Asian Economic and Financial Review
ISSN(e): 2222-6737
ISSN(p): 2305-2147
DOI: 10.55493/5002.v13i5.4773
Vol. 13, No. 5, 293-307.

URL: www.aessweb.com

Impacts of the COVID-19 pandemic on the relationship between the economic factors and stock prices of the transport sector in the stock exchange of Thailand

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Article History
Received: 4 January 2023
Revised: 2 March 2023
Accepted: 20 March 2023
Published: 6 April 2023

Keywords
COVID-19
GMS
Stock price
Thailand
Transport sector
Transportation.

JEL Classification:
E44; E49; G00.

ABSTRACT

The COVID-19 pandemic has affected economic sectors and investment and has particularly affected the stock pricing factors for the transport sector (TRANS). This study compares the relationship of the different factors, i.e., the volume, exchange rate (EXR), consumer price index (CPI), and the oil price on the stock prices of the TRANS on the Stock Exchange of Thailand (SET) between the pre-COVID-19 and during COVID-19 periods. Time series data between January 2017 and December 2019 were used for the pre-COVID-19 period, and data between January 2020 and September 2022 were used for the during COVID-19 period. The effects of the independent variables were considered by estimating the long-run relationship using the autoregressive distributed lag (ARDL) and Granger causality from those variables to each stock price. The results found that the COVID-19 pandemic caused different effects on the volume, EX, CPI, and the oil price on the stock prices of the transport sector in the SET. Thus, investors should closely monitor the situations caused by natural disasters and the change of the EXR and oil price to reduce any problems that may arise.

Contribution/Originality: This study compares the factors on the stock prices of the transportation sector on the Stock Exchange of Thailand between the pre-COVID-19 and during COVID-19 periods. This research invites investors to monitor the situation of the Stock Exchange of Thailand based on many risks from natural disasters.

1. INTRODUCTION

Since 2020, the impact of the COVID-19 pandemic has caused hindrances in economic activities all over the world, particularly to businesses in the transport industry, which have had to overcome the impact of the pandemic control measures (Mogaji, 2020) and adaptations in the private sector and among consumers (Habib, Asif, & Anik, 2021). Furthermore, this affected the demand for public transport, shown by the lower number of air travel passengers in several Asian countries (Talha & Codal, 2020).

Like the impacts in the economic sector, the COVID-19 pandemic changed the forecasted returns for investors in the stock markets depending on the situations that the transport businesses in each country had to confront (Fasanya, Periola, & Adetokunbo, 2022). This was also reflected in the capital market stock prices. In the case of stock

prices in transport businesses in developing countries, e.g., Turkey, India, Thailand, and China, there were more fluctuations than in developed countries, e.g., the USA, UK, Mexico, and France (Farooq, Nasir, Bilal, & Bashir, 2022). Moreover, this impact conformed to the differences of the effects of external factors, e.g., the oil price or exchange rate (EXR) that affected the stock prices in each period of market conditions (bullish, bearish, and normal), as per the case of the capital market in Pakistan (Hashmi, Chang, Huang, & Uche, 2022).

Thailand's transport sector was particularly affected, as it was a tourist destination for almost 40 million tourists in 2019 (World Bank, 2022). Thus, the COVID-19 prevention measures that also limited the number of tourists caused huge losses in the tourism and transport industries, particularly aviation (Thongmeensuk & Rojsirikulchai, 2020). However, the demand for food in other countries due to the pandemic resulted in an expansion of Thailand's agricultural exports and processed agricultural products (Thammachote & Trochim, 2021), which was good for businesses in sea freight, ports, and warehousing services.

The SET contains the stocks of businesses registered in the TRANS with various types of services directly related to land, water, and air (see Table 1), and other related businesses, e.g., warehouse rental services, construction services, management services, infrastructure maintenance related to transportation, etc. (Stock Exchange of Thailand, 2022). Most businesses are usually holding companies as shareholders in minor/subsidiary companies with associated services or with a relationship to their key operation in order to expand their services inclusively with better revenue and to help reduce the dissemination of possible risks in case of any problems.

Table 1. Business operations in the stocks of the TRANS registered on the SET.

Stock name	Company name	Business type
AVV	Asia Aviation Public Company Limited (PCL)	This is a holding company that only holds Thai AirAsia Company Limited, a low-cost airline. Thai AirAsia's revenue is mainly generated by scheduled passenger services and ancillary services.
AOT	Airports of Thailand PCL	AOT is the operator of the airport business in Thailand; its core tasks are airport management and development of the country's six international airports, namely Suvarnabhumi, Don Mueang, Chiang Mai, Mae Fah Luang-Chiang Rai, Phuket, and Hat Yai. All six airports serve domestic and international flights, with Suvarnabhumi designated as the country's main airport.
ASIMAR	Asian Marine Services PCL	This company provides quality ship repairs, conversion, shipbuilding, and engineering work to worldwide owners. It has many years of experience in the ship repair industry and is well known as the leading shipyard in Thailand.
B	Begistics PCL	This company provides comprehensive logistics services, including berths, warehouses, cargo handling, road transport, crane rental, international freight forwarding, and customs clearance services.
BA	Bangkok Airways PCL	The company provides airline, airport, and airport-related services, including ground and passenger, in-flight catering, and cargo terminal services for its own flights and for other airlines.
BEM	Bangkok Expressway and Metro PCL	This company oversees the construction and operation of the expressways and operation management of the Mass Rapid Transit system business and related business.
BIOTEC	Bio Green Energy Tech PCL	Bio Green Energy operates marine transport services as follows: 1) Liner services (Thailand–Japan–South Korea–Vietnam–Thailand; 2) Charter services for voyage charters and time charters; 3) Ship management; 4) Stevedoring; 5) Ship repair and maintenance; 6) Sale and purchase of ships; and 7) Agency.
BTS	BTS Group Holdings PCL	BTS comprises four core businesses: (1) Mass transit (BTS SkyTrain and bus rapid transit (BRT)); (2) Media; (3) Property; and (4) Services.
JWD	JWD InfoLogistics PCL	JWD is one of ASEAN's top specialized logistics and supply chain service providers, which can be classified into four business units, i.e., 1. Integrated logistics and supply chain management, which is the core business; 2. Food services; 3. IT solutions; and 4. Investment.
KIAT	Kiattana Transport PCL	This company conducts the following operations: 1. Transportation, 2. Warehousing, 3. Product sourcing, 4. Customs clearance and

Stock name	Company name	Business type
		documentation, 5. Transportation management, and 6. Petrochemical products.
KWC	Krungdhep Sophon PCL	This company consists of three types of businesses: 1. land development, 2.warehousing businesses, and 3. document storage businesses.
NYT	Namyong Terminal PCL	This company is a roll-on/roll-off (ro-ro) and general cargo terminal operator of the A5 Terminal at Laem Chabang Port, Sriracha district, Chon Buri province. It has had the highest volume of cars exported through the terminal in the past three years with an approximate market share of 80% of the total car exports from Thailand. The company provides a full scope of services for car exports and imports through the A5 Terminal, which can be categorized as follows: 1) terminal services, 2) supporting the car storage area and warehousing services, and 3) other services related to the company's core business.
PSL	Precious Shipping PCL	This company is one of the largest pure dry cargo ship owners operating in the small sector of the tramp freight market. Its operations are global and are divided evenly across five regions: USA/Canada, Europe, Latin America–Africa, Indian subcontinent–Middle East, and the Southeast and Far East Asia. Its cargoes include agricultural products, steel, fertilizers, ores and concentrated minerals, logs, coke, and other items.
RCL	Regional Container Lines PCL	A Thai-based container shipping line, the company operates three core lines of business: shipper-owned containers, carrier-owned containers, and value-added logistics services. The geographical business scope is Asia-centric with business activities covering Northeast Asia, Southeast Asia, the Indian subcontinent, and the Middle East. A network of offices comprising owned offices and agency representation supports the direct links with the company's customers.
TSTE	Thai Sugar Terminal PCL	Thai Sugar operates businesses relating to the transfer and transportation of sugar and certain agricultural products, warehouse rental, land trading operations, land appropriation and construction of buildings on land for sale, rental, and hire purchase for residential, office, and commercial units.
TTA	Thoresen Thai Agencies PCL	This is an investment holding company with five core business groups: 1. Shipping, 2. Offshore services, 3. Agrochemicals, 4. Food and beverage, and 5. Investment.
WICE	Wice Logistics PCL	Wice and its subsidiaries are international logistics service and solution providers, including importing and exporting by both sea and air, customs clearance, and land transportation, through which the company aims to fulfil a wide range of customer requirements. In addition, the company provides door-to-door transfer of goods from one factory to another, and the exporter is responsible for the freight charges. The company also provides ex-works delivery, which is the transfer of goods from one factory to another and the importer is responsible for the freight charges.

Note: The table displays information of the operations for 17 stocks of the transport sector with normal trade from the pre-COVID-19 period (Jan. 2017 to Dec. 2019) to the during COVID-19 period (Jan. 2020–Sep. 2022) out of a total of 27 stocks in this sector.
Source: Kiattana Transport (2022) and Stock Exchange of Thailand (2022).

When comparing the average prices and fluctuation of the stocks between the pre-COVID-19 and during COVID-19 periods (see Table 2), it was found that the average prices of AAV, ASIMAR, B, BA, BIOTEC, and NYT during the COVID-19 period had a lower rate of change compared with the pre-COVID-19 period. To clarify, the prices of AAV, BIOTEC, and BA reduced the most (47.36%, 45.90%, and 35.77%, respectively). In contrast, the prices of AOT, BEM, BTS, JWD, KIAT, KWC, PSL, RCL, TSTE, TTA, and WICE had a higher rate of change. To clarify, the prices of RCL and WICE were the highest (419.54% and 158.94%, respectively). Other than this, in terms of fluctuation, it was found that the prices of ASIMAR, B, JWD, KIAT, NYT, PSL, RCL, TSTE, TTA, and WICE were higher. The prices of RCL, WICE, JWD, and PSL were the highest, while those of AAV, AOT, BA, BEM, BIOTEC, BTS, and KWC were lower. The prices of KWC, BEM, and BTS were reduced the most.

Table 2. Changes and fluctuations of stock prices in the pre-COVID-19 and during COVID-19 periods.

Stock	Pre-COVID-19 (Jan. 2017–Dec. 2019)				COVID-19 (Jan. 2020–Sep. 2022)				Change of the mean (%)	Change of the SD (%)
	Max.	Min.	Mean	Standard deviation (SD)	Max.	Min.	Mean	Standard deviation (SD)		
AAV	6.01	1.74	4.56	1.15	3.20	1.06	2.40	0.50	-47.36%	-56.47%
AOT	76.70	36.85	61.61	10.64	74.00	50.46	62.75	5.94	1.85%	-44.17%
ASIMAR	2.63	0.96	1.94	0.47	2.72	0.67	1.85	0.57	-4.79%	20.30%
B	1.05	0.20	0.54	0.21	1.01	0.14	0.51	0.23	-4.60%	9.07%
BA	19.36	5.78	13.20	3.68	13.50	3.94	8.48	2.55	-35.77%	-30.77%
BEM	10.87	6.46	8.42	1.53	9.54	7.43	8.53	0.52	1.33%	-65.87%
BIOTEC	2.82	0.32	1.62	0.90	1.64	0.21	0.87	0.45	-45.90%	-50.34%
BTS	12.29	6.67	8.59	1.88	11.14	8.07	9.02	0.69	5.05%	-63.33%
JWD	10.52	5.26	7.71	1.30	21.64	4.63	12.19	5.00	58.08%	283.79%
KIAT	0.43	0.21	0.32	0.05	0.69	0.19	0.48	0.11	47.97%	108.10%
KWC	270.22	155.51	221.59	36.58	270.26	226.64	251.90	9.08	13.68%	-75.17%
NYT	5.30	2.90	4.06	0.57	4.89	2.16	3.67	0.72	-9.68%	26.15%
PSL	12.06	4.95	8.59	1.63	20.07	2.19	11.62	5.89	35.25%	260.83%
RCL	7.67	2.28	4.93	1.47	50.18	1.50	25.60	17.11	419.54%	1066.52%
TSTE	7.65	6.16	6.65	0.34	7.09	5.41	6.65	0.36	0.04%	7.80%
TTA	9.14	3.44	6.64	1.71	17.12	1.83	8.19	4.49	23.40%	162.23%
WICE	6.46	1.85	3.64	0.94	20.74	1.25	9.42	5.60	158.94%	493.74%

From the data above, the effects of external factors on the stock prices of the TRANS registered on the SET depend on the market conditions (bullish, bearish, and normal). However, the COVID-19 pandemic may have changed the conditions of the stock market. Thus, the pre-COVID-19 period was referred to as the normal market condition, whereas during the COVID-19 period was referred to as the bearish condition. Furthermore, those stocks were affected by the COVID-19 pandemic differently. More specifically, all businesses were affected by external factors, i.e., the EXR, CPI, and oil price. These differences were caused by the operation of each business. These impacts changed the effects of the external factors on the stock prices in the TRANS during the COVID-19 period from the pre-COVID-19 period in terms of the size and relationship directions between those factors and the stock prices. Additionally, because the investors paid less attention to those factors, they did not affect the stock prices, and the didn't pay attention to the variables, which may not have affected the normal condition much until it finally started to affect the stock prices.

2. LITERATURE REVIEW

In general, a change in stock prices is usually caused by the changing equilibrium of the supply and demand in the stock markets. Each investor has different prices in mind that attract them to such supply and demand depending on the expected returns and risks throughout the time of holding a particular asset. Hence, the change of the factors, which were believed to affect a return or risks, changed the attractive prices and affected the equilibrium of the prices of the stocks. The stock prices in the TRANS were affected by changes in factors such as the volume, EXR, CPI, inflation, the oil prices, and other related factors.

Samakkran, Tangsomchai, Mahabhol, and Chawapon (2019) found a long-run relationship between the stock prices and volume of the information and communication technology groups on the SET. However, when considering the Granger causality, only a single direction was found from the stock prices to the volume. The change in the prices encourages investors to trade in those stocks. In addition, such a relationship conforms with the results of the correlation analysis between the volume and stock prices in Saudi Arabia (Sabri, 2008).

Simultaneously, the studies on the effects of the CPI or inflation on the stock prices found some differences in the relationship trend. Doho, Somé, and Banto (2023) found that the stock price indices of all groups in West Africa were sensitive to inflation. Attarit (2021) found an opposite direction relationship between the CPI and stock prices of the TRANS in the SET. This conforms to the results found by Eldomiaty, Saeed, Hammam, and AboulSoud (2020) in the

US stock market for the stocks of non-financial firms from the Dow Jones Industrial Average 30 (DJIA 30) and the National Association of Securities Dealers Automated Quotations Stock Market-100 (NASDAQ-100), where the relationship was in the opposite direction according to the determined long-run relationship. Eldomiaty et al. (2020) also found that these qualities determine the inflation and interest rate on the stock prices.

For the effects of the EXR, Attarit (2021) found an opposite direction of the EXR between the Thai Baht on the US dollar based on the stock price. This conforms to the study results by Kumeka, Uzoma-Nwosu, and David-Wayas (2022), who found an opposite direction according to the determined EXR to the stock returns for oil exporters in the pre-COVID-19 period with the panel Granger causality test. Nevertheless, the EXR had a relationship in the same direction with those stock prices, resulting in a common determination between the EXR and the stock returns in the post-COVID-19 period.

In addition, when looking at the effects of oil price on stock prices using the nonlinear autoregressive distribution lag (NARDL) model, Raza, Jawad, Tiwari, and Shahbaz (2016) found that oil price had a negative impact on the stock prices in the new market. Moreover, those stock prices had fast responses to the change of the oil price, which was a change from both the positive and negative impacts. Simultaneously, the study results of Kocaarslan and Soytas (2019) for the stocks in clean energy and technology found short-run and long-run relationships from the oil price to stock prices according to the NARDL analysis. For the long-run relationship, oil price was a factor with negative impacts on those stock prices, while the impact of the higher oil price affected the stock prices rather than the lower oil price. In other words, the effects of the oil prices were asymmetric.

For the studies on the impacts of the COVID-19 pandemic, the differences of those impacts on the abnormal stock return of the transport and tourism industry were found between developed countries, e.g., the USA, UK, Mexico, and France, and developing countries, e.g., Turkey, India, Thailand, and China. In the developing countries, there was a fluctuation in the higher returns. The abnormal returns, as stated, were caused by responses to seven situations, i.e., the first epidemic, the highest death rate, the highest number of new patients, lowest oil price, lockdown measures, travel restrictions, and the remedy measures. These all caused less asymmetric information and less technical efficiency in the operation of the stock market (Farooq et al., 2022). It was also found that the COVID-19 pandemic caused an inefficiency of the US stock market (Hong, Bian, & Lee, 2021).

3. METHODOLOGY

This study aimed to compare the relationship of the different factors, i.e., the volume, EXR, CPI, and the oil price on the stock prices of the TRANS in the SET between the pre-COVID-19 period and during the COVID-19 period. Time series data were analyzed (monthly) and divided into two periods, i.e., the pre-COVID-19 period (January 2017 to December 2019, a total of 36 months) and during the COVID-19 period (January 2020 to September 2022, a total of 33 months).

For the stocks of the TRANS in the SET, 11 were selected as suitable for analysis (see Table 3) out of 27 stocks. The selection was based on 1) sufficient data for analysis; 2) stable ARDL in both periods that could be selected by the cumulative sum (CUSUM) and the cumulative sum square (CUSUMSQ), and 3) the relationship that had an ECT coefficient of -1 (below 0) in the error correction mechanism (ECM) developed from the ARDL or reached a long-run adjustment.

The data from these stocks include the price (P) as a dependent variable and volume (V) as one of the independent variables. All data were collected from the Stock Exchange of Thailand (2022).

Other independent variables for analysis included the EXR collected from the Bank of Thailand (2022), the CPI data collected from the Bureau of Trade and Economic Indices (2022), and the Brent oil price collected from Index Mundi (2022). All the data for analysis were converted into natural logarithms for interpretation from the model into percentages of change.

Table 3. Stocks for analysis.

Stock name	Company name
AVV	Asia Aviation Public Company Limited
BEM	Bangkok Expressway and Metro Public Company Limited
BIOTEC	Bio Green Energy Tech Public Company Limited
BTS	BTS Group Holdings Public Company Limited
JWD	JWD InfoLogistics Public Company Limited
KWC	Krungdhep Sophon Public Company Limited
NYT	Namyong Terminal Public Company Limited
PSL	Precious Shipping Public Company Limited
RCL	Regional Container Lines Public Company Limited
TSTE	Thai Sugar Terminal Public Company Limited
TTA	Thoresen Thai agencies Public Company Limited

Source: Stock Exchange of Thailand (2022).

All the time series data for estimation underwent a stationary, or unit root, test at the data levels and the first difference by the augmented Dickey–Fuller (ADF) and the Phillips–Perron (PP) tests. This is because using a non-stationarity test for the estimation by regression analysis could cause biased data or spurious regression (Choochote, Sirimat, Watchallanun, & Nonthapot, 2023).

However, the relationships among the data were reliable in the case of cointegration, or a long-run relationship from the independent variables to the dependent variable, along with finding the long-run adjustment and determining the short-run relationship from the ECM by applying Granger causality (Nonthapot & Srichaiyo, 2017). This study tested the cointegration using the ARDL technique, which was applied to develop the ECM and to test the Granger causality later. It was developed by fixing a stationary data sequence at the same levels (Nonthapot, 2017). However, this analysis still contained a limitation under the stationary sequence that is higher than the first difference. The ARDL model also incorporates the effects of the previous and current dependent variables (autoregressive process term) as well as the previous independent variables into the model. Equation 1 is the regular form of the model.

$$Y_t = \alpha_0 + \alpha_1 t + \sum_{k=1}^{l} \beta_k y_{t-k} + \sum_{m=1}^{n} \sum_{i=1}^{j} \gamma_i x_{m,t-i} + u_t \quad (1)$$

Where Y_t refers to the dependent variable at time t; $X_{m,t}$ refers to an independent variable in sequence "m" at time t; α_0 is a constant; $\alpha_1 t$ refers to a trend; and l and j refer to lags. The equation was set by the Akaike information criterion (AIC). Equation 1 was modified into three different forms for the analysis of the long-run relationship according to the different issues as follows:

1. The condition error correction (CEC) form was used to test for cointegration using the bound test. It was also used to estimate the error correction term, which was used for the ECM modelling later. Pesaran, Shin, and Smith (2001) classified the CEC into five cases as follows:

Case 1: None

CEC form:
$$\Delta Y_t = b_0 Y_{t-1} + \Sigma_{m=1}^{n} b_m X_{m,t-1} + \Sigma_{p=1}^{q-1} d_p \Delta Y_{t-p} + \Sigma_{m=1}^{n} c_m \Delta X_{m,t} + \Sigma_{m=1}^{n} \Sigma_{r_m=1}^{s_m-1} e_m \Delta X_{m,t-r_m} + \epsilon_t \quad (2)$$

Where
$$EC_t = Y_t - \sum_{m=1}^{k} \frac{b_m}{b_0} X_{m,t} \quad (3)$$

Cointegration was tested by the bound test from the following hypotheses:

$H_0: b_0 = b_1 = \ldots = b_m = 0$ Non-cointegration

$H_1: b_0 \neq b_1 \neq \ldots \neq b_m \neq 0$ Cointegration

Case 2: Restricted Constant

CEC form
$$\Delta Y_t = a_0 + b_0 Y_{t-1} + \Sigma_{m=1}^{n} b_m X_{m,t-1} + \Sigma_{p=1}^{q-1} d_p \Delta Y_{t-p} + \Sigma_{m=1}^{n} c_m \Delta X_{m,t} + \Sigma_{m=1}^{n} \Sigma_{r_m=1}^{s_m-1} e_m \Delta X_{m,t-r_m} + \epsilon_t \quad (4)$$

Where
$$EC_t = Y_t - \sum_{m=1}^{k} \frac{b_m}{b_0} X_{m,t} - \frac{a_0}{b_0} \quad (5)$$

Cointegration was tested by the bound test from the following hypotheses:

$H_0: b_0 = b_1 = \ldots = b_m = a_0 = 0$ Non-cointegration

$H_1: b_0 \neq b_1 \neq \ldots \neq b_m \neq a_0 \neq 0$ Cointegration

Case 3: Constant

CEC form
$$\Delta Y_t = a_0 + b_0 Y_{t-1} + \Sigma_{m=1}^{n} b_m X_{m,t-1} + \Sigma_{p=1}^{q-1} d_p \Delta Y_{t-p} + \Sigma_{m=1}^{n} c_m \Delta X_{m,t} + \Sigma_{m=1}^{n} \Sigma_{r_m=1}^{s_m-1} e_m \Delta X_{m,t-r_m} + \epsilon_t \quad (6)$$

Where
$$EC_t = Y_t - \Sigma_{m=1}^{k} \frac{b_m}{b_0} X_{m,t} \quad (7)$$

Cointegration was tested by the bound test from the following hypotheses:

$H_0: b_0 = b_1 = \ldots = b_m = a_0 = 0$ Non-cointegration

$H_1: b_0 \neq b_1 \neq \ldots \neq b_m \neq a_0 \neq 0$ Cointegration

Case 4: Restricted Trend

CEC form
$$\Delta Y_t = a_0 + b_0 Y_{t-1} + \Sigma_{m=1}^{n} b_m X_{m,t-1} + \Sigma_{p=1}^{q-1} d_p \Delta Y_{t-p} + \Sigma_{m=1}^{n} c_m \Delta X_{m,t} + \Sigma_{m=1}^{n} \Sigma_{r_m=1}^{s_m-1} e_m \Delta X_{m,t-r_m} + \epsilon_t \quad (8)$$

Where
$$EC_t = Y_t - \Sigma_{m=1}^{k} \frac{b_m}{b_0} X_{m,t} - \frac{a_0}{b_0} t \quad (9)$$

Cointegration was tested by the bound test from the following hypotheses:

$H_0: b_0 = b_1 = \ldots = b_m = a_1 = 0$ Non-cointegration

$H_1: b_0 \neq b_1 \neq \ldots \neq b_m \neq a_1 \neq 0$ Cointegration

Case 5: Constant and Trend

CEC form
$$\Delta Y_t = a_0 + a_1 t + b_0 Y_{t-1} + \Sigma_{m=1}^{n} b_m X_{m,t-1} + \Sigma_{p=1}^{q-1} d_p \Delta Y_{t-p} + \Sigma_{m=1}^{n} c_m \Delta X_{m,t} + \Sigma_{m=1}^{n} \Sigma_{r_m=1}^{s_m-1} e_m \Delta X_{m,t-r_m} + \epsilon_t \quad (10)$$

Where
$$EC_t = Y_t - \Sigma_{m=1}^{k} \frac{b_m}{b_0} X_{m,t} - \frac{a_0}{b_0} t \quad (11)$$

Cointegration was tested by the bound test from the following hypotheses:

$H_0: b_0 = b_1 = \ldots = b_m = 0$ Non-cointegration

$H_1: b_0 \neq b_1 \neq \ldots \neq b_m \neq 0$ Cointegration

Where Y_t refers to a dependent variable at time t; $X_{m,t}$ refers to an independent variable in sequence "m" at a time t; a_0 refer to a constant; $\alpha_1 t$ refers to a trend; q and s_m refer to lags; and b_0 , b_m , d_p , c_m, and e_l refer to the coefficients of each variable. The equation was set by the AIC.

In this study, the relationship between the independent and dependent variables was tested by the CEC form in all cases. The stable cases were used afterwards when considering the CUSUM and CUSUMSQ for both periods before finding the long-run relationship by post regression derivation of the long-run dynamics.

2. The post regression derivation of the long-run dynamics was used to determine the long-run relationship. In the case of the cointegration, the long-run effects between the independent and dependent variables were found by the following model:

$$Y_t = a_0 + a_1 t + \Sigma_{i=1}^{p} b_i Y_{t-i} + c_1 X_t + \Sigma_{l=1}^{q-1} \mathrm{d_l} \Delta X_{t-l} + \epsilon_t \quad (12)$$

where
$$\alpha_1 = \frac{a_1}{1 - \Sigma_{i=1}^{p} b_i} \quad (13)$$

and
$$\beta_m = \frac{c_m}{1 - \Sigma_{i=1}^{p} b_i} \quad (14)$$

Where α_1 refers to the effect of the trend, and β_m refers to the effect of an independent variable on a considered variable.

After estimating the long-run relationship between the independent and dependent variables, the long-run adjustment was considered when the relationship is disturbed by the short-run effects of the independent variables on the dependent variables. The Granger causality was reflected by the ECM.

3. The ECM presents the long-run adjustment using the EC_t obtained from the CEC form to determine when the long-run relationship was disturbed. It also presents the speed of the long-run adjustment and short-run relationship between the independent and dependent variables. The ECM applied from the ARDL is related to the CEC form as follows:

$$\Delta y_t = a_0 + a_1 t + \theta EC_{t-1} + \Sigma_{p=1}^{q-1} d_p \Delta y_{t-p} + \Sigma_{\mathrm{m}=1}^{\mathrm{n}} \Sigma_{r_m=1}^{s_m-1} e_{r_m} \Delta x_{m,t-r_m} + u_t \quad (15)$$

From Equation 15, if θ was significantly negative, this means the cointegration among all independent variables are speed adjustment from all dependent variables to the dependent variable in the long-run . Simultaneously, there was a short-run determination of the independent variables to the dependent variables. a_0 refers to the constant and $a_1 t$ refers to the trend. a_0 was 0 when the ECM was applied from the CEC form in Cases 1 and 2. $a_1 t$ was 0 when the ECM was applied from the CEC form in Cases 1–4. θ refers to the speed of the long-run adjustment. If θ was significantly negative, the cointegration between the independent and dependent variables would be confirmed. Simultaneously, there was a short-run determination of the independent variables to the dependent variable. This conforms to the Granger causality test from the independent to dependent variables according to the following hypotheses:

$H_0: e_{1_m} = e_{2_m} = \ldots = e_{s_m-1} = 0$ x_m did not Granger-cause y.

$H_1: e_{1_m} \neq e_{2_m} \neq \ldots \neq e_{s_m-1} \neq 0$ x_m did not Granger-cause y.

However, if the ECM was applied from the ARDL in which some independent variables were not lagged, they could not be used to determine the Granger causality, so the vector autoregressive (VAR) model was used instead, and the values of the lag were set by the AIC. The following VAR model was used:

$$y_t = \Sigma_{p=1}^{q} d_p \Delta y_{t-p} + \Sigma_{\mathrm{m}=1}^{\mathrm{n}} \Sigma_{r_m=1}^{s_m} e_{r_m} \Delta x_{m,t-r_m} + u_t \quad (16)$$

From Equation 16, if the cointegration test shows no cointegration, we present the VAR, and the Granger causality will be presented in the short-run.

According to the estimation results from this model, the Granger causality was considered based on the following hypotheses:

$H_0: e_{1_m} = e_{2_m} = \ldots = e_{s_m} = 0$ x_m did not Granger-cause y.

$H_1: e_{1_m} \neq e_{2_m} \neq \ldots \neq e_{s_m} \neq 0$ x_m did not Granger-cause y.

However, if both periods used different models to determine the Granger causality, the results may have contained errors due to the lack of efficiency of the analysis tools. Thus, the results in this issue were not compared for those stocks.

4. RESULTS AND DISCUSSION

From the unit root test, it was found that all variables in the study were stationary at the lower levels rather than at the second difference. However, some variables were stationary at the diverse levels of difference. Thus, the ARDL cointegration test was deemed suitable. When considering the results of the cointegration tested by the CEC form of the ARDL, the long-run relationship of the independent variables to the stock prices of the TRANS was found in the pre-COVID-19 period and during the COVID-19 period in almost all stocks. However, the prices of BEM and NYT in the pre-COVID-19 period and the price of BIOTEC during the COVID-19 period were not cointegrated. Thus, these results could not be compared with the results of the estimation of the long-run relationship of those variables.

Table 4. The ARDL cointegration test: Condition error correction form.

Stock	Period	Case	Lag	F-stat bound test	Cointegration	Stable	
						CUSUM	CUSUMSQ
AVV	Pre-COVID-19	3	4,3,5,4,4	5.37**	Cointegration	Stable	Stable
	COVID-19	3	4,3,3,4,3	5.86**	Cointegration	Stable	Stable
BEM	Pre-COVID-19	3	3,3,4,4,0	1.98	Non-cointegration	Stable	Stable
	COVID-19	3	4,4,4,3,1	4.62*	Cointegration	Stable	Stable
BIOTEC	Pre-COVID-19	2	2,3,0,4,4	4.62**	Cointegration	Stable	Stable
	COVID-19	2	3,4,4,4,3	2.57	Non-cointegration	Stable	Stable
BTS	Pre-COVID-19	4	4,4,4,3,4	12.27***	Cointegration	Stable	Stable
	COVID-19	4	1,4,3,4,3	8.45***	Cointegration	Stable	Stable
JWD	Pre-COVID-19	2	4,3,3,4,3	5.40**	Cointegration	Stable	Stable
	COVID-19	2	4,1,4,3,4	9.47***	Cointegration	Stable	Stable
KWC	Pre-COVID-19	3	4,4,4,4,4	173.40***	Cointegration	Stable	Stable
	COVID-19	3	2,4,3,3,4	8.63***	Cointegration	Stable	Stable
NYT	Pre-COVID-19	2	1,0,0,0,0	2.05	Non-cointegration	Stable	Stable
	COVID-19	2	1,2,2,1,2	10.58***	Cointegration	Stable	Stable
PSL	Pre-COVID-19	4	2,1,2,0,0	5.21**	Cointegration	Stable	Stable
	COVID-19	4	1,1,2,0,1	7.60***	Cointegration	Stable	Stable
RCL	Pre-COVID-19	4	4,2,3,2,3	4.58*	Cointegration	Stable	Stable
	COVID-19	4	1,0,3,1,0	4.59*	Cointegration	Stable	Stable
TSTE	Pre-COVID-19	5	1,0,0,0,0	6.46**	Cointegration	Stable	Stable
	COVID-19	5	4,4,4,4,4	111.90***	Cointegration	Stable	Stable
TTA	Pre-COVID-19	2	1,2,4,4,2	5.09**	Cointegration	Stable	Stable
	COVID-19	2	2,0,2,4,1	6.32***	Cointegration	Stable	Stable

Note: *, ** and *** denote significance at the 99%, 95% and 90% levels, respectively.

In addition, for the estimation of the long-run relationship, the model of the post regression derivation of the long-run dynamics (see Table 4) presents the size and direction of the long-run relationship in which each independent variable affected the stock prices. The coefficient shows the percentage of change for the stock prices that resulted from the changes in the independent variables.

From the study results, it was found that volume was a factor with the long-run relationship in the same direction as the stock prices, particularly those for AVV and TTA, whose relationship direction was found in both periods. In contrast, the relationship was found for BTS and PSL only in the pre-COVID-19 period, and for JWD, KWC, and TSTE during the COVID-19 period. It was also found that RCL was not affected by the volume.

This relationship direction conforms to the study results of Samakkran et al. (2019) in terms of the long-run relationship from the volume to the stock prices. This also supports the results of the tested relationship between the two variables from the correlation in the study by Sabri (2008). This relationship was a result of the effects of the volume direction on the attractiveness of those stocks for the investors because the stock with a regular volume facilitated the fast trade of those stocks. As a consequence, there was liquidity for holding those stocks, including the convenience of the short-run profit speculation. Thus, the volume was a factor in the long-run relationship in the same direction as the stock prices.

Nonetheless, this relationship might not always occur, even in the same stocks, which was possibly due to the change of the profit speculation strategies for some assets from short-run to long-run speculation during the market uncertainty, e.g., the COVID-19 pandemic that caused less liquidity and possibly also an opposite direction for other assets.

For the effects of the EXR, it was found that the long-run relationship between the EXR and the stock prices had different relationship directions for each stock in each period. To clarify, the relationship was in the same direction in the pre-COVID-19 period and during the COVID-19 period for BTS, the opposite direction in both periods for RCL, from the opposite direction in the pre-COVID-19 period to the same direction during the COVID-19 period for JWD and TSTE, the opposite direction in the pre-COVID-19 period only for KWC, and the opposite direction during the COVID-19 period only for PSL and TTA. It was also found that AAV was not affected by the EXR.

These relationship directions conform with the study by Kumeka et al. (2022), who found relationships in both directions from the EXR to the return. The opposite direction occurred in the pre-COVID-19 period, while the same direction occurred during the COVID-19 period. These helped support three phenomena, i.e., the relationship in the same, opposite, and both directions. In particular, relationships in the opposite direction were usually found. In addition to Kumeka et al. (2022) and the results found in this study, this relationship also occurred in the studies by Attarit (2021) and Hashmi et al. (2022). Kumeka et al. (2022) stated that this relationship implies the operational deterioration of the stock markets. Simultaneously, the researchers also described the relationship in the same direction and that currency depreciation increased the stock return.

Table 5. The ARDL cointegration test: Post-regression derivation of the long-run dynamics form.

Stock	Period	Case	Lag	Long-run coefficients					
				Constant	Trend	Volume	Exchange rate	CPI	Oil price
AVV	Pre-COVID-19	3	4,3,5,4,4	-	-	0.33* (2.31)	5.05 (1.80)	-32.93*** (-3.82)	2.25*** (4.21)
	COVID-19	3	4,3,3,4,3	-	-	0.35*** (4.36)	-0.44 (-0.99)	-0.44 (-0.42)	0.96*** (10.70)
BEM	Pre-COVID-19	Non-cointegration							
	COVID-19	3	4,4,4,3,1	-	-	0.04 (1.85)	1.03** (3.28)	0.50 (1.10)	-0.13*** (-7.55)
BIOTEC	Pre-COVID-19	2	2,3,0,4,4	857.68** (2.50)	-	-0.14 (-0.53)	-12.09 (-1.38)	-178.38** (-2.64)	1.53 (1.19)
	COVID-19	Non-cointegration							
BTS	Pre-COVID-19	4	4,4,4,3,4	-	0.02*** (11.80)	0.40*** (9.92)	1.49*** (4.46)	-2.10 (-1.11)	-0.17** (-2.44)
	COVID-19	4	1,4,3,4,3	-	-0.12** (-2.47)	-0.14 (-1.40)	3.29** (2.95)	1.65 (1.1322)	2.45** (2.51)
JWD	Pre-COVID-19	2	4,3,3,4,3	73.05* (1.85)	-	0.07 (1.59)	-2.86* (-1.99)	-13.02 (-1.72)	-0.60** (-2.60)
	COVID-19	2	4,1,4,3,4	27.70*** (3.70)	-	0.23** (3.13)	4.36*** (6.45)	-10.74*** (-7.41)	1.22*** (7.01)
KWC	Pre-COVID-19	3	4,4,4,4,4	-	-	0.04 (0.92)	-4.71* (-4.08)	-20.41 (-1.91)	1.15** (5.36)
	COVID-19	3	2,4,3,3,4	-	-	0.02* (2.16)	-0.36 (-1.69)	1.21** (3.25)	-0.15 (-6.43)
NYT	Pre-COVID-19	Non-cointegration							
	COVID-19	2	1,2,2,1,2	19.27** (2.24)	-	0.04 (1.08)	-0.55 (-1.08)	-4.29** (-2.33)	0.75*** (6.06)
PSL	Pre-COVID-19	4	2,1,2,0,0	-	0.0100 (0.38)	0.70* (1.83)*	3.20 (0.86)	-44.97 (-1.47)	2.61 (2.48)**
	COVID-19	4	1,1,2,0,1	-	0.07*** (3.38)	0.21 (1.18)	-3.59* (-1.99)	-10.58** (-2.37)	0.68* (1.99)
RCL	Pre-COVID-19	4	4,2,3,2,3	-	-0.07*** (-5.29)	-0.05 (-1.48)	-2.98* (-2.05)	31.96*** (3.32)	-0.19 (-0.80)
	COVID-19	4	1,0,3,1,0	-	0.18* (2.05)	0.49 (1.35)	-14.34 (-1.87)*	-4.14 (-0.21)	-1.65 (-0.88)
TSTE	Pre-COVID-19	5	1,0,0,0,0	-	-	-0.01 (-0.05)	-0.74 (-2.06)**	5.98 (2.14)**	-0.30 (-3.94)***
	COVID-19	5	4,4,4,4,4	-	-	0.037 (20.65)***	0.38 (11.37)***	0.059 (0.95)	-0.34 (-9.90)***
TTA	Pre-COVID-19	2	1,2,4,4,2	137.52*** (5.64)	-	0.16*** (4.67)	-0.40 (-0.43)	-30.30*** (-6.60)	0.50*** (3.04)
	COVID-19	2	2,0,2,4,1	-5.9 (-0.18)	- -	0.26** (2.36)	-10.12** (-2.24)	7.03 (0.71)	1.41** (2.65)

Note: *, ** and *** denote significance at the 99%, 95% and 90% levels, respectively.

Even so, Kumeka et al. (2022) did not find the phenomenon of the change of this relationship. Hence, it could be noticed that if there was a linkage in such change under the normal situations, the currency depreciation implied a market devaluation, which would reduce the demand for investment in the stock markets. As a consequence, the

relationship between the EXR and the stocks was in the opposite direction. However, in the case of the external factors, e.g., the COVID-19 pandemic or devaluation/depreciation to a certain level, the stock return, because of the EXR, would increase. This would attract investors to those stocks more, which would finally change such relationship back to the same direction.

For the effects of the CPI on the stock prices, it was found that the CPI had a long-run relationship with them in the same and opposite directions. However, no change of relationship direction was found during COVID-19. In the pre-COVID-19 period, the CPI had a relationship in the same direction with the prices of RCL and TSTE, but opposite for AVV and TTA. Simultaneously, the relationship in the same direction was found for KWC during COVID-19, but opposite for JWD and PSL. The price of the BTS was not affected by the CPI.

From the study, it was found that the relationship directions between the CPI and stock prices conform to the research by Attarit (2021) and Eldomiaty et al. (2020) in terms of relationships in the opposite direction. To clarify, the change of the CPI affected the consumer expenditure in the country. Thus, investors forecasted less income of those businesses, resulting in their demand in holding those stocks. The relationship in the same direction also conformed to the study by Jefry and Djazuli (2020) in terms of the stock prices in the basic industries and the chemical sector of the manufacturing companies in the Indonesia Stock Exchange (IDX). These relationships could occur sometimes for some stocks because, despite the change of the CPI that reflected the change of inflation, purchase power and consumer expenditures could return through macroeconomic mechanisms. As such, this would reduce the worries among investors about the consumer purchasing power that could affect the revenue of those businesses in different situations.

For the relationship of the oil price on the stock prices, the issues that were found include the differences between the relationship directions of the oil price on the stock prices and the change of those directions when compared with the pre-COVID-19 period. There was a relationship in the same direction from the oil price to the prices of AAV, PSL, and TTA in the pre- and post-COVID-19 periods. Moreover, there was a relationship in the opposite direction for TSTE in both periods. There was also a change in the relationship from the opposite to the same direction for BTS and JWD, and from the same to the opposite direction for KWC. The price of RCL was not affected by the oil price.

From these results, the opposite direction conform to the studies of Kocaarslan and Soytas (2019) and Raza et al. (2016), which describe oil as an initial material for energy and fuel production for driving transportation. Thus, the oil price directly affected the cost of all aspects in the transportation industry. For this reason, the change in the oil price could affect investors' business profits forecasts, which would cause less demand for holding those stocks. However, the relationship in the same direction could occur for stocks in the transportation sector, too. That would be because those businesses would have specific advantages with benefits from a higher oil price. Consequently, this could affect their demand for holding this type of stock. Nevertheless, the change of the relationship directions could occur in the case where there were other factors that could generate or reduce the advantages of those businesses, e.g., impacts of the COVID-19 pandemic that caused a number of hindrances in the operation.

In addition, when considering the effects of the independent variables on other stock prices that were not compared between the pre-COVID-19 and during COVID-19 periods, it was found that the price of BEM was determined by the long-run relationship with the EXR and the oil price during the COVID-19 period and was in the same direction with the EXR and the opposite direction with the oil price. Simultaneously, the price of BIOTEC was determined by the long-run relationship from the CPI in the opposite direction. Likewise, the price of NYT was determined by the long-run relationship from the CPI and the oil price in the opposite direction to the CPI and in the same direction with the oil price.

Table 6 presents the long-run relationship, which was reconfirmed by the effects of EC_{t-1} according to the ECM estimation results that showed a significantly negative value. This indicates the speed of the long-run adjustment when the relationship was affected by external factors (see Table 5). Additionally, the analysis results

found that the long-run relationship from the independent variables, as stated by the stock prices, adjusted more slowly (lag) during COVID-19. This was an exception for the prices of BTS, RCL, and TTA, which adjusted faster. There was no comparison of the long-run relationships for BEM, BIOTEC, and NYT.

Table 6. Granger causality test: ECM and VAR models.

Stock	Period	EC_{t-1} (t-statistic)	Short-run causality				
			Model	Volume (F-statistic)	Exchange rate (F-statistic)	CPI (F-statistic)	Oil price (F-statistic)
AVV	Pre-COVID-19	-0.74*** (-6.69)	ECM	11.89***	9.09***	3.91**	7.01***
	COVID-19	-1.39*** (-6.78)	ECM	42.27***	20.06***	15.25***	12.18***
BEM	Pre-COVID-19		VAR	2.80*	4.53**	2.80*	1.13
	COVID-19	-3.04*** (-5.89)	ECM	9.28***	8.67***	5.92**	3.07
BIOTEC	Pre-COVID-19	-0.23*** (-6.13)	VAR	2.22	0.85	2.91**	5.36***
	COVID-19		VAR	2.21	2.44	0.97	1.78
BTS	Pre-COVID-19	-1.50*** (-11.24)	ECM	32.18***	52.40***	19.47***	33.53***
	COVID-19	-1.06*** (-9.08)	ECM	9.44***	25.58***	28.62***	29.60***
JWD	Pre-COVID-19	-1.06*** (-6.97)	ECM	7.80***	2.98*	7.76***	4.46**
	COVID-19	-1.54*** (-9.61)	ECM	37.68***	6.60***	8.86***	8.6761***
KWC	Pre-COVID-19	-0.81 (-50.00)***	ECM	732.90***	579.45***	757.50***	650.23***
	COVID-19	-1.32 (-8.05)***	ECM	10.59***	7.42***	1.89	8.87***
NYT	Pre-COVID-19		VAR	1.4397	0.09	1.62	0.41
	COVID-19	-0.99*** (-9.01)	ECM	1.1921	8.46***	0.59	14.02***
PSL	Pre-COVID-19	-0.36*** (-6.17)	VAR	3.21*	5.74**	2.60	1.64
	COVID-19	-0.73*** (-7.55)	VAR	3.34*	1.3477	3.308*	1.59
RCL	Pre-COVID-19	-1.81 (-6.24)***	ECM	8.23***	8.40***	3.76**	3.78**
	COVID-19	-0.23*** (-5.70)	VAR	2.28	1.44	2.61	1.07
TSTE	Pre-COVID-19	-0.90*** (-6.08)	VAR	1.17	2.02	0.83	3.53*
	COVID-19	-2.80*** (-36.13)	ECM	688.11***	341.50***	599.87***	500.80***
TTA	Pre-COVID-19	-1.04*** (-6.44)	ECM	11.44***	5.24***	7.7446***	3.17*
	COVID-19	-0.46*** (-7.11)	VAR	6.20**	2.66*	1.27	1.24

Note: *, ** and *** are significant at the 99%, 95% and 90% levels, respectively.

Granger causality for testing the effects of the previous independent variables on the current stock prices was applied using the ECM and VAR models (Table 6). It was found that there was a relationship that could use the ECM to compare the effects in four stocks, i.e., AVV, BTS, JWD, and KWC. All the independent variables were the factors

used for determining the prices of all four stocks in the pre-COVID-19 and during COVID-19 periods. CPI was not a factor for determining the price of KWC during the COVID-19 period. Regarding the Granger causality that used the VAR for testing, there were two stocks whose effects were compared, i.e., BIOTEC and PSL. A deterministic relationship was found from the independent variables to the stock prices only in the pre-COVID-19 period with the EXR and CPI as the factors for determining the price of BIOTEC. It was also found that the volume was a factor for determining the PSL price in both periods, while the EXR only determined the PSL price in the pre-COVID-19 period, and the CPI determined the PSL price during the COVID-19 period.

When classifying by the independent variables, the Granger causality of the volume and oil price did not change due to the impacts of the pandemic.

Under the concept that stock prices are a result of the equilibrium of investors' trading demands, which is the result of projections of the returns and risks of holding those assets, a change in the external factors changed the current stock prices. This shows that investors still forecasted that previous impacts of those independent variables still had an impact on the return and risk of holding those stocks. However, under the changing situations due to the pandemic, investors could change the methods of forecasting the impacts from the previous effects. Thus, the effects of the independent factors on the stock prices could possibly change.

The relationships of other stocks were not compared for their effects because different models were used for considering the relationships. Those factors included BEM, NYT, RCL TSTE, and TTA. The deterministic relationship of BEM, NYT, and TSTE was tested by VAR in the pre-COVID-19 period. The ECM was used to determine the relationship during the COVID-19 period. In contrast, RCL and TTA used the ECM to consider the deterministic relationship in the pre-COVID-19 period, and the VAR was used to test the relationship during the COVID-19 period.

The study results of BEM, NYT, and TSTE showed that there was a deterministic relationship from the volume, EXR, and the CPI as the factors that determined the price of BEM in the pre-COVID-19 period. NYT was not determined by any independent variables. The price of TSTE was also only determined by the oil price. Furthermore, when considering the relationship during the COVID-19 period, it was found that the price of BEM was determined by the volume, EXR, and CPI. The price of NYT was also determined by the EXR and oil price, but TSTE was determined by all the independent variables. When using the ECM, the study results of the variables in RCL and TTA revealed that the prices of RCL and TTA were determined by all the factors in the pre-COVID-19 period. The test results during the COVID-19 period revealed that the price of RCL was not determined by all the independent variables, yet the volume and EXR determined the price of TTA.

5. CONCLUSIONS

This study aimed to compare the relationship of the volume, EXR, CPI, and the oil price on the stock prices of the transport industry (TRANS) in the Stock Exchange of Thailand (SET) between the pre-COVID-19 and during COVID-19 periods. The results found that the COVID-19 pandemic caused different effects on the volume, EXR, CPI, and the oil price on the stock prices of the TRANS in the SET in the long-run. The short-run results are different.

For the comparison of the long-run relationship of the independent variables to the stock prices between the two periods, it was found that there were phenomena from three relationship directions as follows: 1) There was no change in the relationship directions between the independent variables to the stock prices. It was only found in the case of a positive relationship of the volume, positive and negative relationships of the EXR, and positive and negative relationships of the oil price. This phenomenon was not found in the relationship of the CPI. 2) There was a change in the relationship direction. This was found in the case of a negative to positive relationship in the EXR and oil price and a positive to negative relationship in the oil price. No such change was found for the volume and CPI. 3) Long-

run relationships occurred in specific periods. To clarify, a positive relationship occurred in the case of the volume and CPI, and a negative relationship occurred in the case of the EXR but not in the case of the oil price.

No change was found for the Granger causality in the volume and oil price. However, the Granger causality of the EXR and CPI could either change or not change. Thus, investors should closely monitor the situations caused by natural disasters and changes in the EXR and oil price in order to reduce any problems caused by the possible risks in the long and short runs.

Funding: This research is supported by Research and Graduate Studies, Khon Kaen University (Grant number: RP66-5-002).
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study.

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