The Performance Evaluation of Food and Beverage Industry between Thailand and Vietnam

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Abstract

When life on earth began, food has become the most fundamental human need. The food market witnessed a significant change in its history to satisfy the customer. Nowadays, the food and beverage industry plays a crucial role in the global economy. Specifically, the sector is considered a key source of economic growth in developing countries. Thailand and Vietnam have great advantages for developing the food and beverage industry, however, these industries in both countries are still in a nascent stage, with a lack of competitiveness. The main purpose of this research is to evaluate and compare the performance in Thai and Vietnamese food and beverage industry as well as propose some suggestions to encourage these industries. This research develops an integrated method, based on grey model (GM) to forecast the input and output values of 22 food and beverage companies in Thailand and 20 companies in Vietnam over a four-year period 2014-2017, Data Envelopment Analysis (DEA) model are used to analyze the performance of these companies. Additionally, the performance of the two industries would be compared by using the t-Test method. The results indicate that the Vietnamese industry are more “productivity change” and “efficient business”, as compared to Thailand. This research suggests both countries need to use the natural resources carefully, apply scientific and technological achievements to production, and build up internal strengths of each firm.

Keywords: Food and beverage industry; Data envelopment analysis; Grey Forecasting; MPI; Super SBM; Thailand; Vietnam.

1. Introduction

1.1. The food and beverage industry

The food and beverage industry is extremely broad. However, it can be defined as the preparation of food and beverage products ready for sale and consumption. It involves the sourcing of ingredients, processing, preservation, and packaging. It also includes product research and design, taste testing and marketing [1]. The industry includes the following nine sub-sectors: meat, fish, fruit, vegetables, oils and fats, dairy products, grain, animal feeds, other food products and beverages [2]. There was an industrialization in food industry to meet customer demands. As a consequence, the balance of power has changed in the food chain. In the past, the power was held by farmers who decided which product to sell in the market, then the power was shifted to food manufactures. However, in recent years the urbanization and globalization trend helped give way the power to consumers. Thus, customers currently hold the power to command of food manufacturers and farmers in order to supply the suitable products [3].

1.2. The food and beverage industry in Thailand

Thailand has long been called "the kitchen of the world" with its abundant natural resources, highly-skilled workforce [4]. Thailand is one of the world's leading agricultural suppliers. The food and beverage industry is the country's third largest industry. Major food exports include rice, canned tuna, sugar, meat, cassava products, and canned pineapple. The food industry contributed about 23% of the gross domestic product (GDP) of Thailand. Thailand is also considered as a large net food exporting country in the world and become the second in Asia with a food trade balance at a record value of $36 billion in 2018 [5]. The government of Thailand has paid huge attention in supporting the sustainable development of this industry. With the support of the government, from the early 1960s Thailand applied new technologies to production through the import from Japan and Taiwan. In the 1970s, international standards for manufacturing and product quality control were introduced and implemented in factories, this is a prerequisite for the development of international export markets. As the result of the effective strategies, Thailand achieved notable successes in building its food industry with a growth rate 26% in the 1990s, well-known brand, safe and sustainable development [4].

However, in recent decade the Thai food and beverage industry faces not only the higher demand of customers but also the significant rise of worldwide competition. The industry has to meet competition from other countries such as China, Malaysia, Vietnam, these countries have lower labor costs and large resources [6]. This forces the industry to strengthen its competitiveness, improve business efficiency for maintaining its position in the market.

1.3. The food and beverage industry in Vietnam

The food and beverage industry occupies around 15% of the GDP of Vietnam [7]. Business Monitor International (BMI) predicts that Vietnam's food industry will continue to grow strongly by 2020 with an average increase of 10.9% [8]. The reason behind this growth is the average resident income increased and the higher value consumer trend in recent years. However, the industry is still considered a lack of competitiveness, especially compared to Thailand. The limitations found in this industry include the high unit cost, the failure to increase labor productivity, and the lack of application of scientific and technical achievements in manufacturing [9]

In recent years, Vietnam launched free-market economic as well as attracted foreign investment, one of the most popular trends is the Mergers and Acquisitions (M&A) in the food and beverage sector. For instance, Thai Beverage held a controlling stake in Saigon Beverage Corporation in 2017, in 2015 Masan Group Corporation and Singha Asia Holding Pte., Ltd became strategic partner through value investment $1.1 billion, Fraser & Neave Ltd purchased about 80 million Vinamilk shares [10]. Along with invest capital, foreign businesses also help Vietnamese companies to improve internal management, organizational structure, human resource quality, and product quality. These change trends have helped develop the technology and management system of the Vietnamese companies.

1.4. The motivation of the research

Food and beverage industry is an important element in Thailand and Vietnam economy. This sector accounts for a large amount of gross domestic product, generates more jobs for farmers who often live in poverty areas, increase exports as well as consumes agricultural products [11]. From the global perspective, Vietnam and Thailand are considered as the largest exporters of food and beverage product. In addition, the trend of international integration and regional connections is the strategic direction of developing countries; Vietnam and Thailand are also members of many free trade organizations such as WTO (World Trade Organization), APEC (Asia-Pacific Economic Cooperation), ASEAN (Association of South East Asian Nations), and TPP (Trans-Pacific-Partnership) etc. This is both the challenge and opportunity for the two countries to develop the market as well as create a huge competitive advantage [11]. To be more precise, although both countries have the same natural and human advantages but the value of the food and beverage industry in Vietnam is a half of Thailand's.

However, the Vietnamese industry was seen a dramatic increase in the recent decades as a result of many enterprises currently have been equitized and received investment from foreign companies.

The research combines a grey model and two DEA models to evaluate the performance in Thai and Vietnamese food and beverage industry in the past-present-future stage. In addition, several recommendations are discussed to encourage these two industries. Moreover, the other purpose of this research is the accurate identification of the target companies that will have good performance in the future. This will help managers in each country to make right decisions on allocating resources.

2. Literature Review

2.1. Performance Measurement

Amaratunga & Baldry [13] describe performance measurement as a process of assessing progress towards achieving pre-determined goals, including information on the efficiency by which resources are transformed into goods and services, the quality of those outputs and outcomes, and the effectiveness of organizational operations in terms of their specific contributions to organizational objectives. On the other hand, according to Neely et al. [14] describe performance measurement as the process of quantifying the efficiency and effectiveness of action. It is particularly important to measure the performance of an organization, when the performance is measured, the organization understands how good or bad the performance is with reference to internal and external benchmarks. It can then take up steps to consume resources efficiently, improve the quality, ensure higher customer satisfaction, and meet the strategic objectives [15].

This research uses productivity and efficiency as a measurement of performance. The reasons for this choice of the method are as follows. Measurement of productivity and efficiency helps to evaluate the activities controlled by the management. In addition, efficiency explains the manner in which resources are used and the outcome obtained, and this helps to improve organizational performance. These factors help to improve technical efficiency, increase revenues by increasing productivity, and meet the organizations' objectives [16]. There are many different approaches to the measurement of productivity and efficiency changes in various types of corporations. However, it is essential to select appropriate measurements for productivity and efficiency to avoid measurement bias in results [17]. The current thesis employs the nonparametric method that belongs to the deterministic approach, name DEA, to measure productivity and efficiency.

2.2. Related Research about Food & Beverage Industry

Rani et al. [18] presented an integrated simulation and DEA in improving the performance of the SME food production system in a food company in Malaysia. The result of the combination of these two models helped the company find the best improvement model. The chosen model is "One of the operators at peeling workstation is transferred to the frying workstation. This is equal to five operators at peeling workstation and three operators at frying workstation". The results also provided useful information and good ideas for the food company to strengthen and raise the efficiency of the production system. Rodmanee and Huang [6] applied the relational two-stage Data Envelopment Analysis to evaluate the efficiency of 23 food and beverage companies in Thailand in the year 2011. The results show that most of the companies perform inefficiently. Only one company have high-efficiency score. This research also indicated the importance of efficiency measurement of the food and beverage industry in order to help these companies survive and develop. Based on DEA, Ali et al. [19] calculated efficiency, productivity changes of food processing industry in Indian, the study proposed recommendations to the government and business for enhancing productivity and efficiency.

2.3. Related Research about Industry Forecasting

Depend on the goal of management decision-maker, the appropriate forecasting method will be chosen in order to predict the output forecast with low cost and higher accuracy. Traditional forecasting methods such as regression, time series, exponential smoothing; modified traditional forecasting methods are as following: adaptive demand forecasting, autoregressive moving-average (ARMA) model; soft computing forecasting methods: genetic algorithms, fuzzy are considered as three main forecasting groups [20].

Grey system theory established by Chinese professor Deng [21] in 1982 is a new method to study uncertain problems, the method requires little data and poor information, as compared to other methods [22]. Many articles were found prove its superiority and give support this method of spreading. There are different Grey models but GM (1,1) is the central model that has been most widely employed. The GM (1,1) model has some advantages such as this model does not need to know whether the prediction variables obey normal distribution, and also does not require too much statistic [22]. Bezuglova and Comert [23] proposed grey theory models to forecast the factor analysis of Short-term freeway traffic. The results indicated that the grey models are easy, adaptive and requiring small data to apply. Lin et al. [24] predicted the further rise of CO_2 emissions in Taiwan using grey model. Based on Grey model, Wang et al. [25] predicted and evaluated the productivity of Vietnamese agroforestry industry. These studies showed that Grey system theory could be successfully applied in many fields of science in many countries.

2.4. Related Research about Industry Evaluation

The operation performance of a business is evaluated to help the managers identify whether the resources in the organization are allocated and used in the most effective way [26]. Due to the extreme necessity of performance evaluation for the survival and development purpose, some models related to assess performance were researched and applied. Depend on the purpose of the evaluation as well as the business type of organization, the researcher will make a decision to choose the appropriate model. Some models used popularly in recent periods, including A fuzzy AHP, Balanced scorecard, Data envelopment analysis, The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW) method, Weighted Product (WP). The Balanced Score-Card was developed in the USA at the beginning of the 1990s by Kaplan and Norton [27]. This is a method aims at making the business strategy more measurable and concrete. Using Balanced scorecard, Shafiee et al. [28] evaluated the performance of the supply chain in the Iranian food industry. The results proved the high efficiency of the applied model. TOPSIS is a unique technique to identify the ranking of all alternatives considered. Wang et al. [29] proposed a TOPSIS and Fuzzy AHP to choose the wind power plant location in Vietnam. The result showed that the chosen model is flexible and practical and can be applied in other countries.

However, Data envelopment analysis model which has more some advantages than other models was chosen in the research. These benefits such as the model does not predefine any functional form for the production function, it is not financially-oriented, instead the objective is to perform an analysis of the process of the transformation of inputs into outputs that generate a measurement or set of measurements, which reflect the efficiency of a firm with regard to this transformation process, in addition, it can incorporate a number of inputs and outputs into the analysis, and, moreover, these inputs and outputs can be of any nature; the only necessity is the availability of a unit of measurement, which allows the assessment of its magnitude [30].

After it was introduced by Charnes, Cooper, and Rhodes (1978) [31], DEA has been widely used to estimate comparative efficiencies in various field in many countries. DEA is an approach to measuring the relative efficiency of a set of decision-making units (DMUs) with multiple inputs and multiple outputs using mathematical programming. DEA-based Malmquist productivity index (MPI) has proven to be a very useful tool for measuring the productivity changes of DMUs whereas the super slack-based measure (Super SBM) model is an analysis tool with a super-efficiency measure in DEA that can solve directly with slacks in inputs/outputs and compare values with the super-efficiency measures using the radial expansion or reduction of input/output directly. Wang and Le [32] in the research of selecting the international market for the Vietnamese export of goods was applied a combined the Super SBM and the MPI model to assess the export market efficiency. The study indicated that the DEA model is one of the best methods of selecting good DMUs. Based on DEA, Xue et al. [33] measured energy use efficiency of the Chinese construction industry. The result proved that the MPI model is a good model to evaluate the energy consumption efficiency. Zhou and Zhu [34] analyzed the efficiency of 12 Chinese banks using DEA. Lu and Xia [35] applied the Super SBM model and the MPI model to evaluate the performance of new-energy-automotive companies. These researches show that the Data envelopment analysis is a good model for measuring the performance of DMUs.

3. Materials and Methods

3.1. Research Framework

The research combines a grey model and two DEA models, including the Malmquist Productivity Index and the super-slack-based measure (Super SBM) as the foundation for evaluating and comparing the performance of Food and beverage industry in Thailand and Vietnam. Figure 1 describes five main stages of research design.

Stage 1: The authors learn about the reality of the food and beverage industry in both countries, identify the specific difficulties of each country in promoting the development. Some theories and business data that relate to the selected topic are studied. Next, the authors also review historical researches in this field.

Stage 2: Firstly, the food and beverage companies in Thailand and Vietnam are chosen. These companies published their financial statement stock market during the period from 2014 to 2017 on Thaistock [36] and Vietstock [37]. In order to achieve more meaningful results, only large-scale companies could be chosen. Secondly, the authors select the input and output variables. The choice of input and output factors will influence the evaluation of efficiency value; therefore, it is critically important to consider thoroughly beforehand and choose the most important ones as key factors to the performance of companies in food and beverage industry. Based on previous studies that researched the productivity, this thesis selects suitable input and output.

Stage 3: The GM (1,1) that is solved by software Excel is used to predict the future data in the period from 2018 to 2021. Since the prediction always exists with errors, the research applies the mean absolute percentage error (MAPE) to check the prediction accuracy of the GM [22]. If the factors have low accuracy (MAPE is too large), they would be replaced by new factors, and the test will be done again to ensure the accuracy of prediction model.

Stage 4: The Pearson Correlation Coefficient test is applied to test the strength of the linear correlation between two variables before using DEA model to analyze. This study primarily analyzes efficiency change, technical change, and Malmquist productivity index. Then, the Super SBM model is used ranking these efficient companies. Finally, the authors carry out a comparison between the performance of the food and beverage industry between Thailand and Vietnam by using T-test method [38, 39].

Stage 5: An accurate view of Thai and Vietnamese the food and beverage industry in the past-present-future are provided. The authors give some suggestions to enhance the competitiveness of these industries.

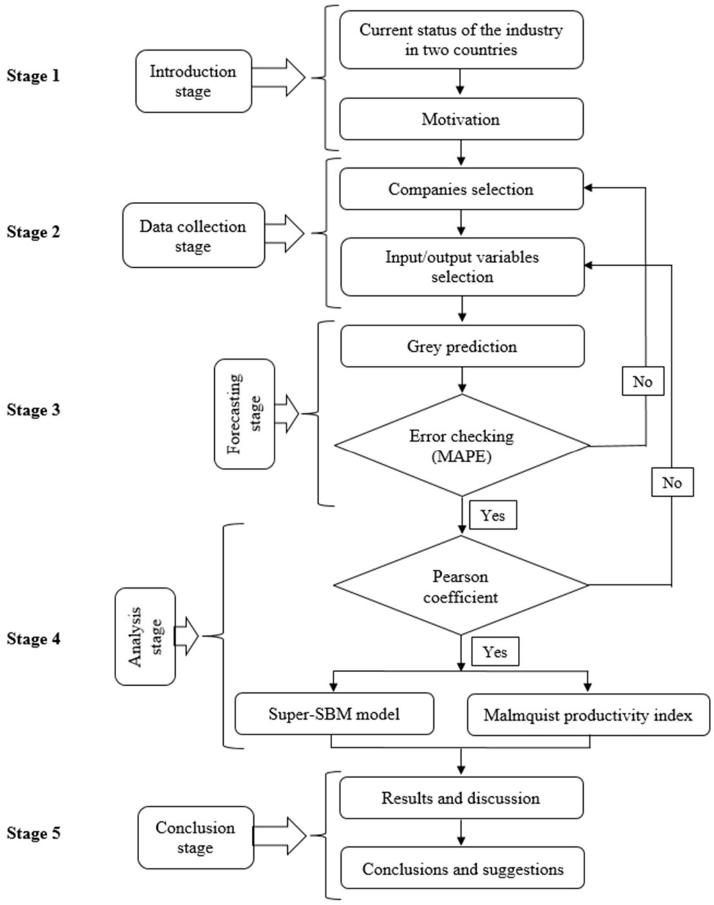

Figure 1. Research process.

3.2. Data Collection

This study uses the database of 22 and 20 food and beverage corporations in Thailand and Vietnam respectively (Appendix A). These companies are the biggest and the major players in the food & beverage industry in the two countries

Table 1. List of corporations in the food and beverage industry in Thailand.

No	Code	Company Name
1	TL1	Charoen Pokphand Foods Public Company Limited
2	TL2	Thai Union Group Public Company Limited
3	TL3	Minor International Public Company Limited
4	TL4	Khon Kaen Sugar Industry Public Company Limited
5	TL5	Mk Restaurant Group Public Company Limited
6	TL6	Carabao Group Public Company Limited
7	TL7	Thai Vegetable Oil Public Company Limited
8	TL8	Patum Rice Mill And Granary Public Company Limited
9	TL9	Oishi Group Public Company Limited
10	TL10	Buriram Sugar Public Company Limited
11	TL11	Chiangmai Frozen Foods Public Company Limited
12	TL12	Haad Thip Public Company Limited
13	TL13	Ichitan Group Public Company Limited
14	TL14	Lam Soon (Thailand) Public Company Limited
15	TL15	Malee Group Public Company Limited

16	TL16	President Bakery Public Company Limited
17	TL17	Premier Marketing Public Company Limited
18	TL18	Sappe Public Company Limited
19	TL19	Thaitheparos Public Company Limited
20	TL20	S & P Syndicate Public Company Limited
21	TL21	S. Khonkaen Foods Public Company Limited
22	TL22	Tipco Foods Public Company Limited

Source: Thaistock [36]

Table 2. List of corporations in the food and beverage industry in Vietnam.

No	Code	Name
1	VN1	Viet Nam Dairy Products Joint Stock Company
2	VN2	Masan Group Corporation
3	VN3	Saigon Beer - Alcohol - Beverage Corporation
4	VN4	Thanh Thanh Cong - Bien Hoa Joint Stock Company
5	VN5	Sao Mai Group Corporation
6	VN6	Hanoi Beer Alcohol And Beverage Joint Stock Corporation
7	VN7	KIDO Group
8	VN8	The Pan Group Joint Stock Company
9	VN9	An Giang Import - Export Company
10	VN10	Bibica Corporation
11	VN11	Travel Investment And Seafood Development Corporation
12	VN12	Dabaco Group
13	VN13	Haiha Confectionery JSC
14	VN14	Nafoods Group Joint Stock Company
15	VN15	Sai Gon Vegetable Oil JSC
16	VN16	Sai Gon - Mien Trung Beer JSC
17	VN17	TuongAn Vegetable Oil Joint Stock Company
18	VN18	Vinacafé Bienhoa Joint Stock Company
19	VN19	Lam Dong Foodstuffs JSC
20	VN20	Sa Giang Import Export Corporation

Source: Vietstock [37]

According to the historical researches and the results of analyzing financial statement the authors choose financial factor that highly correlated to operating performance of the food and beverage industry. As a result, three input variables and two output variables are selected, as follows:

Input variables:

(1) **Total assets (TA)**: Refers to the total value of all resource owned by an organization, total assets are the sum of all current and noncurrent assets.

(2) **Total operating expenses (TO)**: The sum of detailed types of expenses, including selling expenses and general and administrative costs.

(3) Owner's Equity (OE): The sum of invested capital and accumulated retained earnings, which together equal the value of the part of the company that the owners actually own.

Output Factors:

(1) Net revenue (NR): The amount of money received from selling goods or services after all costs have been paid:

(2) Gross profit (GP): The profit makes after deducting the costs associated with making and selling its products, or the costs associated with providing its services.

3.3. Grey Forecasting Theory

The procedure of building a GM (1,1) model is performed as follows [22]:

At the beginning, denote the variable primitive series $X^{(0)}$ the following formula:

$$X^{(0)} = \left(X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n)\right),\ X^{(0)} > 0, n \geq 4 \quad (1)$$

From $X^{(0)}$, the value of $X^{(1)}$ is calculated in the following equation:

$$X^{(1)} = \left(X^{(1)}(1), X^{(1)}(2), \dots, X^{(1)}(n)\right),\ n \geq 4 \quad (2)$$

where: $X^{(1)}(1) = X^{(0)}(1), X^{(1)}(k) = \sum_{i=1}^{k} X^{(0)}(i),\ \ k = 1,2,3, \dots n$

Next, the sequence generated $Z^{(1)}\ of\ X^{(1)}$ is the mean value of adjacent data:

$$Z^{(1)} = \left(Z^{(1)}(2), Z^{(1)}(3), \dots, Z^{(1)}(n)\right), n \geq 4 \quad (3)$$

where $Z^{(1)}(k)$ represents the mean value of adjacent data, i.e. $Z^{(1)}(k) = \frac{1}{2}\left(X^{(1)}(k) + X^{(1)}(k-1)\right), k = 2,3, \dots, n.$

Based on $X^{(1)}$, a GM (1,1) model can be estimated as follows:

$$\frac{dX^{(1)}(k)}{dk} + aX^{(1)}(k) = b \quad (4)$$

Calculate the parameters a and b by the formula as follows:

$$\hat{a} = [a, b]^T = (B^T B)^{-1} B^T Y \quad (5)$$

where $Y = \left[X^{(0)}(2), X^{(0)}(3), \dots, X^{(0)}(n)\right],\ B = \begin{bmatrix} -Z^{(1)}(2) & 1 \\ -Z^{(1)}(3) & 1 \\ \vdots & 1 \\ -Z^{(1)}(n) & 1 \end{bmatrix}$

According to the values of a and b, the time response sequence of the GM (1,1) model is given below:

$$\hat{X}^{(1)}(k+1) = \left(X^{(0)}(1) - \frac{b}{a}\right)e^{-a} + \frac{b}{a}, k = 1,2, \dots, n \quad (6)$$

The forecasted value of the GM(1,1) model is found in the following equation:

$$\hat{X}^{(0)}(k+1) = (1 - e^{a})\left[X^{(0)}(1) - \frac{b}{a}\right]e^{-a} \quad (7)$$

The Mean Absolute Percentage Error (MAPE) is used to measure of forecast errors in this research [40].

$$MAPE = \frac{1}{n}\sum \frac{|Actual - Forecast|}{Actual} \times 100 \quad (8)$$

Table 3. The grades of MAPE.

MAPE	**MAPE ≤ 10%**	**10% < MAPE ≤ 20%**	**20% < MAPE ≤ 50%**	**MAPE > 50%**
Grade levels	Excellent	Good	Reasonable	Unqualified

3.4. Data Envelopment Analysis Models

Malmquist Productivity Index (MPI): Firstly, the authors use the Malmquist Productivity Index (MPI) to evaluate the productivity change of a company between two periods.

The output-based MPI with time t technology is defined by Caves et al. [41] as:

$$\mathrm{MPI}^{t} = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}\right] \quad (9)$$

Similarly, the index with time t+1 technology is:

$$\mathrm{MPI}^{t+1} = \left[\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right] \quad (10)$$

Fare et al. [42] decomposed DEA-MPI into the components of efficiency and technical changes. Their index is the geometric mean of two contemporaneous Malmquist indexes as in Caves et al. [41] to avoid difficulties choosing reference technologies, i.e., whether to use time t or t+1 technology. Their index is defined as follows:

$$\mathrm{MPI}(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} \quad (11)$$

It can be decomposed as:

$$\mathrm{MPI}(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \times \frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} \quad (12)$$

Equation (12) can be simplified as:

$$\mathrm{MPI} = \mathrm{E} \times \mathrm{T}, \text{ Where: } \mathbf{E} = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \text{ and } \mathbf{T} = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \times \frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} \quad (13)$$

The E is the "efficiency change" which is defined as the diffusion of best-practice technology in the management of the activity and is attributed to investment planning, technical experience and sustainability management of the activity and is attributed to investment planning, technical experience. The T is "technological changes", or the so called "frontier-shift", this component captures the effect of the shift in the frontier of the productivity change of individual labs for an exposition of the effect of technical change on productivity change using production functions. The Malmquist productivity index of productivity change is a multiplicative composite of efficiency and technical change, the major cause of productivity improvements can be ascertained by comparing the values of the efficiency change and technique change indexes. MPI greater than 1 indicates productivity improvement between period t and t+1 while MPI less than 1 indicates productivity deterioration between the two time periods.

Super Efficiency SBM Model: Secondary, the authors use Super Efficiency SBM Model to rank the efficient company [43].

Tone [43] based on SBM to present a Super-efficiency measure. At the beginning, SBM is briefly proposed as follows:

The input and output of n DMUs are defined as $X = (x_{ij}) \in R^{m \times n}$ and $Y = (xy_{ij}) \in R^{s \times n}$, X, Y > 0. The production possibility is calculated as follows:

$P = (x, y)$, where $x \geq X\lambda$, $y \leq Y\lambda$, $\lambda \geq 0$, λ is a non-negative vector in R^n (14)

A DMU (x_0, y_0) is explained as

$$x_0 = X\lambda + s^-, \; y_0 = Y\lambda - s^+ \quad (15)$$

when $\lambda \gg 0$, $s^- \gg 0$, $s^+ \gg 0$. The vectors $s^- \in R^m$, $s^+ \in R^s$ are considered as the input excess and output shortfall. The ρ is defined as follows:

$$\rho = \frac{1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{io}}{1 + \frac{1}{s}\sum_{i=1}^{s} s_i^+ / y_{io}} \quad (16)$$

According to (14), (15): $0 < \rho \leq 1$ (17)

Calculate the SBM by the formula as follows:

$$\min \; \rho = \frac{1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{io}}{1 + \frac{1}{s}\sum_{i=1}^{s} s_i^+ / y_{io}} \quad (18)$$

Subject to: $x_0 = X\lambda + s^-$, $y_0 = Y\lambda - s^+$, $\lambda, s^-, s^+ \gg 0$

A DMU is defined as an SBM-efficient (if $\rho^* = 1$) based on the condition of the optimal solution for [SBM] $(\rho^*, S^{-*}, S^{+*}, \lambda^*)$. This condition is that $S^{-*} = 0$, $S^{+*} = 0$ and no inputs excess as well as output is fixed.

At the next step, the authors present the Super-efficiency with the DMU (x_0, y_0) is assumed to be an SBM-efficient $(\rho^* = 1)$.

[Super SBM] $$min\delta = \frac{\frac{1}{m}\sum_{i=1}^{m} \bar{x}_i / x_{i0}}{\frac{1}{s}\sum_{r=1}^{s} \bar{y}_i / yx_{r0}} \quad (19)$$

Subject to: $\bar{x} \geq \sum_{j=1, j\neq 0}^{n} \lambda_j x_j$, $\bar{y} \leq \sum_{j=1, j\neq 0}^{n} \lambda_j y_j$, $\bar{x} \geq x_{i0}$; $\bar{y} \leq y_{r0}$, $\bar{y} \geq y_0$, $\lambda \geq 0$

If the input r has no position, then it is considered as $\overline{x_r^+} = x_r^+ = 1$. The super-SBM model is estimated as follows:

$$min\delta = \frac{1}{m}\sum_{i=1}^{m} \overline{x_\iota} / x_{i0} \quad (20)$$

Subject to: $\bar{x} \geq \sum_{j=1, j\neq 0}^{n} \lambda_j x_j,\ \bar{y} \leq \sum_{j=1, j\neq 0}^{n} \lambda_j y_j,\ \bar{x} \geq x_{i0}; \bar{y} = y_0, \lambda \geq 0$

4. Results

4.1. Results and Analysis of the Grey Forecasting

The GM (1,1) model is used to forecast the historical input and output variables of selected companies in Thailand and Vietnam from 2018 to 2021. The authors use the "Total asset data" of TL1 to describe the step-by-step process.

Table 4. The historical input and output variables (2014-2017) of TL1.

TL1	**Inputs** (Millions of USD)			**Outputs** (Millions of USD)	
	(I) TA	**(I) TO**	**(I) OE**	**(O) NR**	**(O) GP**
2014	12,502.92	1,364.45	3,525.97	13,151.12	1,863.10
2015	14,827.88	1,503.01	3,490.94	13,182.42	1,940.77
2016	17,465.37	1,472.79	4,010.93	14,300.48	2,357.70
2017	17,804.91	1,685.28	5,040.46	15,695.40	2,001.01

The sequence of raw data

$X^{(0)} = \left(X^{(0)}(1), X^{(0)}(2), X^{(0)}(3), X^{(0)}(4)\right)$ = (12,502.92, 14,827.88,17, 465.37, 17,804.91)

simulate this sequence $X^{(0)}$ by respectively using the following three GM (1,1) models and compare the simulation accuracy:

From $X^{(0)}(k) + az^{(1)}(k) = b$; compute the accumulation generation of $X^{(0)}$as follows:

$X^{(1)} = \left(X^{(1)}(1), X^{(1)}(2), X^{(1)}(3), X^{(1)}(4)\right)$ = (12,502.92, 27,330.79, 44,796.16, 62,601.07)

The next stage the different equations of GM (1,1) was created with the mean equation is:

$Z^{(1)}(2)$ = 0.5(12,502.92+27,330.79) = 19,916.85

$Z^{(1)}(3)$ = 0.5(27,330.79+44,796.16) = 36,063.48

$Z^{(1)}(4)$ = 0.5(44,796.16+62,601.07) = 53,698.62

To be continue, the values for coefficients a and b were found

$$B = \begin{bmatrix} -19{,}916.85 & 1 \\ -36{,}063.48 & 1 \\ -53{,}698.62 & 1 \end{bmatrix} \qquad Y_N = \begin{bmatrix} 14{,}827.88 \\ 17{,}465.37 \\ 17{,}804.91 \end{bmatrix}$$

By using the least square estimation, we obtain the sequence of parameters $\hat{a} = [a, b]^T = (B^T B)^{-1} B^T Y = \begin{bmatrix} -.08707 \\ 13516.15 \end{bmatrix}$

We establish the following model $\frac{dX^{(1)}(k)}{dk} - 0.08707X^{(1)}(k) = 13516.15$ and its time response formula: $\hat{X}^{(1)}(k+1) = \left(X^0(1) - \frac{b}{a}\right) e^{a(k)} + \frac{b}{a} = 167{,}736.066 * e^{-0.0870} - 155{,}233.146$

Substitute different value of k into the equation:

k = 1, $X^{(1)}(1)$ = 12,502.92 k = 2, $X^{(1)}(2)$ = 27,762.37 k = 3, $X^{(1)}(3)$ = 44,410.01

k = 4, $X^{(1)}(4)$ = 62,572.14 k = 5, $X^{(1)}(5)$ = 82,386.53 k = 6, $X^{(1)}(6)$ = 104,003.5

k = 7, $X^{(1)}(7)$ = 127,587 k = 8, $X^{(1)}(8)$ = 153,316

Compute the simulated value of $X^{(0)}$ the original series according to the accumulated generating operation of by using $\hat{X}^{(0)}(k+1) = \alpha^1 \hat{X}^{(1)}(k+1) - \hat{X}^{(1)}(k)$:

$$X^{(0)}(1) = x^{(1)}(1) = 12{,}502.92 - for\ the\ year\ 2014$$

$$X^{(0)}(2) = X^{(1)}(2) - X^{(1)}(1) = 15{,}259.45 - forecasted\ for\ 2015$$

$$X^{(0)}(3) = X^{(1)}(3) - X^{(1)}(2) = 16{,}647.65 - forecasted\ for\ 2016$$

$$X^{(0)}(4) = X^{(1)}(4) - X^{(1)}(3) = 18{,}162.13 - forecasted\ for\ 2017$$

$$X^{(0)}(5) = X^{(1)}(5) - X^{(1)}(4) = 19{,}814.39 - forecasted\ for\ 2018$$

$$X^{(0)}(6) = X^{(1)}(6) - X^{(1)}(5) = 21{,}616.96 - forecasted\ for\ 2019$$

$$X^{(0)}(7) = X^{(1)}(7) - X^{(1)}(6) = 23{,}593.52 - forecasted\ for\ 2020$$

$$X^{(0)}(8) = X^{(1)}(8) - X^{(1)}(7) = 25{,}728.98 - forecasted\ for\ 2021$$

Table 5. The predicted input and output variables data (2018–2021) of TL1.

DMUTL1	**Inputs** (Millions of USD)			**Outputs** (Millions of USD)	
	(I) TA	**(I) TO**	**(I) OE**	**(O) NR**	**(O) GP**
2018	19,814.39	1,749.67	5,998.39	17,089.87	2,157.16
2019	21,616.96	1,858.23	7,243.30	18,653.08	2,186.48
2020	23,583.52	1,973.53	8,746.58	20,359.27	2,216.20
2021	25,728.98	2,095.98	10,561.85	22,221.52	2,246.33

The forecasting results of all the DMUs from 2018 – 2021 are calculated based on the above process (Appendix B). The research uses Mean Absolute Percentage Error (MAPE) to check the forecasting accuracy.

Table 6. Average MAPEs of decision-making units (DMUs)

THAILAND				**VIETNAM**			
DMU	**MAPE**	**DMU**	**MAPE**	**DMU**	**MAPE**	**DMU**	**MAPE**
TL1	2.57%	TL12	1.31%	VN1	2.63%	VN11	1.49%
TL2	1.59%	TL13	3.52%	VN2	4.90%	VN12	1.88%
TL3	1.37%	TL14	0.52%	VN3	2.22%	VN13	3.52%
TL4	2.66%	TL15	3.26%	VN4	14.44%	VN14	2.46%
TL5	0.26%	TL16	0.84%	VN5	4.22%	VN15	10.11%
TL6	1.37%	TL17	1.23%	VN6	2.34%	VN16	2.45%
TL7	4.95%	TL18	2.65%	VN7	10.77%	VN17	3.66%
TL8	2.60%	TL19	1.27%	VN8	6.82%	VN18	6.03%
TL9	0.96%	TL20	1.00%	VN9	3.02%	VN19	5.67%
TL10	4.40%	TL21	1.19%	VN10	1.86%	VN20	2.19%
TL11	2.47%	TL22	1.50%				
Average MAPE		**1.98%**		**Average MAPE**		**4.63%**	

Based on the MAPE values, most of DMU have MAPE smaller than 10%. Moreover, the average MAPE of the two groups in Thailand and Vietnam is 1.98% and 4.63%, respectively (below 10%,), this indicates the GM (1,1) applied in this research is a high accuracy prediction method.

4.2. Pearson Correlation

The mandatory requirement of DEA model application is the relatedness between input and output factors. In the research, the Pearson correlation is used to measure the linear relationship between the input and output factors. The correlation coefficient ranges from -1 to +1, the value of 0 indicates no linear relationship between two variables. When the value of Pearson correlation is less than 0.2 shows the degree of correlation is "very low"; the value between 0.2–0.4 shows the degree is "low", the value between 0.4–0.6 shows the degree is "average high"; the value between 0.6–0.8 shows the degree is "high"; the value more than 0.8 the degree is "very high".

The results of the Pearson correlation in the research show strong positive correlations between input and output factors. Therefore, all the variables are acceptable in order to apply in the DEA model.

4.3. The Malmquist Productivity index

4.3.1. Catch-Up Efficiency change

According to results in figure 2, the average "efficiency change" of 22 DMUs in Thailand underwent a fluctuation between the period 2014-2015 to the period 2020-2021. The index reached a peak at 1.185569 in the period 2016-2017, after that declining slightly to 0.97218 in 2020-2021. Among 22 companies, TL1, TL2, TL5, TL6, TL9, TL10, TL11, TL12, TL13, TL14, TL17, TL19, and TL20 had average "efficiency change" score greater than 1. Especially, there was a quick rise in the score of TL12 in the period, from 0.799566 the period 2014-2015 to 1.002826 in the period 2020-2021 (rose around 25%). By comparison, a quick drop was recorded in the "efficiency change" score of TL1, TL7. TL11 in the period 2014-2021. There was the highest fall in the score of TL1, from 1.362845 to 0.975481 (decreased about 28%). In general, the industry saw an improvement during 2014–2017 but showed negative efficiency during 2018–2021.

According to results in figure 3, the average "efficiency change" of 20 DMUs in Vietnam witnessed a small fall in the early stage, but later slightly increased in the later stage. Among 20 companies, VN1, VN2, VN3, VN5, VN7, VN9, VN11, VN16, VN17, VN18, VN19, and VN20 had average "efficiency change" score greater than 1. Especially, there was a quick rise in the score of VN7, VN18, VN19 in the period, with a rise is about 101%, 53%, 63%. By comparison, a quick drop was recorded in the "efficiency change" score of VN4, VN12. VN15 in the period 2014-2021. There was the highest fall in the score of VN4, from 1.599822 to 0.830126 (decreased about 48%). In general, the industry saw a slight increase and decrease around 1 during the period. This clearly indicates that the entire industry had not shown many big changes.

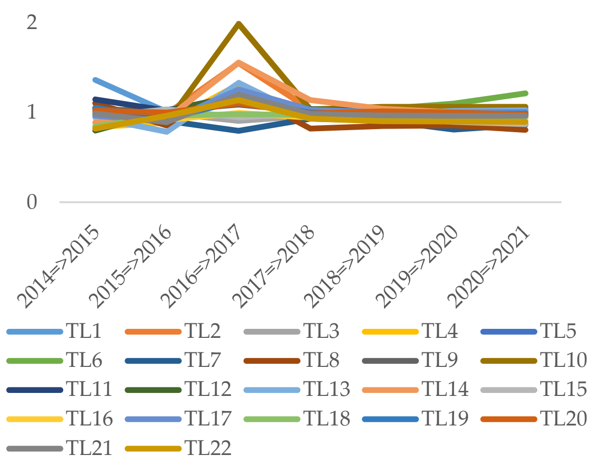

Figure 2. Catch-up efficiency change in Thailand

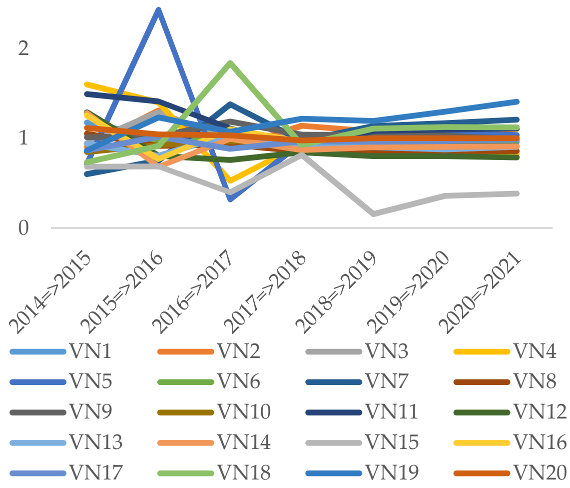

Figure 3. Catch-up efficiency change in Vietnam

4.3.2. Frontier-shift change

Figure 4 shows the "technological change" (frontier-shift) of 22 DMUs in Thailand. It is clear that the average "technological change" score of all DMUs fluctuated wildly in the period 2014-2021. After rising rapidly in the first period, the number dropped remarkably in two periods 2015-2016 and 2016-2017 but later went up slightly in the remaining period. Except for TL17, TL21, other DMUs saw an upward technological change, although most of them declined the score during 2016-2017. This means most of these companies had enhanced their technological capabilities. The frontier-shift score of TL1 underwent a slight rise but stayed at below 1, indicating that it had no actively improved its technology.

Figure 5 indicates the "technological change" (frontier-shift) of 20 DMUs in Vietnam. The average "technological change" score of all DMUs increased minimally in the period 2014-2021. After reaching a peak of 1.135582 in 2018-2019, the number fluctuated in the last two periods. Most of the DMUs had average "technological change" score under 1 except

VN5. Moreover, a quick rise (with about 83%) was recorded in VN11 in the period. This means most of these companies saw an upward change in technological capabilities.

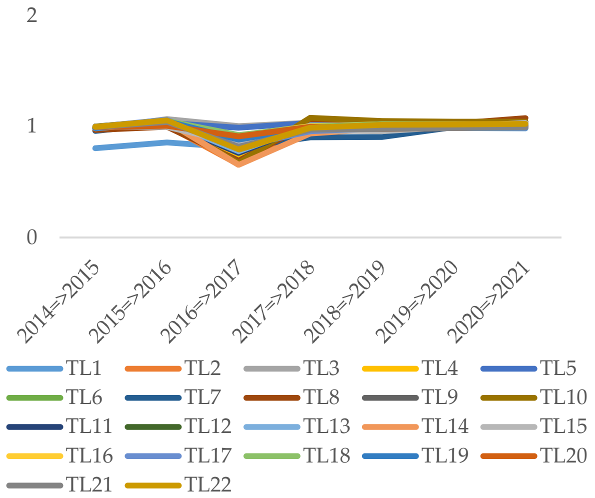

Figure 4. Frontier-shift change in Thailand

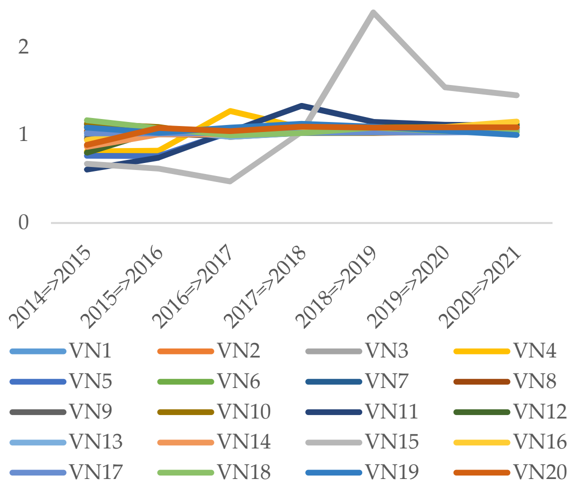

Figure 5. Frontier-shift change in Vietnam

4.3.3. The Malmquist productivity index

The results, as shown in figure 6, indicate that the MPI average of all DMUs in Thailand maintained at level less than 1 during the period 2014-2021, this means a reduction of productivity was recorded. Only 5 companies performed efficiently with the MPI greater than 1. In particular, the period also sees a dramatic decrease in the MPI of TL7, TL8, and TL11 (with a fall is about 15%, 19%, 14%). On the contrary, TL4, TL6, and TL12 significantly improved their productivity. In conclusion, due to the highest of MPI scores, TL5, TL6, and TL10 can be seen as the top three best companies. These companies need to focus on investments to motivate the development of the Thai food industry. In contrast, TL7, TL8, and TL22 were the top three worst companies. These firms did not pay enough attention in managing their operations.

The results, as shown in figure 7, indicate that the MPI average of all DMUs in Vietnam small rose during the period 2014-2021. Most companies were seen an upward trend in the period. In particular, VN5, VN7, VN19 saw a dramatic growth in their productivity (with a rise is 112%, 95%, 50%). On the contrary, the productivity index of VN4, VN8, VN12 declined in the research period. Summary, VN11, VN18, and VN19 are the top three best companies with a higher of MPI scores. These are the key element in investment in the Vietnamese food industry. In contrast, VN12, VN13, VN15 are the top three worst companies. Specifically, VN15 had productivity index maintained at the level below 1 in all the period. These companies need to consider changes to meet competition requirements.

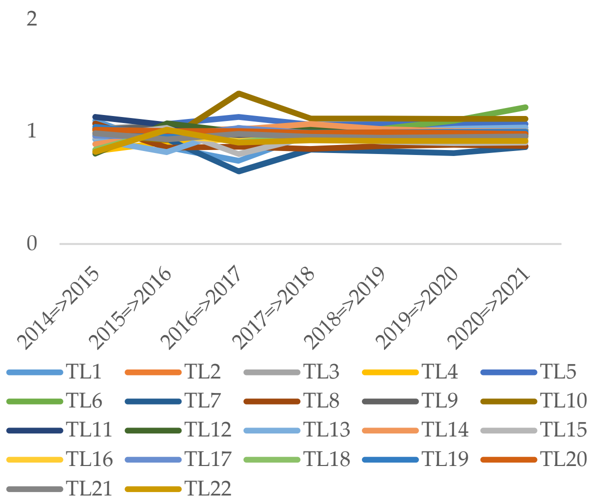

Figure 6. The MPI change in Thailand

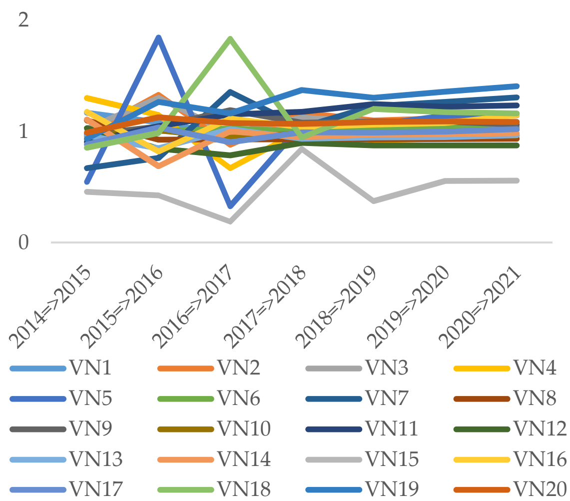

Figure 7. The MPI change in Vietnam

4.4. Performance Rankings: Super SBM

Tables 7 and 8 show the rankings of food and beverage company in Thailand and Vietnam from 2014 to 2021. The positions of corporations in Thailand witnessed a slight change or no change during the research period. Among 22 companies, TL3, TL5, and TL11 maintained the high position over the period of 2014-2021, with the ranking from 1st to 4th. These companies could be seen as the effective business. TL2, TL6, and TL10 had significant progress in the period. At the beginning with the low position (ranking is 9th, 18th, 16th, respectively), the company saw an enormous rise in their position (ranking is 4th, 8th, 7th, respectively). By contrast, TL8, TL13, TL22 had inefficient business in the period. These companies stayed the level from 18th to 22nd during the period of 2014-2021. In addition, there were a significant efficiency fall in the efficiency of TL15, TL18, TL21. They were effective firms in the past but were predicted to become ineffective firms in the future.

On the other hand, the positions of corporations in food and beverage in Vietnam dramatically changed during the research period of 2014-2021. Over the past-present period of 2014-2017, VN15, VN17, VN20 presented the highest performance; VN15 maintained the highest position during the period while VN17 and VN20 changed their rankings from 2nd to 6th. On the contrary, VN7, VN8 had inefficient business in the past-present period (ranking is from 16th to 20th). However, in the future period of 2018-2021, VN19 showed a rising trend in efficiency to replace VN17 in combination with VN15 and VN20 to become the most efficient among 20 companies. Besides, with the lowest position, VN5 and VN8 had inefficient business in the future period. Moreover, there was a significant fall in efficiency of VN12, the ranking of the DMU continuous decreased from 3rd in 2014 to 19th in 2021.

Table 7. Ranking of all DMUs in Thailand

DMU	2014	2015	2016	2017	2018	2019	2020	2021
TL1	12	11	11	13	13	12	13	12
TL2	9	7	9	12	10	8	7	4
TL3	4	4	5	2	2	2	1	1
TL4	21	21	21	21	21	21	21	21
TL5	3	3	3	3	4	3	3	3
TL6	18	17	18	17	17	14	9	8
TL7	2	2	2	6	6	6	6	5
TL8	22	22	22	22	22	22	22	22
TL9	7	8	8	10	11	13	12	11
TL10	16	16	15	5	5	5	5	7
TL11	1	1	1	1	1	1	2	2
TL12	14	18	17	16	15	16	16	15
TL13	19	19	20	19	19	19	18	18
TL14	13	14	13	9	7	7	8	9
TL15	8	9	7	11	12	11	14	16
TL16	17	15	16	18	18	18	19	19
TL17	10	10	10	8	9	9	10	10
TL18	11	12	12	14	16	17	17	17
TL19	15	13	14	15	14	15	15	13
TL20	5	5	4	4	3	4	4	6
TL21	6	6	6	7	8	10	11	14
TL22	20	20	19	20	20	20	20	20

Table 8. Scores and rankings of all DMUs in Vietnam

DMU	2014	2015	2016	2017	2018	2019	2020	2021
VN1	10	3	12	11	11	10	11	12
VN2	17	17	8	15	7	8	8	10
VN3	8	8	4	5	3	3	5	6
VN4	18	6	5	6	5	13	14	5
VN5	4	19	6	19	20	19	18	16
VN6	15	16	18	14	13	12	13	14
VN7	16	20	20	20	18	14	9	9
VN8	20	18	19	18	19	20	20	20
VN9	7	11	11	9	9	6	7	8
VN10	12	14	15	17	16	16	15	15
VN11	19	9	7	2	6	5	2	3
VN12	3	5	9	10	14	18	19	19
VN13	11	7	14	13	14	15	16	17
VN14	14	12	16	16	17	17	17	18
VN15	1	1	1	1	1	1	4	7
VN16	13	10	13	12	12	11	12	13
VN17	2	2	2	4	8	9	10	11
VN18	9	15	17	7	10	7	6	4
VN19	5	13	10	8	2	2	1	1
VN20	6	4	3	3	4	4	3	2

4.5. Comparing Food and Beverage Industry performance between Thailand and Vietnam

This study compares the Malmquist productivity index in these two countries by using the t-Test method. Firstly, "F-Test Two-Sample for Variances" was used to determine the variance of the two MPI samples in Thailand and Vietnam. This result indicated the variance of the two MPI samples is unequal. Thus, at the second step, the authors applied "Two-sample Assuming Unequal Variances" to test statistical hypotheses. These null hypothesis (Ho) and alternative hypothesis (Ha) are presented, as follows:

Ho: The average MPI of Vietnamese food and beverage industry is less than or equal to the index of Thai food and beverage industry

Ha: The average MPI of Vietnamese food and beverage industry is greater than the index of Thai food and beverage industry

The Table 9 shows that the t-Test value of MPI is -2.7536594 and the average score of Thailand and Vietnam is 0.9735337 and 1.0151253 respectively. Besides, P value is 0.014176971and 0.028353942, less than α value (0.05). From these points, it is significant and enough evidence to conclude that the Malmquist productivity index of the Vietnamese food and beverage industry more than Thailand's. It is clear that most of the years, Vietnam had well done in its performance with the index larger than 1 whereas in the same time, in Thailand have many companies had not well done in their performance (MPI < 1). This may be come from the better results of technological changes in Vietnam than Thailand.

Table 9. t-Test: Two-sample Assuming Unequal Variances

Malmquist Productivity Index		
Mean	0.973533705	1.015125177
Variance	9.58957E-05	0.001501035
Observations	7	7
Hypothesized Mean Difference	0	
df	7	
t Stat	-2.753659767	
P(T<=t) one-tail	0.014176971	
t Critical one-tail	1.894578605	
P(T<=t) two-tail	0.028353942	
t Critical two-tail	2.364624252	

Based on Table 10 and Figure 8, the effective business of the food & beverage industry in Vietnam more than Thailand during the period of 2014-2017. However, the effective business of Vietnam slightly decreased from 1.3688 in 2017 to 1.1396 in 2019 when the index of Thailand sees a small rise from 2.0723 to 1.1084 during the time period of 2017-2019. In the remaining years, it is predicted that there will be balanced in the effective business in both countries and a slight rise will be recorded in these indexes.

Table 10. The average of effective business scores of companies in Thailand and Vietnam

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
THAILAND	1.0291	1.0182	1.0083	1.0723	1.0914	1.1084	1.1488	1.1767
VIETNAM	1.3288	1.3601	1.3131	1.3688	1.2476	1.1396	1.131	1.2098

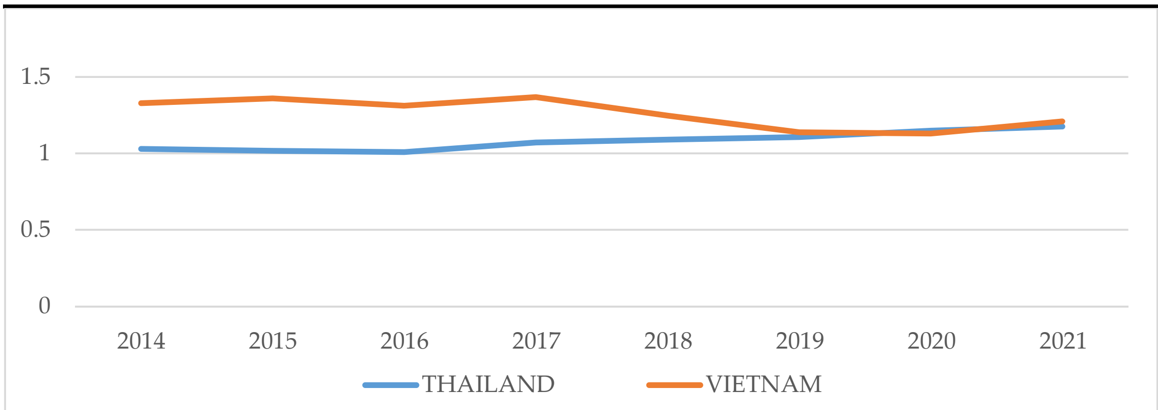

Figure 8. The average of scores of companies in Thailand and Vietnam

4.5. Discussion

This research tries to evaluate and compare the performance of food and beverage companies in Thailand and Vietnam by combining a Grey forecast model and two DEA models. The findings indicate that Vietnamese companies are more "productivity change" and "efficient business" than Thai's during the past-present period, but with the future perspective the balance in "effective business" will be found in these two countries. These results can be explained as follows:

- Thai food and beverage industry has witnessed a miraculous growth as well as achieved great achievements since the early 1990s thanks to the positive impact of government policies and take advantage of the abundant natural resources, the low labor cost. However, in recent years, the industry has to meet some difficulties, both domestically and internationally. The slow growth of the Thai economy leads to the domestic consumption of food and beverage no longer growing as before. About international aspect, there are a boom in the food industry of certain countries such as China, Vietnam, Malaysia etc.

This creates huge competition for the Thai food industry in the world market. These factors can be considered as the cause of lower about "productivity change" and "effective business" in Thai food companies. However, it easy to see that the good management system of Thai food and beverage industry continue to help the industry develop in the future.

- Although there has enormous potential in the natural, climatic and large domestic market, but with the inefficient management system and bad planning capacity restrained the development of food and beverage in Vietnam during a long time period in the past. This led to the value of the food and beverage industry in Vietnam is half of Thailand's. However, the limitation can be seen as room for growth at present. In addition, a high GDP growth rate has been maintained in this decade that have brought the development of the domestic market. Moreover, Vietnamese government launched a free-market economic as well as actively participated world trade organizations (ASEAN, WTO, TPP). Those potential made the industry become a favorite destination for domestic and foreign investors. As a result, Vietnamese companies have achieved successes based on investment capital and modern technologies transferred from international investors.

Further details on each country, the results of Super SBM model show TL3, TL5, TL11 are the top performance in Thai food and beverage industry, these companies keep the high position about performance from past, present to future while TL8, TL13, TL22 show a failure in improving their effective business during the past-present-future period. Similarly, in the future of Vietnamese food and beverage industry, VN15, VN19, and VN20 are the top performance whereas VN5 and VN8 are the most inefficient business. The results are the basis for helping the government and business owners in promoting food industry in each country. Companies with effective business are the driving force for the development of the food industry while ineffective businesses are the cause of reducing the competitiveness of the industry. Thus, the managers need to pay more attention to make decisions about allocating resources in the best way. For the sustainable development, the problem of rational use of natural resources (water, land) and limitation of environmental pollution must be considered as the essential elements in the development of the food industry. Moreover, both countries should take advantage of international cooperation trends in order to transfer and apply the advanced technologies from developed countries such as Germany, The United States of America, Japan, Taiwan, etc. Furthermore, the best methods to develop performance are to improve the quality management system as well as enhance the quality of human resources.

5. Conclusions

The food industry will continue to play an important role in the economy of Thailand and Vietnam in the future. Therefore, it is necessary to the evaluate the performance of the industry in both counties. The research not only provides specific insights into the food industry in Thailand and Vietnam but also help compare the performance of the industry in both countries. Moreover, based on the results, the government of Thailand and Vietnam, businessman, investors are provided with reliable information to get the better results in investment.

For improving the research results, the future researches are suggested to analyze other input and output factors (financial data, human resource data, etc.). This will help the comparison of productivity become more accurate and complete. Although Grey and DEA model have shown effectiveness in this research, other forecasting and evaluation models could be approached in the future. Furthermore, the combined models in the research can be used in other fields, and be applied to compare many countries in a special region.

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