Firm Efficiency and Stock Returns during the Covid-19 Crisis: Evidence in Thailand

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Abstract

This study examines the relationship between firm efficiency and stock return in Thailand during the Covid-19 pandemic, which runs from January 13 to December 28, 2021.The observation included 375 firms listed on the Thai Stock Exchange and was divided into four major waves of Covid-19 periods. The firm's efficiency can be measured by its capacity to manage its resource efficiency. In an uncertain scenario, an efficient firm has a lesser sensitivity than an inefficient firm as well as a greater ability to handle revenue shock. To determine firm efficiency, two methods are used: data envelopment analysis (DEA) and stochastic frontier analysis (SFA). The SFA results show a significant positive relationship between the stock return and the firm efficiency. As a result, the SFA provides more accuracy than DEA. The DEA can also be used to determine firm efficiency roughly for estimated results.

Keywords: Covid-19 in Thailand, SFA, DEA, Firm efficiency

Introduction

In 2019, during the global COVID-19 pandemic, particularly in Thailand, many factors pulled the stock price downward (Narayan and Phan, 2020). The firms encountered the disturbance factor to their core business, which led to the generation of low revenue immediately after city lockdowns and social distancing policies. At that moment, the uncertainty factor collapsed all the stock markets from many directions. All firms faced

uncertainty regarding cash inflow and their business plan, increasing default risk (Liu et al., 2021). A firm must allocate its available resource to the productive segment (Kuppuswamy and Villaglonga, 2016; Matvos and Seru, 2014; Stein, 1997, 2003). Most firms focus on their cost and production efficiency. The cost minimization will improve the profitability of the firm. Most firm performance and athletic activity are respectively represented on the balance sheet and the annual report (Nickell, Nicolitsas, & Dryden, 1997). Investors will also examine the details before taking any investment action.

This research aims to find the relationship between stock return and firm efficiency in the Thailand Stock Market during the revenue shock and uncertainty of the Covid-19 crisis. An additional objective is to capture the abnormal return by using firm efficiency. Investors should value efficient firms more than inefficient ones during a crisis. An efficient firm with a low cost will allow additional companies to maintain their position during the economic downtrend. Therefore, an efficient firm should generate more return than an inefficient one, reflecting the stock price (IMF, 2000). The efficiency measures how well the firm can convert the input to output; it is also an important element in asset pricing (Cochrane, 1991). An efficient firm can determine its performance and resourcefully use its limited resource by minimizing its cost and maximum profitability (Demesetsz, 1973; Peltzman, 1977). This research will use the competence of the firm performance to imply efficiency. The efficiency of using resources will reflect future cash flows and stock prices (Fama, 1990; Subrahman & Titman, 2001; Vuolteenaho, 2002). Several firm efficiency measures, such as financial resources (Nickell, Nicolitsas, & Dryden, 1997), capital structure (Margaritis & Psillaki, 2010), and corporate research and development (Kumbhakar, Ortega-Argilés, Potters, Vivarelli, & Voigt, 2012), are available. The earliest firm performance will indicate the firm efficiency. The efficiency of the firm, which is determined from the earliest firm performance to capture the relation between stock return and firm efficiency, will be obtained based on stochastic frontier analysis (SFA) (Nguyen & Swanson,2009) and data envelopment analysis (DEA) (Frijns et al., 2012). Investors should value the efficient firm more than the inefficient one (Frijns et al., 2012) during the stock collapse and the uncertainty of the economy.

This research uses the data of a listed company on the Stock Exchange of Thailand for at least two years before 2020. The stock return data set does not include the financial sectors and the stock with a price of less than one baht. An observation period is classified into four waves by the World Health Organization Thailand. The efficiency score was obtained from the

SFA and DEA methodology. The SFA and DEA calculated the accounting data and financial ratios for 2019 and 2020.

The empirical research presents the positive relationship between stock return and firm efficiency based on the US market during Covid-19 (D. Neukirchen et al., 2020). The current study uses the SFA and DEA to score firm efficiency. Covid-19 is a medical crisis that impacts world business. As an emerging market, Thailand also experienced the impact of spreading Covid-19. Therefore, efficient firms in Thailand still received a minimal impact from the shock in business activities during Covid-19. This research also aims to investigate the effect of firm efficiency and stock return during each wave of the Covid-19 pandemic in Thailand.

Review of Literature

Firm efficiency measures how well the firm production can convert the input (resource) to the output (goods). High efficiency is observed when a single unit of input can produce increased output. Firm efficiency is classified as productive and allocative. Productive efficiency is the concept of producing with the lowest average cost in the short run of production, while allocative efficiency is the resource optimization to reach the lowest cost. The firm must manage to obtain the lowest cost at the optimal point to provide the same output. The efficiency will be present in the output ratio over the input (Fried et al., 2008). The input and output demonstrate a relationship under the cost and revenue functions. The cost function is established from the given output, and the optimal input that must be used is identified. Most companies use this function to minimize costs. The revenue function is employed to find the maximum output from the given input. This function aims to find the maximum output from the available resource. During a crisis that impacts revenue, the company should use the cost function to determine the appropriate input for its production to generate the highest firm efficiency. Therefore, the efficiency of the firm can be determined from the production frontier, which represents the relation between the maximum output for each input condition. Thus, each production plot on the production frontier is an efficient portion. Suppose the plotline below the production frontier will represent the firm inefficient. The optimal point of the production function that leads to the scale of the economy is the point that tangents to the production frontier, which can produce the maximum possible productivity (Coelli et al., 2010). The low production cost of the company during the Covid-19 should improve firm profitability and increase firm efficiency.

The firm efficiency score in this research comes from two methods. The first one is DEA, which uses linear programming and determines the score by ranking the most efficient firm. The second method is SFA, which determines the efficiency score from the parametric variable and is computed as the efficiency score from the input and output.

The firm efficiency can be determined by its operation. The operation represents the ability to manage the resources to generate the company's cash flow. (Fama, 1990; Subrahmanyan and Titman, 2001; Vuolteenaho, 2002). This cash flow will provide a strong position for the company and reflect the price in the financial market. The efficient firm will also have relatively large market shares and high profits because of its low production cost (Demsetz, 1973; Peltzman, 1977). These kinds of reasons are attractive to risk-averse because of the increased certainty of the company's operating cash flow and return to equity. The certainty of the cash flow will minimize the default risk of the company (Frijins et al., 2012).

This research will focus on the relationship between the firm efficiency score of the firm, which can be computed from SFA and DEA, and stock return. Several research papers link firm efficiency and the stock return or firm value measurement. For example, the study of SFA to determine firm efficiency (Habib & Ljunqvust, 2005) used firm inefficiency as the agency cost proxy. Results revealed that inefficiency decreases the firm value. The study of DEA determines the efficiency score as a proxy for managerial ability (Demerjan et al., 2009). The result shows a positive relationship between ability, compensated schemes, and performance. Some research used firm efficiency as an important component of the asset pricing model (e.g., Cochrane, 1991; Liu, Whited, & Zhang, 2009). Previous research was conducted using the SFA to determine firm efficiency in the US market from 1975 to 2004, and their result shows a negative relationship between the efficiency of the firm and stock return (Ang, Lam, & Wei, 2020; Imrohoroglu & Tüzel, 2014; Nguyen & Swanson, 2009). The relationship between firm efficiency by DEA and US stock return from 1988 to 2007 (Frijns et al., 2012) is positive. They showed that the efficient firm outperformed the inefficient firm. During the Covid-19 crisis, the firm efficiency of SFA and DEA has a positive relationship and a significant explanatory power to stock returns (Daniel Neukirchen,2022).

H_1: The investor should value the efficient firm more than the inefficient one during the Covid-19 crisis.

In 2019, the global health crisis called Covid-19 significantly impacted the world, particularly in Thailand. Companies continue to face the impact of the pandemic, and the effects have differed across sectors, financial markets, and economies (Ratnasingam et al., 2020). The companies suffered declining performance (Fu and Shen 2020). The crisis produced an unknown shock to the society and economy worldwide. The unpredictable speed of virus spread, its intensity level to humans, the timing of the spread and recovery, and unavailable vaccination led to low activities in society (Ozili & Arun, 2020). The economy is also affected by the slowdown of social activities (Yun Ke, 2022). Consumers immediately lowered their consumption. Companies slowed down their production and immediately stopped some sectors due to the low consumption and the lockdown announcement from the government. Firm costs continued to increase as the revenue from productivity slowed down (Banker et al., 2013). The necessary fixed costs and personnel expenses drove the cashout. A long-term "cash deficit" leads to colossal cash flow pressure for firms in industries seriously affected by the pandemic (Qin et al., 2020). Therefore, the low cost of the business production will reduce the firm expenditure, which is the most significant effect on profit or loss immediately from the revenue shock (Demsetz, 1973: Peltman, 1977).

H_2: The high production efficiency company will receive minimal impact from the revenue shock during Covid-19.

Research Methodology

Data

The observation data contained 375 listed firms in Thailand's stock market before 2018. The sample excludes the financial sector. The stock price of the data is not lower than one baht. The data are separated into two main parts. The first part is the accounting data used to calculate the firm efficiency score and control variable. The second part is a stock price used for calculated stock and abnormal returns.

Table 1 present the comparison of the estimated parameter and expected sign between SFA assuming Cobb -Douglas and Linear regression based on the accounting data of the year 2019 and 2020. Both of them are include industry fixed effect based on the sector classification of SET. Standard error are reported in parenthesis, with ***, **, * denoting statistical significant as the 1%,5% and 10% level.

Dependent variable ln (Market equity)	Linear Regression	SFA assuming Cobb -Douglas	Expected sign
ln (Total asset).	1.0047*** (0.0210)	1.6857*** (0.0399)	+
CAPEX/Sales.	0.3510* (0.1565)	0.0132*** (0.0035)	+
Long-term debt/asset.	-1.8966*** (0.2415)	-0.0054*** (0.0016)	-
EBITDA/sales.	0.2369*** (0.0579)	0.0193*** (0.0035)	+
R&D / sales.	14.1549 (9.1447)	-0.0056 (0.0064)	+
NET property/ sales.	-0.0533* (0.0241)	-0.0228*** (0.0041)	-

Table 1 represents the independent and dependent variables for determining the firm efficiency score. The independent variable can be used from the accounting and financial sections of the balance sheet and the company's annual report, respectively. This research will use the yearend data of 2019 and 2020 of Thailand's listed company on its stock exchange.

The first variable is the natural logarithmic of total assets, which is a positive expected sign (Demsetz and Villalonga, 2001). The log function downsizes the total assets for the calculation. The positive expected sign means that the size of the firm positively impacts the firm valuation. The second variable is the CAPEX per sale used to determine the hard spending for the firm Habib and Ljungqvist (2005). The expected sign is positive for the firm seeking an

investment opportunity to generate the valuation and expand its capacity. The third variable is the negative long-term debt per asset because it is interpreted as the firm leverage. The positive expected sign shows the high concentration of credit monitoring, which controls the firm use of funds based on regulation and debt policy. Meanwhile, the negative expected sign determines the high cost of capital in the extended run liability, which reduces the firm value by a limited profit margin. The fourth variable is EBITDA/sales, represented by the free cash flow to firm Palia (2001). This variable is a positive expected sign because it is the primary effect, which indicates that high free cash flow to a firm increases the firm valuation. The R&D represents the soft spending of the firm. Morck, Shleifer, and Vishny (1988) and McConnell and Servaes (1990) indicate that soft spending is a positive expected sign, which can generate firm valuation by increasing the reputation and being well known to the customer. It also reduces their cost of equity by increasing firm liquidity and visibility. The last parameter is the net property per sale. This parameter can interact with the degree of capital intensity. The negative expected sign shows the contrast of the high leverage of the firm in funding. These variables are all used to conduct the SFA based on the rationale and its expected relationship.

Table 1 compares the sign of parameters among the SFA assuming the Cobb–Douglas production function, which is the default setting of SFA and the linear regression, and the expected sign from the collecting data with their standard error and the statistical significance. The independent variables of data collection all agree with the expected sign. For SFA, most independent variables agree with the expected sign and significantly explain the market value. However, five out of six independent variables have significantly explained the market equity, which is the dependent variable. R&D is an unexplainable factor in Thailand's stock market. Most companies are in the mature stage and contain minimal growth. Thus, the accounting report of the Thai firm from 2019 to 2020 shows fewer data on R&D than the US firm

The observation period is separated into four main waves. The first wave started from the first case of the Covid-19 announcement in Thailand until zero cases of Covid-19 infection were maintained for five days. Therefore, the period started from 13 JAN 2020 to 13 MAY 2020. The second wave is the Samutsakorn cluster, which started on 18 DEC 2020 to 31 MAR 2021. The third wave of the Thonglor cluster started from 1 APR 2021 to 20 MAR 2021. The fourth wave is the construction campsite from 21 MAR 2021 to 28 DEC 2021. The wave classification is based on the announcement of the World Health Organization Thailand. The super spreader

cluster mainly classifies the first two waves. Waves three and four are classified by the detection of a new type of variant in Thailand. The stock return is the output or the dependent variable. The stock return must change to log return before regression. The abnormal return is computed from the market model estimation based on 2019.

Firm efficiency

Firm efficiency measures how well the firm production converts the resource or the input and turns it into the output. This research uses SFA and DEA methods for efficiency measurement. The efficiency of the firm will use the accounting data as a proxy to determine the firm efficiency. The firm efficiency is examined on a market-based model. The market value of a firm is used as the output measure and the ability of a firm to transform inputs into shareholder value is considered. The input of the production function is the firm asset, capital expenditure per sale, long-term debt per asset, EBITDA per sales, R&D per sales, and net property plant and equipment per sales, that is, the efficiency score measures among the firm in a similar industry in the same year. The efficiency is controlled by the industry classification of the Stock Exchange of Thailand.

DEA is a nonparametric function conducted through linear programming. The parameter is the same as the SFA for the input and output variables. The score is between 0 and 1, representing the efficiency score in percentage form. The score is compared among the peer groups. The highest efficiency will represent the maximum score. The equation of the linear programming aims to determine the directional distance function from maximized distance to the frontier from the input, output, and VRS constrain. The frontier is created by the most efficient score. The most efficient firm has $\boldsymbol{\lambda}$=0, which is consistent with the frontier. The large value of $\boldsymbol{\lambda}$ or $\boldsymbol{\lambda}$>0 indicates minimal efficiency deviation from the frontier considering input to output conversion. The DEA equation for this research is shown as Eq. (1). The DEA function has three constraints: the maximized output from the $\boldsymbol{\lambda}$, minimized input from the $\boldsymbol{\lambda}$, and the VRS constraint. The firm efficiency is computed from the output/input in Eq. (1).

$$\vec{D}(x_i, y_i, g_x, g_y) = \max \lambda$$
$$s.t. \sum_{J=0}^{J} z_j \, y_{jm} \geq y_m + \lambda g_{ym} \quad \forall m \tag{1}$$

$$\sum_{J=0}^{J} z_j \, x_{jn} \leq x_n - \lambda g_{xn} \quad \forall n$$

$$z_j \geq 0 \; \forall j \;\; and \sum_{j=0}^{j} z_j = 1$$

The Second method this research uses to find firm efficiency is SFA. It was founded by Aigner, Lovell, and Schmidt (1997). Therefore, we apply the SFA equation from Nguyen and Swanson (2009). It starts by classifying the group of the company ($\emptyset_i$) facing the same operating condition. The inputs of the equation are referred to as each of the opportunity set that the firm uses to create the firm value, which is the output of the equation. All of the variable and the parameter is shown as eq (2).

$$\ln(MARKET\ EQUITY)_i = \emptyset_i + \beta_0 + \beta_1 \ln(TOTAL\ ASSET)_i + \beta_2 \left(\frac{CARPEX}{SALES}\right)_i + \beta_3 \left(\frac{LONGTERM\ DEBT}{ASSETS}\right)_i + \beta_4 \left(\frac{EBITDA}{SALES}\right)_i + \beta_5 \left(\frac{R\&D}{SALES}\right)_i + \beta_6 \left(\frac{NET\ PROPERTY}{SALES}\right)_i + v_i - u_i \quad (2)$$

SFA is the second method in this research that is used to find firm efficiency. This method was founded by Aigner, Lovell, and Schmidt (1997). Therefore, the SFA equation from Nguyen and Swanson (2009) is used. The method starts by classifying the group of the company ($\emptyset_i$) under the same operating condition. The inputs of the equation are referred to as each of the set opportunities that the firm uses to create the firm value, which is the output of the equation. All the variables and parameters are shown as in Eq. (2).

The SFA estimates the relative firm efficiency scores of all firms in the sample year (Tze Chuan et al., 2021). The frontier will compare the efficiency from the function of input, output, and the error term. The highest efficiency of the firm is the point on the frontier. The point that deviated from the frontier is determined to form the error term of the function, which represents an inefficiency. The efficiency score is calculated from the error term of the equation. The high-efficiency firm has a high SFA score. The efficiency score will range between 0 and 1 as shown in Eq. (3).

$$EFF_i = \frac{\ln(Y)_i}{f(X,\beta)exp(v_i)} \quad (3)$$

Cross-sectional Regression

The two models for run regression are used in this section. The first model runs the log daily cumulative stock return regression as a dependent variable and the firm efficiency and other control variables as an independent variable. This model captures the significant explanation factor of firm efficiency by SFA and DEA during each wave of the Covid-19 pandemic. The second model, which runs the regression between abnormal returns based on the market model from 2019, is used to regress with the firm efficiency score from SFA and DEA with and without the firm control variable. The main reason is to find the relationship between the firm efficiency and abnormal return during the Covid-19 pandemic. The characteristic of the firm comprises total assets, long-term debt per asset, short-term debt per asset, cash per asset, ROA, and historical volatility. The total asset determines the firm size effect. The long-term debt per asset presents the leverage percentage on a fixed asset and project planning. The short-term debt per asset shows the leverage percentage on operating activity. ROA shows how the company utilizes their asset to generate income. The book-to-market value shows the valuation of investors compared with the book value. Historical volatility shows the fluctuation of the stock price. The independent variable is firm efficiency, and the firm characteristic control variable is shown in Eq. (4). The regression will determine the coefficient and the significance of the parameter. The model will control the industry classification as a dummy variable. The firm efficiency score is calculated from the accounting data for one lag period.

$$\ln(RAW\ RETURN)_{it} = \emptyset_i + EFF_{it-1} + \beta_2 \ln(TOTAL\ ASSET)_{it} + \beta_3 \left(\frac{LONG\ TERM\ DEBT}{ASSETS}\right)_{it} + \beta_4 \left(\frac{SHORT\ TERM\ DEBT}{ASSETS}\right)_{it} + \beta_5 \left(\frac{CASH}{ASSETS}\right)_{it} + \beta_6\ ROA_{it} + \beta_7\ MARKET\ TO\ BOOK_{it} + \beta_8\ HISTORICAL\ VOLATILITY_{it} + u_{it} \quad (4)$$

The abnormal return, firm efficiency, and characteristic regression are shown in Eq. (5). The abnormal return is calculated from the return of 2020 minus the expected return from the market model from Jan 2019 to DEC 2019. T_1 and t_2 are the starting and ending windows in each wave of the Covid-19 pandemic, respectively. The regression of commutative abnormal return in each wave and the firm efficiency by controlling the industry dummy from the Stock Exchange of Thailand classification is based on the explanation factor of the firm

efficiency score. This research mainly focuses on how much the firm efficiency can explain the abnormal return during the Covid-19 crisis. The firm efficiency score is determined on the basis of the accounting data for one lag period.

$$CAR_{i,(t1,t2)} = \emptyset_i + EFF_{it-1} + \beta_2 \ln(TOTAL\ ASSET)_{it} + \beta_3 \left(\frac{LONG\ TERM\ DEBT}{ASSETS}\right)_{it} + \beta_4 \left(\frac{SHORT\ TERM\ DEBT}{ASSETS}\right)_{it} + \beta_5 \left(\frac{CASH}{ASSETS}\right)_{it} + \beta_6\ ROA_{it} + \beta_7\ MARKET\ TO\ BOOK_{it} + \beta_8\ HISTORICAL\ VOLATILITY_{it} + u_{it} \quad (5)$$

Where: $CAR_{i,(t1,t2)} = \sum_{t=t_1}^{t_2} AR_{i,t}$, $AR_{i,t} = R_{i,t} - \hat{\alpha}_i - \hat{\beta}_i R_{m,t}$, $R_{i,t} = \alpha_i + \beta_i R_{m,t} + u_{i,t}$,

Results And Discussion

The observation period of Covid-19 in this research paper is identified in four waves. The return and abnormal return for each wave are classified in the descriptive statistic table. The stock return in the first wave is negative and shows a slightly positive abnormal return. In the second wave, the stock and abnormal returns rapidly increased compared with the first wave. The stock and abnormal returns demonstrated high trends in the third and fourth waves of Covid-19.

Table 2 presents the firm efficiency score from 2019 and 2020. Each year contains SFA and DEA firm efficiency. The scores from the program range from 0 to 1. A high score indicates high firm efficiency. The other independent variables include the firm characteristics with high concerns from most investors. Therefore, this research used these firm characteristics as the control variable. The descriptive statistic of all variables is presented in Table 2 The total observation contains 375 firms from 2019 and 375 firms from 2020. The total observation is 750. The correlation between the SFA and DEA firm efficiency in 2019 is approximately 36%, while the correlation between SFA and DEA in 2020 is 43% based on the observation data.

Table 2 This table shows the descriptive statistic of the 375 companies on Thailand's Stock exchange of Thailand during the covid-19 pandemic. Wave 1 (13 JAN 2020 to 13 MAY 2020). Wave 2 (18 DEC 2020 to 31 MAR 2021). Wave 3(1 APR 2021 to 20 MAY 2021). Wave 4 (21 MAY 2021 to 28 DEC 2021). The firm efficiency 2019 and 2020. Stock and accounting data are from Data steam. The definition of all variables is in the appendix

Variable	Obs.	Mean	Median	Std.	Min	Max
Return wave 1	375	-0.17	-0.15	0.21	-1.17	0.74
Return wave 2	375	0.14	0.11	0.19	-0.29	0.96
Return wave 3	375	0.02	-0.01	0.15	-0.44	0.75
Return wave 4	375	0.07	0.02	0.24	-0.52	1.69
Abnormal return wave 1	375	0.01	0.00	0.24	-0.95	1.10
Abnormal return wave 2	375	0.12	0.11	0.23	-0.42	1.16
Abnormal return wave 3	375	0.06	0.02	0.16	-0.43	0.84
Abnormal return wave 4	375	0.09	0.06	0.30	-0.74	1.45
SFA 2019	375	0.94	0.95	0.02	0.85	0.98
DEA 2019	375	0.95	0.96	0.05	0.80	1.00
Size 2019 (Million)	375	37,900.00	5,515.04	149,000.00	332.53	2,440,000.00
Long-term-debt 2019 (Million)	375	9,777.12	238.67	38,400.00	0	563,000.00
Short-term-debt 2019 (Million)	375	3,351.43	555.03	10,700.00	0	137,000.00
Cash 2019	375	2,743.49	256.62	16,100.00	0.10	281,000.00
ROA 2019	375	5.74	5.28	6.47	-20.02	38.22
Market-to-book 2019	375	2.15	1.46	2.32	0.31	26.90
Historical volatility 2019	375	0.31	0.29	0.16	0.05	2.20
SFA 2020	375	0.94	0.94	0.02	0.84	0.98
DEA 2020	375	0.95	0.96	0.05	0.80	1.00
Size 2020 (Million)	375	41,500.00	6,188.84	158,000.00	480.50	2,490,000.00
Long-term-debt 2020 (Million)	375	13,000.00	454.79	51,400.00	0	710,000.00
Short-term-debt 2020 (Million)	375	3,843.14	583.12	11,900.00	0	144,000.00
Cash 2020	375	3,369.35	296.46	18,800.00	0.10	325,000.00
ROA 2020	375	4.27	4.28	7.13	-24.15	29.47
Market-to-book 2020	375	1.74	1.13	1.83	0.2	13.01
Historical volatility 2020	375	0.30	0.28	0.13	0.05	1.37

Table 3 shows the OLS regression with the cumulative stock return during the covid-19 pandemic in Thailand in four different waves. Column (1) and (2) is the first wave of the Covid-19 pandemic (13 JAN 2020 to 13 May 2020). Columns (3) and (4) are the second wave (18 DEC 2020 to 30 Mar 2021). Columns (5) and (6) are the third wave of the pandemic (1 Apr 21 to 20 Mar 21). Columns (7) and (8) are the fourth wave of the pandemic (21 Mar 21 to 28 Dec 21) as a dependent variable. For the independent variable DEA score from the years 2019 and 2020. All of the regression is controlled by the industry fixed effect based on the SET classification sector. Standard errors are reported in parenthesis, with ***, **, and * denoting statistically significant as the 1%,5%, and 10% levels.

Dependent Variable: Raw returns

	Wave 1		Wave 2		Wave 3		Wave 4	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DEA	0.3864	0.3433	- 0.7053**	-0.4885*	-0.2829	-0.1940	0.1063	-0.040
	(0.2174)	(0.2715)	(0.1969)	(0.2431)	(0.1514)	(0.1943)	(0.2385)	(0.3085)
Size		-0.0224**		-0.0173*		-0.0049		-0.0121
		(0.0081)		(0.0071)		(0.0057)		(0.0090)
Long-term		0.1755		-0.0255		-0.0902		-0.0108
debt / assets		(0.1035)		(0.0827)		(0.0661)		(0.1050)
Short-term		0.0207		0.3476***		0.2738***		0.1349
debt/ assets		(0.0931)		(0.0948)		(0.0758)		(0.1203)
Cash/assets		-0.031		0.2721*		-0.0244		0.5023**
		(0.1551)		(0.1231)		(0.0984)		(0.1563)
ROA		0.0040*		0.0022		-0.0018		-0.0052**
		(0.0017)		(0.0014)		(0.0011)		(0.0018)
Market-to		0.0040		-0.0189**		-0.0115*		-0.0020
-book		(0.0054)		(0.0063)		(0.0050)		(0.0080)
Historical		-0.1216		0.2550**		-0.1027		-0.1048
Volatility		(0.0660)		(0.0780)		(0.0623)		(0.0990)
Observations	375	375	375	375	375	375	375	375
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects								
F-test	39.06	22.41	29.1	21.93	2.65	3.50	8.24	6.20
R^2	0.46	0.48	0.39	0.47	0.05	0.13	0.15	0.21
Adjusted- R^2	0.45	0.46	0.37	0.46	0.03	0.09	0.13	0.17

Table 4 shows the OLS regression with the cumulative abnormal return during the covid-19 pandemic in Thailand in four different waves. Column (1) and (2) is the first wave of the Covid-19 pandemic (13 JAN 2020 to 13 May 2020). Columns (3) and (4) are the second wave (18 DEC 2020 to 30 Mar 2021). Columns (5) and (6) are the third wave of the pandemic (1 Apr 21 to 20 Mar 21). Columns (7) and (8) are the fourth wave of the pandemic (21 Mar 21 to 28 Dec 21) as a dependent variable. For the independent variable DEA score from the years 2019 and 2020. All of the regression is controlled by the industry fixed effect based on the SET classification sector. Standard errors are reported in parenthesis, with ***, **, and * denotes statistically significant as the 1%,5%, and 10% levels.

Dependent Variable: Abnormal returns

	Wave 1		Wave 2		Wave 3		Wave 4	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DEA	0.2481	0.2623	- 0.9188***	-0.7359**	-0.4697**	-0.2851	-0.4693	-0.5678
	(0.2605)	(0.3283)	(0.2299)	(0.2749)	(0.1609)	(0.2044)	(0.3045)	(0.3734)
Size		-0.0019		-0.0328***		-0.0057		-0.0326**
		(0.0098)		(0.0080)		(0.0060)		(0.0109)
Long-term		0.1595		-0.0979		-0.1007		-0.1356
debt / assets		(0.1252)		(0.0936)		(0.0696)		(0.1271)
Short-term		0.0601		0.3876***		0.3046***		0.2119
debt/ assets		(0.1125)		(0.1072)		(0.0797)		(0.1456)
Cash/assets		0.0014		0.2395		-0.0203		0.4752*
		(0.1875)		(0.1392)		(0.1035)		(0.1891)
ROA		-0.0005		-0.0004		-0.0011		-0.0100***
		(0.0021)		(0.0016)		(0.0012)		(0.0022)
Market-to		0.0121		-0.0288***		-0.0172**		-0.0181
-book		(0.0066)		(0.0072)		(0.0053)		(0.0097)
Historical		0.0609		0.1379		-0.0504		-0.1860
Volatility		(0.0798)		(0.0882)		(0.0656)		(0.1198)
Observations	375	375	375	375	375	375	375	375
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects								
F-test	2.48	1.95	19.69	18.81	8.98	7.72	8.89	9.99
R^2	0.05	0.08	0.30	0.44	0.16	0.24	0.16	0.29
Adjusted-R^2	0.03	0.04	0.29	0.42	0.16	0.21	0.14	0.26

Table 5 shows the OLS regression with the cumulative stock return during the covid-19 pandemic in Thailand In four different waves. Column (1) and (2) is the first wave of the Covid-19 pandemic (13 JAN 2020 to 13 May 2020). Columns (3) and (4) are the second wave (18 DEC 2020 to 30 Mar 2021). Columns (5) and (6) are the third wave of the pandemic (1 Apr 21 to 20 Mar 21). Columns (7) and (8) are the fourth wave of the pandemic (21 Mar 21 to 28 Dec 21) as a dependent variable. For the independent variable SFA score from the years 2019 and 2020. All of the regression is controlled by the *industry* fixed effect based on the SET classification sector. Standard errors are reported in parenthesis, with ***, **, and * denotes statistically significant as the 1%,5%, and 10% levels.

Dependent Variable: Raw returns

	Wave 1		Wave 2		Wave 3		Wave 4	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SFA	1.0867*	0.8883	- 2.9586***	-2.6499**	-1.1444***	-0.7864	-0.7439	-0.7137
	(0.4441)	(0.5893)	(0.3818)	(0.2749)	(0.3069)	(0.4057)	(0.4890)	(0.6457)
Size		-0.0243**		-0.0166		-0.0045		-0.0072
		(0.0082)		(0.0080)		(0.0056)		(0.0089)
Long-term		0.1544		0.0290		-0.0669		-0.0072
debt / assets		(0.0966)		(0.0726)		(0.0598)		(0.0951)
Short-term		0.0383		0.2556**		0.2502**		0.1042
debt/ assets		(0.0947)		(0.1072)		(0.0766)		(0.1219)
Cash/assets		-0.0910		0.2884*		-0.0219		0.5104**
		(0.1547)		(0.1392)		(0.0977)		(0.1555)
ROA		0.0032		0.0036**		0.0022		-0.0049**
		(0.0018)		(0.0016)		(0.0011)		(0.0018)
Market-to		0.0015		-0.0044		-0.0078		0.0069
-book		(0.0056)		(0.0072)		(0.0054)		(0.0086)
Historical		-0.1099		0.2125**		-0.1125		-0.1207
Volatility		(0.0667)		(0.0882)		(0.0620)		(0.0987)
Observations	375	375	375	375	375	375	375	375
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects								
F-test	39.71	22.5	38.42	25.07	4.01	3.71	8.55	6.30
R^2	0.46	0.48	0.45	0.51	0.08	0.13	0.16	0.21
Adjusted-R^2	0.45	0.46	0.44	0.49	0.06	0.10	0.14	0.17

Table 6 shows the OLS regression with the cumulative abnormal return during the covid-19 pandemic in Thailand In four different waves. Column (1) and (2) is the first wave of the Covid-19 pandemic (13 JAN 2020 to 13 May 2020). Columns (3) and (4) are the second wave (18 DEC

2020 to 30 Mar 2021). Columns (5) and (6) are the third wave of the pandemic (1 Apr 21 to 20 Mar 21). Columns (7) and (8) are the fourth wave of the pandemic (21 Mar 21 to 28 Dec 21) as a dependent variable. For the independent variable SFA score from the years 2019 and 2020. All of the regression is controlled by the industry fixed effect based on the SET classification sector. Standard errors are reported in parenthesis, with ***, **, and * denoting statistically significant as the 1%,5%, and 10% levels.

Dependent Variable: Abnormal returns

	Wave 1		Wave 2		Wave 3		Wave 4	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SFA	1.3407*	1.8147*	- 4.2719***	-3.5592***	-1.8178***	-1.2116**	-3.399***	-2.4673**
	(0.5301)	(0.7072)	(0.4282)	(0.5508)	(0.3208)	(0.4249)	(0.6023)	(0.7743)
Size		-0.0056		-0.0316		-0.0052		-0.0316**
		(0.0098)		(0.0076)		(0.0059)		(0.0107)
Long-term		0.1863		-0.0132		-0.0670		-0.0686
debt / assets		(0.1159)		(0.0811)		(0.0626)		(0.1141)
Short-term		0.1136		0.2701**		0.2673***		0.1349
debt/ assets		(0.1136)		(0.1040)		(0.0802)		(0.1462)
Cash/assets		-0.0154		0.2574		-0.0159		0.4849**
		(0.1856)		(0.1327)		(0.1024)		(0.1866)
ROA		-0.0019		0.0015		0.0017		-0.086***
		(0.0021)		(0.0015)		(0.0012)		(0.0922)
Market-to		0.0058		-0.0102		-0.0113*		-0.0059
-book		(0.0067)		(0.0074)		(0.0058)		(0.0103)
Historical		0.0899		0.0853		-0.0663		-0.2192
Volatility		(0.0800)		(0.0842)		(0.0650)		(0.1184)
Observations	375	375	375	375	375	375	375	375
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects								
F-test	3.20	2.38	34	22	12.42	8.26	13.26	10.72
R^2	0.07	0.09	0.43	0.48	0.21	0.26	0.22	0.31
Adjusted- R^2	0.04	0.05	0.41	0.47	0.20	0.23	0.21	0.28

Tables 3 and 5 show the relationship between the firm efficiency and the cumulative daily stock return in each wave of Covid-19 in Thailand. The relationship of abnormal returns is present in Tables 4 and 6. The research presents the positive relationship between firm efficiency and stock return. Covid-19 created a shock to the revenue in the business operation. This shock came from the prevention and control policy of the government. The unknown

shock occurred in the first wave of Covid-19. An efficient firm can manage its resources to reduce the impact by minimizing input and maximizing output in production. The cost minimization of the firm production during the economic slowdown provides the firm with increased profitability or a reduced loss that reaches the probability of default. The efficient firm has more chance to maintain its position and lower default than the inefficient firm. The investors value the efficient firm more than the inefficient one in the first unknown shock. The result shows that the impact on efficient firms in the first wave was less than that on the inefficient firm.

The second, third, and fourth waves of the Covid-19 demonstrated the negative relationship between firm efficiency and stock return. The impact of Covid-19 in the aforementioned waves simultaneously disturbed production and revenue. The effect of the shutdown and site separation is inefficient for the available resources of the firm. The transportation and shock in the supply chain also impacted the firm production. A firm with high efficiency usually has a higher production cost than an inefficient firm. Therefore, the efficiency score of the efficient firm drops more than the inefficient firm in the second to the fourth wave.

The cause and effect of Covid-19 are unpredictable. However, the impact of this pandemic on businesses lies in the lockdown event, which shocks the firm activity and revenue. This research paper covers the observation period from 13 JAN 21 to 28 DEC 21. The observation period is divided into four waves, which are extended from firm efficiency and stock returns during the COVID-19 crisis based on the US market. The paper covers only the collapsed period (3 Feb 2020 to 23 Mar 2020), which is defined in Fahlenbrach et al. (2020). Therefore, the result of the explainable factor of firm efficiency (SFA and DEA) is consistent compared with the first wave of Covid-19 in Thailand with the collapsed period in the US market. An observation period of the first wave of Covid-19 in Thailand is similar to the collapsed period in the US market as defined in the main paper (D. Neukirchen et al., 2021). Another research on the US market from 1988 to 2007 shows that efficient firms outperform inefficient firms (Frijns et al., 2012). However, firm efficiency (SFA) is still the explainable factor for stock return for the first three waves and abnormal return for all four waves of the observations. The sample period is excessively long, and disturbance from another event

during the crisis is unavoidable. However, the negative relationship between stock return and firm efficiency (SFA) is stated in financial research papers. The paper shows the negative relationship between firm efficiency (SFA) and cross-sectional stock return from1999 to 2019 evidence on the Australian market (Tze Chuan et al., 2021). Alternatively, the SFA is more precise than the DEA for measuring the firm efficiency analysis. The correlation between the SFA and DEA in the sample is 36% to 43%. Therefore, both analyses technically measure the firm efficiency using similar input and output parameters. However, the difference lies in the method used to compute the firm efficiency. The SFA computed the efficiency from the output and input, whereas the DEA computed the efficiency compared with the firm having the highest efficiency among their peers.

Nevertheless, using an explainable factor may be an option in this case. The most efficient accounting item is always cash and short-term debt during the pandemic, which shows the liquidity of the firm for passing the pandemic.

Conclusions and Recommendations

The research shows the positive relationship between firm efficiency using accounting data to calculate firm efficiency and the cumulative stock return during the first wave of the Covid-19 pandemic in Thailand. The first wave includes the first lockdown until the government announcement of zero Covid-19 infections. The SFA results show a significant positive relationship between the stock return and the firm efficiency. Therefore, an efficient firm receives minimal impact during the first shock of a pandemic. The firm efficiency positively relates to the abnormal return in the first wave of the Covid-19 pandemic. This result is the fulfillment of the objective of the study. The efficient firm calculated from SFA and DEA outperformed the inefficient firm in the first wave of Covid-19 in Thailand. Therefore, a high production efficiency received a minimal impact from the uncertainty in revenue shock, that is, investors value the efficient firm more than the inefficient firm.

The second, third, and fourth waves of the Covid-19 pandemic in Thailand show the negative relationship between firm efficiency and stock return in each wave. Nevertheless, the explainable concept is that the number of Covid-19 infected second, third, and fourth waves higher than that in the first wave. The firm efficiency from accounting information 2020 is used

in these waves. The impact of the lockdown and revenue shock changes the rank and the efficiency firm score. The efficiency of the efficient firm dropped more than the inefficiency firm. The efficient firm in the same industry obtained a high production cost considering the quality and performance of their operation. The second to the fourth wave impacts the operational activity of the factory and company in a larger area than the first wave of Covid-19. This rationale supports the negative relation between the firm efficiency and the stock return or event to the abnormal return.

The firm efficiency (SFA) and the firm efficiency (DEA) show similar signs and meaning in all four waves of Covid-19. Nevertheless, the firm efficiency (SFA) is more significant in explaining all four waves of Covid-19 than the firm efficiency (DEA). The correlation between SFA and DEA is 39%. The difference in the computation method for the firm efficiency impacts the significance of the score.

This research contributed to finding firm efficiency in other emerging markets. Firm efficiency in each wave of Covid-19 is also emphasized. The firm efficiency might capture the stock return during a panic sell other uncertain scenarios, such as a war or future medical crisis. Using the efficiency score from SFA than DEA in the research study is recommended in further studies of the efficiency. The SFA provides more accuracy than DEA. The DEA can also be used to determine firm efficiency roughly for estimated results.

An investor can obtain the arbitrage opportunity from the short inefficient firm and long efficient firm result. The valued investor might use firm efficiency as an additional criterion to form the portfolio. The brokerage can use firm efficiency as a guideline to investors and firms during a panic sale. The fund manager might add the firm efficiency criteria for tracking and analysis of the firm performance of the valued stock.

The regulator might research additional details on firm efficiency and analyze the data on firm efficiency in each industry. The benchmark level is then set as the index for the investor as an alternative criterion for improving an investment strategy. Another application of firm efficiency is the efficiency level, which can be considered in the performance of firm management for improving and identifying the cause of the issue before the occurrence of poor scenarios. The prevention is more effective for the firm than the solution.

The policy maker might use firm efficiency as a criterion for analysis: the cause of efficiency reduction after the crisis in a specific industry, improvement of firm efficiency after the crisis, and supporting the firm to maintain or minimize the impact of the crisis.

The limitation of this research is that it does not cover the entire period of Covid-19. The Covid-19 situation in Thailand is still ongoing until the present time. The Covid-19 pandemic might be excessively long and sensitive to be disturbed by another event. The firm efficiency is determined yearly; however, this research might not reflect the real-time efficiency.

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