第 48 卷 第 5 期
2021 年 5 月

湖 南 大 学 学 报（自 然 科学版）
Journal of Hunan University（Natural Sciences）

Vol. 48. No. 5.
May 2021

Open Access Article

Forecasting Import Demand for Soybean Meal in Thailand Using Box-Jenkins Method

Korawat Tanong[1], Chalermpon Jatuporn[1,*], Vasu Suvanvihok[1], Nareerut Seerasarn[2]

[1] School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, Thailand

[2] School of Agriculture and Cooperatives, Sukhothai Thammathirat Open University, Nonthaburi, Thailand

Abstract: The objective of this research was to forecast the import demand for soybean meal, which is used in animal feeds, in Thailand using a monthly time series from January 2011 to December 2020 (a total of 120 months). Econometric analysis was employed, which was comprised of: (1) stationary test of the time series using the ADF unit root method; and (2) forecast of the import demand for soybean meal in Thailand using the Box-Jenkins method or SARIMA(p,d,q)(P,D,Q)s model, respectively. The empirical results revealed that: (1) The time series of import demand for soybean meal in Thailand contained non-seasonal and seasonal stationarities at level stage and first differencing order, respectively. (2) The most suitable model to forecast the import demand for soybean meal in Thailand was SARIMA(0,0,1)$(0,1,1)_{12}$ based on the lowest value of AC and SC statistics. (3) The forecasting import demand for soybean meal in Thailand predicted that the volume in 2021 should increase by 1.71% compared to 2020. The government and related stakeholders should further promote and support domestic soybean production to replace imports from abroad.

Keywords: livestock, forage crop, animal feed, time series forecasting, SARIMA.

基於博克·詹金斯方法的泰國豆粕進口需求預測

摘要：這項研究的目的是使用從 2011 年 1 月到 2020 年 12 月的每月時間序列（總共 120 個月）來預測泰國用於動物飼料的豆粕的進口需求。採用計量經濟學分析，包括：（1）使用 ADF 單位根法對時間序列進行固定檢驗；（2）分別使用博克·詹金斯方法或薩里瑪（p，d，q）（P，D，問）s 模型預測泰國豆粕的進口需求。實證結果表明：（1）泰國豆粕進口需求的時間序列分別在水平階段和一階差分階上具有非季節性和季節性平穩性。（2）根據交流電和 SC 統計值的最低值，最適合預測泰國豆粕進口需求的模型是薩里瑪（0,0,1）(0,1,1）12。（3）泰國對豆粕進口需求的預測表明，到 2021 年，豆粕的進口量將比 2020 年增長 1.71%。政府和相關利益攸關方應進一步促進和支持國內大豆生產，以替代國外的進口。

关键词：牲畜，飼料作物，動物飼料，時間序列預測，薩里瑪。

1. Introduction

Today, the production structure of Thailand's economy has transformed from being almost solely reliant on the agricultural sector, now generating more income from the manufacturing and service sectors than ever before. Concerning the agricultural sector in terms of gross domestic product (GDP) percentage in Thailand, we have seen a decrease from 44.70% in 1961 to 6.64% in 2020. However, regardless of the direction that the economy has changed, the agricultural sector remains the country's main production sector, which plays an important role in the country's overall economic development. The agricultural sector is the main food production source,

Received: February 17, 2021 / Revised: March 19, 2021 / Accepted: April 13, 2021 / Published: May 28, 2021

About the authors: Korawat Tanong, Chalermpon Jatuporn, Vasu Suvanvihok, School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, Thailand; Nareerut Seerasarn, School of Agriculture and Cooperatives, Sukhothai Thammathirat Open University, Nonthaburi, Thailand

Corresponding author Chalermpon Jatuporn, Chalermpon.Jat@stou.ac.th, jatuporn.stou@gmail.com

and precursor raw materials must support the industrial and service sectors and provide a source of labor and professional support for many people in the country. The agricultural sector can be classified into five subsectors: crops, livestock, fishery, agricultural services, and forestry [1].

In 2020, Thailand was faced with the Covid-19 pandemic situation, which greatly impacted the overall economy, including the agricultural sector. It has been shown that the livestock sector is the only subsector in the wider agricultural sector that has shown an increase in value-added growth. The livestock sector expanded economic growth by 2.7%, while other sectors in the agricultural sector decreased in terms of growth. For example, the crops sector decreased by 4.7%; the fishery sector decreased by 2.6%; the agricultural services sector decreased by 3.6%; the forestry sector decreased by 0.5% [1]. Regarding the livestock sector, which showed value-added growth expansion, it is due to the production trend of livestock, which is expanding according to the increasing demand for livestock products for domestic and international consumption. For this reason, it has led to the growth of animal feed demand in response to the expansion of livestock production.

The main benefit of raw materials for animal feed being a substitution for packaged animal feed is to help decrease overall animal production costs as the raw materials used to produce animal feed are cheaper. Meanwhile, essential nutrients and minerals for the growth of the animals are still preserved. Raw materials that farmers and entrepreneurs commonly use in the mix for animal feed include fish meal, soybean meal, maize, and broken-milled rice. The reason is that such raw materials help to reduce the production costs of animal feeding compared with using only packaged animal food. Furthermore, raw materials for animal feed are useful and nutritious, making them suitable for animal growth. In terms of the use of raw materials for domestic animal feed in 2019, it was found that maize is the most popular crop for animal feed production with a volume of 8,514,091 tons, followed by soybean meal with a volume of 4,893,087 tons, broken-milled rice with a volume of 1,806,229 tons, and fish meal with a volume of 788,839 tons, respectively [2].

Soybean is an important cash crop for the Thai agricultural sector. It mostly uses in the oil extraction industry (67%), animal feed production (30%), and food processing goods (3%). However, in 2020, to meet almost all of the soybean demand in the country, Thailand had to import approximately four million tons of soybean with an import value equal to 50,493 million Baht while Thailand could only produce about 28,223 tons of soybean or 0.69% of the overall quantity needed in the country [3, 4]. The imported soybeans were mainly from Brazil, the USA, and Canada. Apart from importing soybean for animal feed production, Thailand also imported soybean meal from abroad to use as raw material for animal feed production with a quantity equal to 2,655,594 tons or 31,747 million Baht in value [5]. Hence, soybean in the form of soybean meal plays an important role for the livestock sector to provide the raw material used in animal feed production and response to the expansion of animal production in Thailand.

Forecasting the demand for imported goods is important to manage the domestic demand and supply, especially as raw materials in various industries and household consumption. For example, the study by Jatuporn et al. [6] forecasted the demand for the import of table grapes in Thailand by using a monthly time series from January 2007 to April 2020 with the Box-Jenkins method or SARIMA(p,d,q)(P,D,Q)s model. The results of Jatuporn et al. [6] showed that the best forecasting model or SARIMA(1,1,3)(2,1,0)$_{12}$ had an efficiency of 92.58% concerning forecasting the import demand for table grapes in Thailand. The results coincide with the study of Ratsaminet [7], which forecasted the demand for imported coffee beans in Thailand using a monthly time series from January 2008 to September 2020. This study forecasted the 15 periods leading up to December 2021. The results of Ratsaminet [7] found out that the best forecast model was SARIMA(0,1,2)(0,1,1)$_{12}$. Apart from the forecasting based on the Box-Jenkins method that is well-known for forecasting the import of several agricultural commodities, such forecasting technique is also used to forecast the export of various agricultural commodities. For example, Rueangrit et al. [8] forecasted the export quantity of durians from Thailand to the world market and Chinese market using a monthly time series from January 2005 to June 2020 based on the Box-Jenkins method. The results of Rueangrit et al. [8] revealed that the best forecasting models for durian export quantity from Thailand to the world market and Chinese market were SARIMA(2,1,1)(0,1,1)$_{12}$ and SARIMA(2,1,1)(0,1,1)$_{12}$, respectively, with model efficiencies at 78.10% and 80.09%, respectively. Furthermore, several researchers have applied the Box-Jenkins method to forecast the production, export, and import of agricultural commodities; for example, Co and Boosarawongse [9] forecasted the export of various rice products from Thailand. Badmus and Ariyo [10] forecasted the harvest area and maize production in Nigeria; Paul et al. [11] forecasted the meat export volume from India; Upadhyay [12] forecasted the wood export and import volumes of India; Jatuporn and Sukprasert [13] forecasted para rubber production and export volume of Thailand; Pannakkong et al. [14] forecasted tapioca starch exports from Thailand; Başer et al. [15] forecasted the chestnut production and export volume of Turkey; and Islam et al. [16] forecasted tea production, consumption, and export volume of

Bangladesh.

For this reason, forecasting raw material import volume for animal feed, such as soybean meal, is important for animal feed production in the livestock sector of Thailand, which tends to show dramatic continuous growth. Hence, the main objective of this study is to forecast the import demand for soybean meal using the Box-Jenkins approach, which is a widely-used and well-known forecasting technique because it requires neither complicated nor sophisticated procedures. It is also flexible for application in various situations, such as being applied as a model to seasonality (Seasonal ARIMA), as a model to unforeseen situations (Seasonal with Intervention), etc. The results of this study will be beneficial for entrepreneurs in the animal feed production sector along with governmental and private sectors concerning adopting supply and demand management guidelines for the country's animal feed crops.

2. Materials and Methods

2.1. Data and Variables

Data used in this study were secondary data in the form of a monthly time series from January 2011 to December 2020 (a total of 120 months). Regarding the variable used in forecasting the soybean meal (SBM) import demand in Thailand, volume in terms of kilograms of imported soybean meal in Thailand was used. Data were obtained from Thailand's Office of Agricultural Economics, Ministry of Agriculture and Cooperatives.

2.2. Econometric Methodology

The process of forecasting using the Box-Jenkins method or SARIMA(p,d,q)(P,D,Q)s model consisted of five steps [17, 18], as follows:

Step 1: The stationary test of the time series used the ADF unit root [19, 20]. In other words, it is used to test the stationary time series or the order of integration. Suppose it is found that the time series is a non-stationary time series. In that case, it is necessary to add more differencing orders and continue the test until the time series contains stationarity. The equation used for testing data stationarity using the ADF unit root is displayed below:

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

$$\Delta SBM_t = \alpha_0 + \delta T + \beta_1 SBM_{t-1} + \sum_{i=1}^{p} \beta_2 \Delta SBM_{t-i} + \varepsilon_t \quad (2)$$

where:
SBM is the time series variable
Δ is the differencing order of time series
α is the constant term
T is the time trend
t is period
p is the optimal time lag selection of the autoregressive process or AR(p) starting from 1, 2, 3, …, p, respectively.
β is the estimated coefficient
ε is the error term

Step 2: The identification of a preliminary model is considered from the correlogram by specifying the diction of an autoregressive or AR(p) and seasonal AR or SAR(P) from the correlogram in the part of the Partial Autocorrelation Function (PACF) and specifying the diction of a moving average or MA(q) and seasonal MA or SMA(Q) from the correlogram in the part of the Autocorrelation Function (ACF), respectively.

Step 3: The parameter estimation using the maximum likelihood estimator (MLE) is based on the statistical significance level of 0.05. The equation used in this forecast model is shown below:

$$(1 - \phi_p L)(1 - \Phi_P L^s)(1 - L^d)(1 - L^D) SBM_t = \alpha + (1 - \theta_q L)(1 - \Theta_Q L^s)\varepsilon_t \quad (3)$$

where:
ϕ_p is the estimated coefficient of non-seasonal AR at the p period.
Φ_P is the estimated coefficient of seasonal SAR at the P period.
θ_q is the estimated coefficient of non-seasonal MA at q period.
Θ_Q is the estimated coefficient of seasonal SMA at the Q period.
L is the lag operator.
d is the differencing order of non-seasonal patterns.
D is the differencing order of seasonal patterns.

Step 4: The diagnostic checking of the forecasting model is conducted to prevent autocorrelation using the Ljung-Box statistics (Q-statistic: Q_{LB}). However, if it is found that the SBM time series has SARIMA(p,d,q)(P,D,Q)s more than one model, the most appropriate forecasting model will be chosen through the consideration of the Akaike Criterion (AC) and Schwarz Criterion (SC) statistics with the lowest value.

Step 5: The forecasting of the volume of import demand for soybean meal in Thailand for 12 periods, starting from January to December 2021.

3. Empirical Results

Data used in this study were secondary data in the form of a monthly time series from January 2011 to December 2020 (a total of 120 months). The variable used in forecasting soybean meal (SBM) import demand in Thailand was kilograms of imported soybean meal in Thailand. Data were obtained from Thailand's Office of Agricultural Economics, Ministry of Agriculture and Cooperatives.

Table 1 The results of the ADF unit root

ADF Model	Non-seasonal I(0)		Seasonal I(1)	
	t-ratio	p-value	t-ratio	p-value
With α	-12.519*	<0.001	-9.361*	<0.001
With α & trend	-12.574*	<0.001	-9.418*	<0.001

* The statistical significance level of 0.05

Table 1 displays the results of stationary testing of SBM using the ADF unit root. It was found that at a level stage of non-seasonal I(0) of SBM, the time series would give t-ratio from the model with α (equation 1) and the model with α & Trend (equation 2) equal to (-12.519) and (-12.574), respectively. The statistics show that the variable can reject the null hypothesis (H_0: Non-stationary time series) with a statistical significance level of 0.05. It could be summarized that the SBM time series had an order of non-seasonal stationarity at a level stage or had I(d) equal to I(0). The stationary testing in the seasonal pattern of SBM revealed that the first order of seasonal difference showed the statistical value from the model with α (equation 1) and the model with α & Trend (equation 2) equal to (-9.361) and (-9.418) respectively. The statistics show that the variable can reject the null hypothesis with a statistical significance level of 0.05. Hence, it could be summarized that the SBM time series had seasonal stationarity at the first differencing order or had I(D) equal to I(1). Therefore, the preliminary model of SARIMA(p,d,q)(P,D,Q)s should be SARIMA$(p,0,q)(P,1,Q)_{12}$.

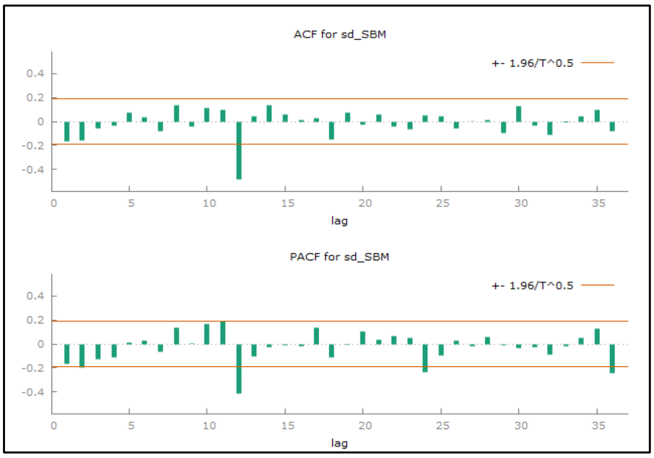

Fig. 1 The correlogram of Δ_{12}SBM

Fig. 1 displays the correlogram of Δ_{12}SBM (sd_SBM), showing that the highest diction of AR(p) has the value of no more than AR(2) and the diction of SAR(P) has the value of no more than SAR(3) while the diction of MA(q) has the value of no more than MA(0) and the diction of SMA(Q) has the value of no more SMA(1). Hence, it could be identified that the preliminary model of SARIMA(p,d,q)(P,D,Q)s to forecast SBM time series should be SARIMA$(2,0,0)(3,1,1)_{12}$.

However, using a correlogram was to determine the model as a preliminary consideration [18]. In other words, the SARIMA$(2,0,0)(3,1,1)_{12}$ was used to estimate the coefficient value by using the highest probability needed to have a statistically significant value of 0.05 without having the issue of the relationship between periods of errors or autocorrelation problem.

Table 2 The results of the estimated SARIMA(p,d,q)(P,D,Q)s model

Variable	Coefficients of SARIMA$(p,d,q)(P,D,Q)_{12}$					
	$(1,0,0)(1,1,0)_{12}$	$(1,0,0)(3,1,0)_{12}$	$(0,0,1)(1,1,0)_{12}$	$(0,0,1)(2,1,0)_{12}$	$(0,0,1)(3,1,0)_{12}$	$(0,0,1)(0,1,1)_{12}$
ϕ_1	-0.190*	-0.189*				
θ_1			-0.253*	-0.265*	-0.223*	-0.221*
Φ_1	-0.578*	-0.883*	-0.571*	-0.770*	-0.875*	
Φ_2		-0.634*		-0.378*	-0.625*	
Φ_3		-0.359*			-0.348*	
Θ_1						-1.000*
Q_6(p-value)	4.293(0.368)	2.842(0.241)	3.065(0.547)	3.850(0.278)	1.815(0.403)	3.065(0.547)
Q_{12}(p-value)	9.367(0.498)	5.526(0.700)	8.124(0.617)	6.876(0.650)	4.396(0.820)	6.639(0.759)
AC	4295.372	4279.161	4294.143	4285.357	4278.488	4273.251
SC	4303.418	4292.571	4302.190	4296.086	4291.899	4281.298

* The statistical significance level of 0.05

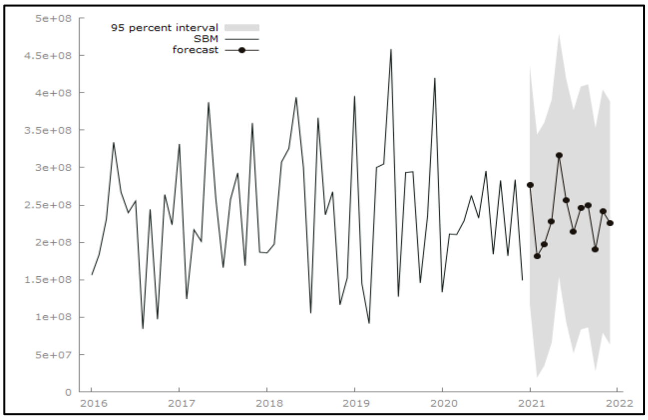

Fig. 2 Monthly forecasting import demand for soybean meal of Thailand in 2021

Table 3 The forecasted value of import demand for soybean meal of Thailand in 2021 (Unit: Kilogram)

The year 2021	**Forecasted value**	**Growth (MoM)**
January	276,980,922	27.09
February	181,513,505	-9.38
March	197,797,898	1.23
April	228,113,894	1.49
May	316,474,699	0.28
June	255,741,307	-4.39
July	214,080,079	-3.50
August	245,869,103	7.11
September	248,913,625	-3.89
October	190,156,063	2.85
November	241,829,308	-0.28
December	225,844,861	4.22
Total (Average)	2,823,315,262	(1.71)

Table 2 displays the results of the estimated coefficient of the SARIMA(p,d,q)(P,D,Q)$_{12}$ model by using the highest probability of SBM time series; this reveals that SARIMA(p,d,q)(P,D,Q)$_{12}$ is appropriate for SBM time series forecasting, consisting of SARIMA(1,0,0)(1,1,0)$_{12}$, SARIMA(1,0,0)(3,1,0)$_{12}$, SARIMA(0,0,1)(1,1,0)$_{12}$, SARIMA(0,0,1)(2,1,0)$_{12}$, SARIMA(0,0,1)(3,1,0)$_{12}$, and SARIMA(0,0,1)(0,1,1)$_{12}$, respectively.

Based on the SARIMA(p,d,q)(P,D,Q)$_{12}$ by six models, the autocorrelation problem between periods was not found because the Q_{LB} statistics did not reject the null hypothesis (H_0: Forecasting model has no autocorrelation between periods) as the statistical significance which has been confirmed with Q_{LB} statistics at the 6th (Q_6) period and 12th (Q_{12}) period which gave a p-value higher than the statistically significant level of 0.05. However, the SARIMA(p,d,q)(P,D,Q)s model that was the most appropriate for forecasting of SBM time series was SARIMA(0,0,1)(0,1,1)$_{12}$ because it gave the lowest AC and SC statistical values in comparison with the five models mentioned above. Hence, the SARIMA(0,0,1)(0,1,1)$_{12}$ model was selected to forecast the monthly import demand for soybean meals in Thailand from January to December 2021.

Fig. 2 and Table 3 display the trends and forecasting values of monthly import demand for soybean meals in Thailand in 2021. It reveals that in 2021, Thailand will import soybean meal in quantity equal to 2,823,315,262 kilograms, representing an increase of 1.71% compared to the year 2020, which showed an import amount of 2,775,955,573 kilograms. In 2021, Thailand will import soybean meal, with the highest volume being in May with a quantity equal to 316,474,699 kilograms and the lowest volume being in February with a quantity equal to 181,513,505 kilograms.

4. Concluding Remarks

The objective of this research was to forecast the import demand for soybean meal in Thailand using a monthly time series from January 2011 to December 2020 (a total of 120 months). The data were analyzed using an econometric method comprised of stationary testing of the time series by using the ADF unit root and the Box-Jenkins forecasting method or the SARIMA(p,d,q)(P,D,Q)s model. From the analysis of the empirical results, it was found that: (1) the import demand for soybean meal in Thailand (SBM) had non-seasonal stationarity and seasonal stationarity at the level stage or I(d) equal to I(0) and first differencing order or I(D) equal to I(1); (2) the estimated SARIMA(p,d,q)(P,D,Q)s model using the highest probability of import demand for soybean meal in Thailand by considering AC and SC criteria along with the consideration of autocorrelation between periods stated that SARIMA(0,0,1)(0,1,1)$_{12}$ was the most appropriate forecasting model; and (3) the import demand for soybean meal in Thailand in 2021 was forecasted to increase by 1.71% in comparison with the year 2020.

This analysis revealed that in 2021, Thailand would be showing signs of revival from the Covid-19 pandemic impact. The outbreak of the virus has caused many business sectors to grind to a halt since 2020, with the Thai government issuing an emergency decree on public administration, barring individuals from leaving their houses from March 26, 2020, to June 14, 2020; these curfew measures started to be relaxed from June 15, 2020, although the government still retained control of land, water, and air arrivals to the country. On June 29, 2020, the government extended the curfew declaration until July 31, 2020, and started to allow "risky" group businesses to open and run as usual at a later stage [21]. With the virus pandemic still ongoing, the government, therefore, extended the emergency decree until August 31, 2020, to minimize the danger posed by Covid-19 [22]. Later, in December 2020, it was found that there was a new wave of virus in Thailand. Hence, the government implemented another emergency decree to control the spread of the virus once again before relaxing measures in February 2021. For this reason, the private business sector concerning various activities in Thailand once again ground to a halt. Many organizations and private businesses that did not have enough funding had to announce the closure of their businesses. However, it was revealed that animal feed businesses did not experience the same impact from the Covid-19 situation compared to other business activities. This implied that the livestock supply chain of the country was stable and able to grow under crises. This is because animal feeds are important products for animal production in livestock farms. Hence, such industries were permitted to carry on as usual or close to usual following new safety guidelines. Even though the Covid-19 situation has heavily impacted the purchasing power in other business sectors, livestock products remain an essential food source for humans. These products include meat, milk, and eggs. Therefore, the use of raw materials, especially animal feed ingredients like soybean meal, continues to be in high demand even amid the Covid-19 pandemic.

Recommendations are that government and related stakeholders should have policies and supported standards to encourage and support Thai farmers to grow soybean and increase the efficiency of soybean production as the demand for soybean and soybean meal in animal feed production in Thailand shows a tendency to increase continuously. Furthermore, it is important to identify the advantages of soybean production and motivate farmers to grow more soybean. For the limitations, since this study applied only one forecasting method, it could not compare with any other forecasting model. For selecting the most appropriate model, the other techniques such as SARIMAX, ANNs, and VAR methods should be considered to compare with the efficiency of the model selection as well as other external factors that influenced the import of soybean meal should be included in the analysis because it will make the rational explanation more interesting. Following this research, it is suggested that there should be a further study about the factors affecting the effectiveness/efficiency of soybean production by farmers in Thailand so that the area used for soybean production in each region is more appropriate. Moreover, there should be a further study about the costs and benefits between soybean production and other crops (after rice production) to establish guidelines for encouraging farmers to grow soybean in substitution of crops (after rice production), which uses large amounts of water.

References

[1] OFFICE OF AGRICULTURAL ECONOMICS. *Agricultural economic outlook in 2020 and trends in 2021.* Agricultural Development Policy and Planning Division, Office of Agricultural Economics, Bangkok, 2020.

[2] THAI FEED MILL ASSOCIATION. *The table of estimated animal population, feed quantity, and the use of raw materials in 2019,* 2019. http://www.thaifeedmill.com/

[3] OFFICE OF PERMANENT SECRETARY MINISTRY OF COMMERCE. *International trade of Thailand: Soybean,* 2021. http://www2.ops3.moc.go.th

[4] OFFICE OF AGRICULTURAL ECONOMICS. *Import statistics: Soybean meal,* 2021. http://impexp.oae.go.th/service/import.php

[5] OFFICE OF AGRICULTURAL ECONOMICS. *Major agricultural commodity situation and trends in 2021.* Bureau of Agricultural Economic Research, Office of Agricultural Economics, Bangkok, 2021.

[6] JATUPORN C., SUKPRASERT P., TONGCHURE S., SUVANVIHOK V., and THONGKAEW S. Forecasting import demand of table grapes: Empirical evidence from Thailand. *Asian Journal of Agriculture and Rural Development,* 2020, 10(2): 578-586. http://www.aessweb.com/pdf-files/5-960-10(2)2020-AJARD-578-586.pdf

[7] RATSAMINET P. *Forecasting import quantity of coffee of Thailand: The empirical study using Box-Jenkins approach.* School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, 2021.

[8] RUEANGRIT P., JATUPORN C., SUVANVIHOK V., and WANASET A. Forecasting production and export of Thailand’s durian fruit: An empirical study using the Box–Jenkins approach. *Humanities and Social Sciences Letters,* 2020, 8(4): 430-437. https://doi.org/10.18488/journal.73.2020.84.430.437

[9] CO H. C., & BOOSARAWONGSE R. Forecasting Thailand’s rice export: Statistical techniques vs. artificial neural networks. *Computers & Industrial Engineering,* 2007, 53(4): 610-627. https://doi.org/10.1016/j.cie.2007.06.005

[10] BADMUS M. A., & ARIYO O. S. Forecasting cultivated areas and production of maize in Nigerian using ARIMA model. *Asian Journal of Agricultural Sciences,* 2011, 3(3): 171-176. https://maxwellsci.com/jp/abstract.php?jid=AJAS&no=116&abs=03

[11] PAUL R. K., PANWAR S., SARKAR S. K., KUMAR A., SINGH K. N., FAROOQI S., and CHOUDHARY V. K. Modelling and forecasting of meat exports from India. *Agricultural Economics Research Review,* 2013, 26(2): 249-255. https://doi.org/10.22004/ag.econ.162149

[12] UPADHYAY V. K. Modelling and forecasting export and import of Indian wood based panel using ARIMA models. *Elixir Statistics,* 2013, 63: 18145-18148. https://www.researchgate.net/publication/271833558_Modelling_and_forecasting_export_and_import_of_Indian_wood_based_panel_using_ARIMA_models

[13] JATUPORN C., & SUKPRASERT P. Forecasting models for rubber production and export quantity of Thailand. *Khon Kaen Agriculture Journal,* 2016, 44(2): 219-228.

[14] PANNAKKONG W., HUYNH V. N., and SRIBOONCHITTA S. ARIMA versus artificial neural network for Thailand’s cassava starch export forecasting. In: HUYNH V. N., KREINOVICH V., and SRIBOONCHITTA S. (eds.) *Causal Inference in Econometrics. Studies in Computational Intelligence,* Vol. 622. Springer, Cham, 2016: 255-277. https://doi.org/10.1007/978-3-319-27284-9_16

[15] BAŞER U., BOZOĞLU M., EROĞLU N. A., and TOPUZ B. K. Forecasting chestnut production and export of Turkey using ARIMA model. *Turkish Journal of Forecasting*, 2018, 2(2): 27-33. https://doi.org/10.34110/forecasting.482789

[16] ISLAM M. A., SUMY M. S. A., UDDIN M. A., and HOSSAIN M. S. Fitting ARIMA model and forecasting for the tea production, and internal consumption of tea (per year) and export of tea. *International Journal of Material and Mathematical Sciences*, 2020, 2(1): 8-15. https://doi.org/10.34104/ijmms.020.08015

[17] BOX G. E. P., JENKINS G. M., and REINSEL G. C. *Time series analysis: Forecasting and control.* 3rd ed. Prentice-Hall, Englewood Cliffs, New Jersey, 1994.

[18] GUJARATI D. N., & PORTER D. C. *Basic econometrics.* 5th ed. McGraw Hill, New York, 2009.

[19] DICKEY D. A., & FULLER W. A. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 1979, 74(366a): 427-431. https://doi.org/10.2307/2286348

[20] DICKEY D. A., & FULLER W. A. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, 1981, 49(4): 1057-1072. https://doi.org/0012-9682(198107)49:4<1057:LRSFAT>2.0.CO;2-4

[21] THANSETTAKIJ. *Update "emergency decree", "curfew" and "order of centre for covid-19 situation administration"*, 2021. https://www.thansettakij.com/content/normal_news/426464

[22] THAIRATH ONLINE. *Full announcement extended declaration of an emergency situation pursuant to the emergency decrees on public administration in emergency situation due to people do not pay attention to social distancing measures*, 2020. https://www.thairath.co.th/news/politic/1900519

参考文：

[1] 農業經濟辦公室。2020 年農業經濟前景和 2021 年趨勢。農業經濟辦公室農業發展政策和規劃司，曼谷，2020。

[2] 泰國飼料廠協會。該表列出了 2019 年，2019 年的動物種群估計，飼料數量和原料使用情況。http://www.thaifeedmill.com/

[3] 常設商務部辦公室。泰國的國際貿易：大豆，2021。http://www2.ops3.moc.go.th

[4] 農業經濟辦公室。進口統計數據：2021 年的豆粕。http://impexp.oae.go.th/service/import.php

[5] 農業經濟辦公室。2021 年主要農產品形勢和趨勢。農業經濟研究局，農業經濟辦公室，曼谷，2021。

[6] JATUPORN C.，SUKPRASERT P.，TONGCHURE S.，SUVANVIHOK V. 和 THONGKAEW S. 預測鮮食葡萄的進口需求：來自泰國的經驗證據。亞洲農業與農村發展雜誌，2020，10（2）：578-586。http://www.aessweb.com/pdf-files/5-960-10(2)2020-AJARD-578-586.pdf

[7] RATSAMINET P. 預測泰國咖啡的進口量：使用博克·詹金斯方法的實證研究。暖武里府素可泰他瑪瑟拉特開放大學經濟學院，2021。

[8] RUEANGRIT P.，JATUPORN C.，SUVANVIHOK V. 和 WANASET A。預測泰國榴蓮果實的生產和出口：使用博克·詹金斯方法進行的實證研究。人文與社會科學快報，2020，8（4）：430-437。https://doi.org/10.18488/journal.73.2020.84.430.437

[9] CO H. C. 和 BOOSARAWONGSE R. 預測泰國大米出口：統計技術與人工神經網絡的比較。計算機與工業工程，2007，53（4）：610-627。https://doi.org/10.1016/j.cie.2007.06.005

[10] BADMUS M. A. 和 ARIYO O. S. 使用有馬模型預測尼日利亞人的玉米種植面積和產量。亞洲農業科學，2011，3（3）：171-176。https://maxwellsci.com/jp/abstract.php?jid=AJAS&no=116&abs=03

[11] PAUL R. K.，PANWAR S.，SARKAR S. K.，KUMAR A.，SINGH K. N.，FAROOQI S. 和 CHOUDHARY V. K. 對印度肉類出口的建模和預測。農業經濟研究評論，2013，26（2）：249-255。https://doi.org/10.22004/ag.econ.162149

[12] UPADHYAY V. K. 使用有馬模型對印度人造板的進出口進行建模和預測。藥劑統計，2013，63：18145-18148。https://www.researchgate.net/publication/271833558_Modelling_and_forecasting_export_and_import_of_Indian_wood_based_panel_using_ARIMA_models

[13] JATUPORN C. 和 SUKPRASERT P. 泰國橡膠產量和出口量的預測模型。孔敬農業學報，2016，44（2）：219-228。

[14] PANNAKKONG W.，HUYNH V. N. 和 SRIBOONCHITTA S. 有馬對比人工神經網絡對泰國木薯澱粉的出口進行預測。在：HUYNH V. N.，KREINOVICH V. 和 SRIBOONCHITTA S.（主編）計量經濟學中的因果推論。計算智能研究，第一卷。 622.施普林格，湛，2016：255-277。https://doi.org/10.1007/978-3-319-27284-9_16

[15] BAŞER U.，BOZOĞLU M.，EROĞLU N. A. 和 TOPUZ B. K. 使用有馬模型預測土耳其的栗子生產和出口。土耳其天氣預報，2018，2（2）：27-33。https://doi.org/10.34110/forecasting.482789

[16] ISLAM M. A.，SUMY M. S. A.，UDDIN M. A. 和 HOSSAIN M. S. 擬合有馬模型並預測茶的產量，茶的內部消耗量（每年）和茶的出口量。國際材料與數學科學雜誌，2020，2（1）：8-15。

https://doi.org/10.34104/ijmms.020.08015

[17] BOX G. E. P.，JENKINS G. M. 和 REINSEL G. C. 時間序列分析：預測和控制。第三版。普倫蒂斯·霍爾，新澤西州恩格爾伍德懸崖，1994。

[18] GUJARATI D. N. 和 PORTER D. C. 基本計量經濟學。第五版。紐約，麥格勞·希爾，2009。

[19] DICKEY D. A. 和 FULLER W. A. 具有單位根的自回歸時間序列的估計量分佈。美國統計協會雜誌，1979，74（366 一種）：427-431。https://doi.org/10.2307/2286348

[20] DICKEY D. A. 和 FULLER W. A. 具有單位根的自回歸時間序列的似然比統計。計量經濟學，1981，49（4）：1057-1072。https://doi.org/0012-9682(198107)49:4<1057:LRSFAT>2.0.CO;2-4

[21] THANSETTAKIJ。更新 2021 年的“緊急法令”，“宵禁”和“ covid-19 情況管理中心命令” https://www.thansettakij.com/content/normal_news/426464

[22] 泰莎在線。完全公告根據公共行政中的緊急法令擴大了對緊急情況的宣布，以應對由於人們不重視社會疏離措施而導致的緊急情況，2020。https://www.thairath.co.th/news/politic/1900519