the model without both the constant and time trend, the model with only the constant, and the model with both the constant and time trend. According to the result in Table 1, it was found that at a level stage of the time series of P_{TH}, EX_{CN}, and EX_W, these are statistics that cannot reject the null hypothesis (H_0: non-stationarity) in every variable; therefore, the time series at the level stage is non-stationary property. Thus, the first order of difference must be added in order to start testing again with the ADF unit root method. As a result, it was found that the time series of P_{TH}, EX_{CN}, and EX_W contain the statistics which can reject the null hypothesis; in other words, P_{TH}, EX_{CN}, and EX_W time series are stationary at the first order of difference. Next, the stationarity of the season (seasonal unit root) was tested and it was discovered that P_{TH}, EX_{CN}, and EX_W time series contain seasonal stationarity at the first order of difference as well, thereby defining the preliminary model, SARIMA(p,1,q)(P,1,Q)$_{12}$.

To indicate the AR(p), MA(q), SAR(P), and SMA(Q) orders, the correlogram was used. The order of AR(p) and SAR(P) can be seen from the partial autocorrelation function (PACF); additionally, the order of MA(q) and SMA(Q) can be seen from the autocorrelation function (ACF). After that, in order to estimate the parameters, the ML estimator method was used as well as the coefficient used in the forecasting models. Every variable must provide a 0.05 level of statistical significance and must contain the lowest value of AC and SC to state the result of the SARIMA(p,d,q)(P,D,Q)s models, which were the most suitable for P_{TH}, EX_{CN}, and EX_W time series forecasting (SARIMA(2,1,1)(0,1,1)$_{12}$, SARIMA(2,1,1)(0,1,0)$_{12}$, and SARIMA(4,1,1)(0,1,0)$_{12}$ respectively). According to the

aforementioned models, there was no serial correlation problem occurring regarding the Ljung–Box Q statistics in the P_{TH}, EX_{CN}, and EX_W models. Meanwhile, the analysis of the forecasting model performance in Table 2 was considered from the correlation coefficient, which was 88.654% for P_{TH}, 80.090%, for EX_{CN}, and 78.095% for EX_W.

Table 1. The results of the stationarity test using the ADF unit root.

Variable	I(d) = I(0)		I(d) = I(1)		I(D) = I(1)	
	t-statistics	p	t-statistics	p	t-statistics	p
Without α and T						
P_{TH}	0.785	11	-19.252*	10	-8.646*	7
EX_{CN}	3.007	11	-13.210*	10	-10.742*	3
EX_W	1.346	11	-14.224*	10	-9.263*	6
With α and without T						
P_{TH}	0.120	11	-19.236*	10	-8.631*	7
EX_{CN}	2.283	11	-13.600*	10	-10.717*	3
EX_W	-0.454	11	-8.672*	13	-9.226*	6
With α and T						
P_{TH}	-1.084	11	-19.644*	10	-8.594*	7
EX_{CN}	1.158	11	-13.920*	10	-10.745*	3
EX_W	-2.975	11	-8.704*	13	-9.191*	6

Note: * denotes the statistical significance at a 5% level.

The models of the ADF unit root for the stationarity test in Table 1 are based on equations 1-3: (1) the model without both the constant and time trend (without α and T), (2) the model with only the constant (with α and without T), and (3) the model with both the constant and time trend (with α and T), respectively.

Table 2. The results of selected SARIMA(p,d,q)(P,D,Q)s.

Variable	Model: P_{TH}			Model: EX_{CN}			Model: EX_W		
	Coefficient	S.E.	z	Coefficient	S.E.	z	Coefficient	S.E.	z
α	129.085*	27.660	4.667	-	-	-	-	-	-
ϕ_2	-0.229*	0.081	-2.815	-0.235*	0.090	-2.601	-0.195*	0.083	-2.335
ϕ_4	-	-	-	-	-	-	-0.169*	0.084	-2.008
θ_1	-1.000*	0.027	-36.230	-0.881*	0.040	-21.892	-1.000*	0.037	-26.398
Θ_1	-0.494*	0.101	-4.866	-	-	-	-	-	-
Q_4 (p-value)	2.445 (0.118)			1.923 (0.382)			1.416 (0.234)		
Q_8 (p-value)	6.709 (0.243)			3.538 (0.739)			2.193 (0.822)		
AC	3489.568			3220.524			3416.953		
SC	3504.587			3229.536			3428.969		
r (%)	88.654			80.090			78.095		

Note:
* denotes the statistical significance at a 5% level.
r denotes the correlation coefficient.
Q_{LB} denotes the Ljung–Box Q statistics.
AC and SC denote the Akaike criterion and Schwarz criterion.
ϕ, θ, Φ, and Θ denote the estimated parameters of AR(p), MA(q), SAR(P), and SMA(Q) respectively.

5. CONCLUDING REMARKS

The objectives of this study were to forecast the quantity of durian production in Thailand, and the quantities of durian exports from Thailand to the Chinese and world markets by using monthly time series data from January 2005 to June 2020 in order to forecast data until December 2021, 18 months in total. Moreover, the Box–Jenkins method, also known as SARIMA(p,d,q)(P,D,Q)s was used as a forecasting technique containing four processes: identify the preliminary SARIMA(p,d,q)(P,D,Q)s model by using the ADF unit root and correlogram; estimate the parameters by using the maximum likelihood method, mostly emphasizing the coefficients that contain a 0.05 level of statistical significance; verify the suitability of forecasting models in order to prevent the problem of serial correlation by considering the Ljung-Box Q statistics, and choose the most suitable forecasting model; and produce

a forecast for 18 time periods (months). Apart from that, the correlation coefficient was used to analyze the performance of the models, and as a result, it was found that the established forecasting model had a 78.095% - 88.654% forecasting performance. The duration of the Covid-19 pandemic has affected the overall Thai economy, especially the export of goods and products. In the first half of 2020, the growth of Thailand's exports and products has decreased by 8.293%, when compared with the same period last year. However, regarding the quantity and value of durian exports in the first half of the year, figures are likely to increase significantly to 9.495% and 75.735%, respectively. It is noteworthy that Thai durian exports to the Chinese market in the first half of the year have grown at a higher rate than overall exports. The quantity of durian exports grew by 51.211% and the value of durian exports grew by 144.919% (Office of Agricultural Economics, 2020a; Office of the Permanent Secretary, 2020). Furthermore, the level of durian exports in the first half of the year is consistent with the forecast from this research, showing that Thai durian exports in the second half of 2020 are likely to increase. Additionally, Thai exports of durian to the Chinese market in the second half of 2020 will grow by 43.398% compared with the same period last year; while, the overall Thai exports of durian in the second half of 2020 will grow by 0.542% compared with the same period last year. The reason why the overall quantity of Thai durian exports is likely to slow down after the first half of 2020 is that the supply of Thai durian cannot meet the rising demand in the world market; more importantly, it is consistent with the production quantity forecast of Thai durians, which only increased by 2.419% in the second half of 2020 compared with the same period last year. The expansion of production quantity is in accordance with the durian planted areas of Thailand, which are likely to increase by only 1.968% per year on average; this is a calculation of the average durian planting area expansion over the past ten years (Office of Agricultural Economics, 2020a). Nevertheless, the durian planted areas by farmers in Thailand are still growing consistently following the increasing needs of the domestic and international markets, especially in China, which is the most important market for Thailand with an increasing growth rate at present, and has driven an increase in the durian planted areas in all regions in the past few years. The predictions for 2021 estimate that the quantity of durian production in Thailand will increase by 13.480% and the quantity of durians exported from Thailand to the Chinese and the world markets will increase by 31.299% and 6.023%, respectively. Therefore, the recommendations from this research focus on the government and related stakeholders, who should provide policies or implement measures to manage durian demand and supply to suit the needs of the domestic and international markets since it can cause fluctuations in the durian price in the country, and an increase in price could discourage the Thai people from purchasing durian products. Even though the Chinese market has an increasing durian consumption and has imported durian from Thailand in large amounts, at present, many countries have developed the same durian species as Thailand; in other words, they can be significant competitors of Thailand in the future and they can increase durian supply in the world market, which will affect the price of durian. Therefore, there has to prevent any adverse effects impacting the business of durian entrepreneurs as well as the income of durian farmers in Thailand. In addition, the government and related stakeholders should seek new markets in order to support Thai durian production in the future, which is likely to increase, instead of depending on a single major market, such as China.

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