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Research Article

Partner Selection in Supply Chain of Vietnam's Textile and Apparel Industry: The Application of a Hybrid DEA and GM (1,1) Approach

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Vietnam is currently among the top-five textile and apparel exporters, and the industry is considered quite attractive to foreign investors. Nevertheless, the global textile and garment industry is experiencing important changes. The three main producing regions in the world are China, Southwest Asia (India, Pakistan, Bangladesh, and Turkey), and ASEAN. In order to maintain its positioning and to establish stable and sustainable Vietnam textile and apparel development, there must be radical changes. Due to this necessity, the authors conducted this study by using grey forecasting to predict and reflect the condition of businesses in the period of 2017–2020, together with combining a DEA model to help businesses select the most appropriate strategic partner in the supply chain in order to achieve economic goals and promote the strength of the businesses partaking in the association. Besides, this helps businesses exploit market opportunities and take advantage of the capabilities of the textile and apparel industry.

1. Introduction

1.1. Overview of Vietnam's Textile and Apparel Industry. After more than 20 years of continuous development with an average growth rate at 17% per year, the textile and apparel industry has become a major economic industry and is a leading export industry in Vietnam, accounting for 10%–15% gross domestic product (GDP) [1]. By the end of 2014, there were 5,214 textile and apparel companies in Vietnam with the majority of those being small- and medium-sized companies. The textile and apparel work force occupied more than 20% of the nation-wide work force and nearly 5% of the nation-wide work force. Garment companies accounted for the largest share (84%), followed by textile and spinning companies (15%). Vietnam was one of the top 10 textile exporters in the world with the market share at 3.1% in 2014. The country's main export markets included the United States, European Union (EU), Japan, and Korea (85% of the total export goods), providing the garment for mostly the low and middle classes (see Table 1). Although foreign direct investment (FDI) enterprises represented only 25% in the volume, they contributed to more than 65% of Vietnam's export turnover [2].

Currently, Vietnam is involved in the process of the lowest value-added, that is, the "cut–make–trim" with the simple outworks production method (the "cut–make–trim" comprises 85%; see Table 2). Vietnam's garment sector still depends on imported raw materials (70%–80%), mainly from China, Taiwan, and Korea. The size of the Vietnamese textile and apparel market is limited at only $3 billion, and per capita expenditures for the textile and apparel are rather low [2]. Also, the Vietnamese garment enterprises are encountering difficulties in occupying the domestic market, as those companies have to compete with fake and non-quota imported goods. Branding includes just a few small and successful firms; the majority of Vietnamese textile and apparel enterprises are inadequate in absorbing knowledge such as building distribution systems, design, and branding.

Table 1: Main export markets of Vietnam's textile and apparel in 2016.

Nation	Unit	Value
United States of America	Billions of U.S Dollars	11.45
Japan	Billions of U.S Dollars	2.9
Korea	Billions of U.S Dollars	2.284
China	Millions of U.S Dollars	825
Germany	Millions of U.S Dollars	726.2
England	Millions of U.S Dollars	715
Holland	Millions of U.S Dollars	538

Sources: [14].

Free trade agreements, such as the Vietnam-Korea Free Trade Agreement (VKFTA), European Union–Vietnam Free Trade Agreement (EVFTA), and Trans-Pacific Partnership Agreement (TPP), open up many opportunities for the export turnover growth in Vietnam's textile and apparel industry. The industry is expected to reach \$50–\$55 billion in 2025 thanks to FTA [2]. On the other hand, Vietnam has to face many difficulties and challenges in obeying origin rules, labor standards, strict social responsibilities, eco labels, environmental protection, and so on. Currently, Vietnam is relying on the supply of main fabrics and fibers from China and Taiwan; those that are not in the TPP. Thus, when the agreements come into force, Vietnam may have little chance to inherit tax incentives. The textile and apparel industry with the majority of small- and medium-sized companies having low financial capacity and competitiveness will experience difficulties when the economy is opened. Hence, in order to promote the overall strength of the industry, the implementation of coalition among textile enterprises has to be driven in force for the enterprises to complete and move up to a higher value chain, aiming to gain benefits from alliances, for example, achieving economies of scale; reducing production costs and transaction costs; increasing access to technology, new production resources, and markets; leveraging negotiation position and competitiveness; improving the organizational and knowledge capacity through the sharing of experience within coalition group; and building risk reduction. Joining alliances is to better serve the market. It is the only way for new textile and apparel enterprises to provide a large number of products with consistent quality and timely delivery for many partners and integrate deeper and wider into the world economy.

1.2. Global Textile and Apparel Value Chain. Gereffi introduced the global textile and apparel value chain in 2002 [3]. Whereby the textile and apparel value chain is affected by purchasers, creating finished products must go through many stages, and production activities are often carried out in many countries. In particular, well-known manufacturers, big wholesalers, and retailers play key roles in establishing production networks and shaping mass consumption through a series of strong brands and outsourcing activities to satisfy this demand. The global textile and apparel value chain is divided into five basic stages: (1) supply of raw materials, including natural cotton, thread, and so on; (2) production of intermediate goods; products of this stage are fibers and fabrics provided by weaving, knitting, and dyeing companies; (3) design and manufacture of finished products implemented by garment companies; (4) export by commercial intermediaries; (5) marketing and distribution [3]. (See Figure 1.)

In order to study and present the context of the whole supply chain, more research is required. Within this study, we feature an in-depth study of consumer products for textile companies and suppliers for apparel companies. Moreover, this study is mainly focused on partner selection, which is just a part of the supply chain.

1.3. Literature Review. In 1989, Deng introduced the grey system theory, which is an interdisciplinary scientific area and has become quite common in systems to process and predict partially unknown parameters [4]. The grey model (GM) can estimate the behavior under grey system theory in the future based on a limited amount of available data. The GM (1,1) is one of the most important parts of grey system theory and is considered to be the core of the grey prediction model. The advantage of this model is that it can be used when the amount of data is insufficient to perform statistical analysis methods. It requires only a small amount of data and random sample data to calculate and produce the forecast results. Many studies have applied the grey system. For example, in 1989, Bunn conducted a study about forecasting with more than one model [5]. In 2001, Chen et al. studied application of an innovative combined forecasting method in power [6]. In 2005, Yamaguchi et al. studied new grey relational analysis for finding the invariable structure and its applications [7]. In 2009, Lingbin et al. used the grey theory model to predict the number of international tourists in China [8]. Besides, some researchers have conducted strategic alliance studies. For example, Büyüközkan et al. (2008) provided a decision support to make a careful assessment of an e-logistics partner [9]. This research proposed a multicriteria decision-making approach to effectively evaluate e-logistics based on strategic alliance partners. Candace et al. (2011) affirmed strategic alliances as an efficient means to access the resources needed for innovation in dynamic environments [10]. Several researches used hybrid DEA (data development analysis) and GM (1,1) to study strategic alliance, which revealed high reliability. This was a complementary concept, which assumed that two complementary companies to be good partners could make an alliance and perform better business. Because this method can estimate the behavior of data in the future based on a limited amount of available data, this complementary concept appeared in the hybrid DEA and GM (1,1) to study strategic alliance for the electronic manufacturing service industry [11]. In 2016, Wang et al. used DEA and a grey theory model to analyze the selection strategic alliance partner in the automobile industry [12]. In 2017, Wang and Nguyen used the grey and DEA model to study enhancing urban development quality based on the results of appraising efficient performance of investors in Vietnam [13].

Strategic alliances between organizations are now ubiquitous; it has been used in the past for enterprises that have

TABLE 2: Overview of Vietnam's textile and apparel industry.

Indicators	Unit	Value
Number of companies	Companies	6.000
Enterprise scale	People	SMEs of 200–500 + Account for a large proportion
Company structure based on ownership		Private (84%), FDI (15%), State-owned (1%).
Company structure based on operation		Sewing (70%), spinning (6%), weaving/knitting (17%), dying (4%), ancillary industries (3%)
Geographical allocation of company		North (30%), Central and plateau (8%), South (62%).
Number of employees	People	2,5 Million
Average income per worker	VND	4,5 Million
Number of working days per week	Day	6
Number of hours worked per week	Hour	48
Number of shifts per day	Shift	2
Value of textile export in 2016	US$	23.841 Billion
Method of production	%	Cut - Make – Trim: 85%; others: 15%

Sources: [2].

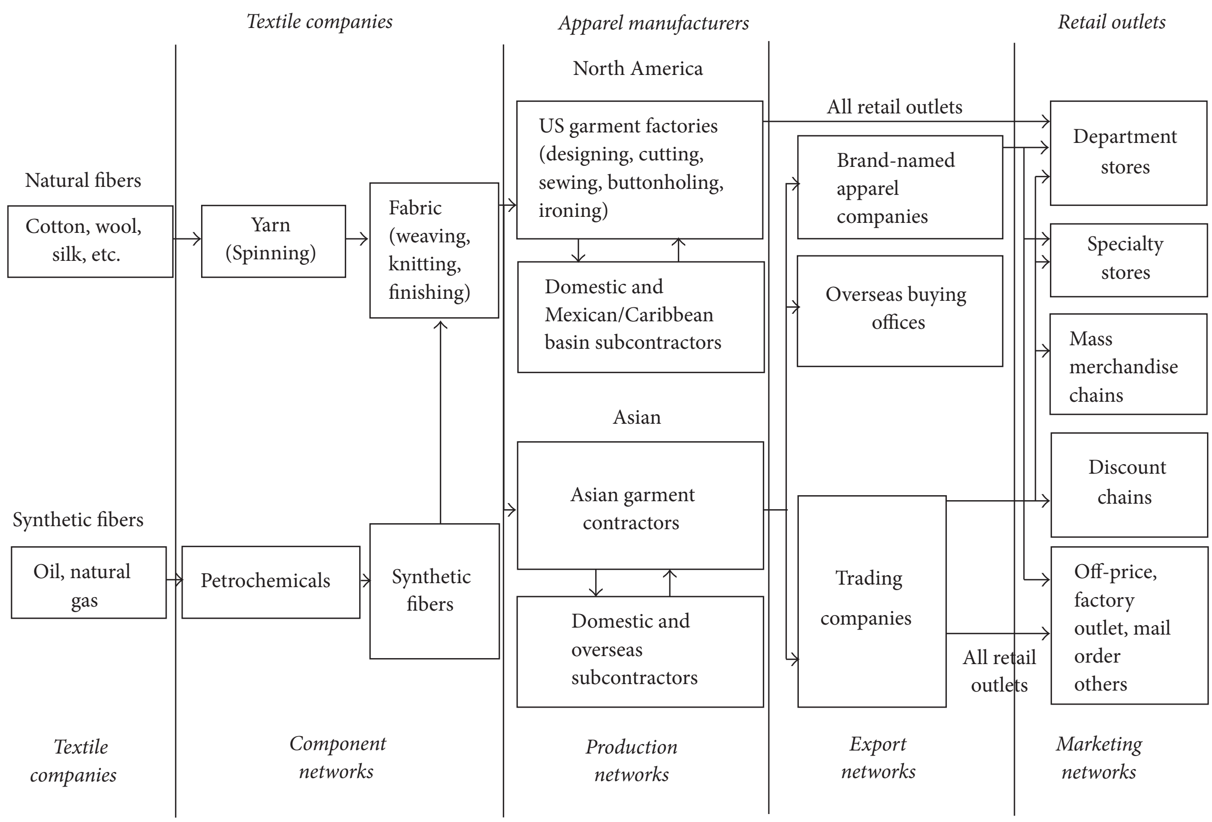

FIGURE 1: Global textile and apparel value chain [3].

the same expertise and targets. In the current economy of integration and development, along with the limited capacity of enterprises, the technology has not been developed nor has it met the quality and quantity requirements of partners who continue to operate individually; thus, they will encounter difficulties when facing competitors. If we combine each other's strengths, we will create a value chain in each product line, offer prestigious and quality products, and enhance competitiveness in the domestic and international markets. Therefore, strategic alliances between enterprises are urgent. Thus, combining a hybrid DEA model and grey system theory helps us to choose the strategic alliance for textile and apparel enterprises to make the best of their business goals and possibly exploit the opportunities of the environment, address challenges, and take advantage of the capacity of the textile and apparel industry in Vietnam. This study proposes an effective new method. Through the realities in Vietnam's textile and apparel industry, we would recommend finding

Table 3: List of Companies in textile and apparel industry.

Order	DMUs	Companies name
1	DMU1	Hue Textile Garment Joint Stock Company (J.S.C)
2	DMU2	SaiGon Garment Manufacturing Trade J.S.C
3	DMU3	TNG Investment and Trading J.S.C
4	DMU4	Nha Be Garment Corporation J.S.C
5	DMU5	Ha Dong Textile J.S.C
6	DMU6	DongNai Garment Corporation
7	DMU7	HoaTho Textile–Garment J.S.C
8	DMU8	Phan Thiet Garment Import–Export J.S.C
9	DMU9	Saigon 3 Garment J.S.C
10	DMU10	ThangLoi International Garment J.S.C
11	DMU11	HaNoi Industrial Textile J.S.C
12	DMU12	HaNoi Textile and Garment J.S.C
13	DMU13	March 29 Textile Garment J.S.C
14	DMU14	G.HOME Textile Investment J.S.C
15	DMU15	Viet Tien Garment J.S.C

Source: synthetic by researcher [15–29].

the alliance partners for companies to solve those existing problems that they cannot overcome when doing business by using grey theory GM (1,1) to predict what would happen about their business situation in the period 2017–2020. After that, we use a DEA model to evaluate ranking and score of all decision-making units (DMU) in 2016. Combining analytical results from super-SBM model, we put out analysis; alliance suggests bringing high economic efficiency for enterprises as well as Vietnam's textile and apparel industry.

2. Materials and Methods

2.1. DMUs Collection. After researching Vietnam's textile and apparel industry, this study reveals 15 companies collected from the General Statistics Office's website [15–29]. We did not choose other enterprises because of this reason: the company scale is small, the uptime does not align with the data requirements, and the business data of those companies do not match with the demand of grey theory model that we used in this research. The synopsis is shown in Table 3.

2.2. Inputs/Outputs Collection. The inputs/outputs element will directly affect the results of the analysis and evaluation. From the literature review, this research summarizes finance factors that were not previously considered. This study carefully selects four inputs and two outputs, which are collected from financial statements of 15 DMUs.

(i) Input factors include the following:

Total assets (TA), which reflect the entire value of existing assets of the business in reporting.

Cost of sold capital (CS), which is the total input cost of the enterprise to produce products, including the cost of inputs, fuel costs, machinery, direct labor, and other expenses.

Selling expenses (SE), which include all costs incurred in the process of consuming products, goods, or services.

General and administration expenses (AE), which are the total costs of business management, administrative management, and other general services related to the operation of the business.

(ii) Output factors include the following:

Revenue of sales (RS), which reflects sales and services revenue of the enterprise in an accounting period of production and business activities from transactions, sales, and servicing operation.

Profit after tax (PT), which reflects the total net profit after tax relating to the enterprise's business activities.

The selected factors reflect wholly a firm's assets, costs, and profits, which can be used as the foundation for analysis, calculation, and evaluation of this study. Researcher synthetics are shown in Tables 4, 5, 6, and 7.

2.3. Research Development. The authors use the GM (1,1) model to predict the business situation of all DMUs and the super-SBM-I-V model to select strategic alliance partners for the textile business in the future. The process of conducting this study is shown in Figure 2.

Step 1 (objectives identification). Based on the requirements of professional, managerial, and practical needs of the textile and apparel industry, the authors select the objectives of the study.

Step 2 (literature review). By researching and exploring the chosen topic, the authors examine available resources, identifies research purposes, and develops hypothesis for his/her research topic to implement the research. If the topic, time, and method overlap with another study, the authors revert to Step 1.

Step 3 (methodology).

Prediction Method. There are many prediction methods, and the authors use the GM (1,1) to predict the data from the DMUs from 2017 to 2020 because this is a highly reliable prediction method and suitable with the data of DMUs.

DEA Models. There are many methods to choose an alliance partner, and the authors use the super-SBM-I-V, a method of choosing the right strategic alliance partner and is popular nowadays.

Step 4 (research planning). The authors plan to carry out the main tasks, to manage time well, and to scientifically control the progress.

Table 4: Data of 15 DMUs in 2013 (currency unit: 1,000,000 VND).

DMUs	Inputs				Outputs	
	(I)TA	(I)CS	(I)SE	(I)AE	(O)RS	(O)PT
DMU1	509991	1152459	42110	54446	1306653	30880
DMU2	657777	1062372	18633	90818	1228479	57032
DMU3	961199	962177	26726	102633	1186685	14057
DMU4	1878363	2291270	199623	192508	2818958	88070
DMU5	158855	225771	6666	9543	255462	11518
DMU6	454291	898732	18704	39094	983038	29553
DMU7	974923	2217252	70805	86102	2454787	48340
DMU8	103426	142211	1202	5371	172208	21481
DMU9	968574	1713273	38784	77527	1861925	36189
DMU10	72358	118064	18227	14084	162747	6888
DMU11	140479	398557	14232	24012	459383	11949
DMU12	1633770	1232482	46967	72444	1395956	29079
DMU13	263782	326142	10801	37282	396971	9796
DMU14	201567	178629	2769	1554	196211	1127
DMU15	2456738	4159024	226059	209707	4831173	237117

Source: synthetic by researcher [15–29].

Table 5: Data of 15 DMUs in 2014 (currency unit: 1,000,000 VND).

DMUs	Inputs				Outputs	
	(I)TA	(I)CS	(I)SE	(I)AE	(O)RS	(O)PT
DMU1	588788	1221869	46946	53530	1379742	35119
DMU2	637070	1201404	21510	115432	1409479	60497
DMU3	1197910	1115111	27499	107228	1377234	53158
DMU4	2127350	2454015	223486	269719	3079348	92309
DMU5	163659	257292	6585	9756	292352	44954
DMU6	581485	1137097	21124	45117	1250242	40105
DMU7	1283842	2336302	82537	79718	2593478	64483
DMU8	112973	169561	1281	6774	200017	21650
DMU9	1144414	1042259	41498	60037	1264576	89755
DMU10	73739	133775	18326	13416	176581	5879
DMU11	230140	522542	17807	27507	592539	14565
DMU12	1573948	1394663	51566	79990	1570431	46171
DMU13	316593	412595	11231	34509	490648	18879
DMU14	5771	200702	3592	2396	227138	5771
DMU15	2908907	4749674	220757	200589	5482404	296592

Source: synthetic by researcher [15–29].

Step 5 (DMUs collection). The authors collected information of 15 Vietnam textile and apparel companies, which was in line with research objectives through the General Statistics Office's website.

Step 6 (inputs/outputs collection). Input factors include total assets, cost of capital sold, cost of sale, and general and administration expenses.

Output factors include revenue of sales and profit after tax.

Step 7 (grey prediction). The prediction sequence is as follows.

Forecasting. Use business data of 15 DMUs from 2013 to 2016 and apply GM (1,1) to predict business performance from 2017 to 2020.

Check Accuracy. The authors use mean absolute percentage error (MAPE) to calculate predicted errors, thus ensuring the predicted data are accurate compared with the requirements. In case the accuracy does not meet with the requirements, DMUs must be selected accordingly.

Step 8 (check Pearson coefficient). The authors use the Pearson coefficient to check the correlation between inputs and outputs. Suppose the inputs and outputs have a positive

Table 6: Data of 15 DMUs in 2015 (currency unit: 1,000,000 VND).

DMUs	Inputs				Outputs	
	(I)TA	(I)CS	(I)SE	(I)AE	(O)RS	(O)PT
DMU1	606216	1309806	51544	53208	1480821	44063
DMU2	836542	1249641	35649	136582	1502065	63458
DMU3	1613646	1574939	36668	146519	1923940	71300
DMU4	2735885	3538699	306195	383943	4433111	115164
DMU5	243803	232900	6489	8237	262779	13084
DMU6	458819	976675	20858	47048	1083273	19945
DMU7	1369356	2656957	107899	114281	3005032	74018
DMU8	145849	238988	1694	6378	275864	29061
DMU9	1235441	1145009	47629	62771	1349758	96707
DMU10	73484	127695	18151	13368	171465	5412
DMU11	257599	516094	26273	39332	625326	26404
DMU12	1918836	1510140	54745	79196	1756114	39766
DMU13	487229	526497	8161	47275	627916	23900
DMU14	11659	265671	2831	4351	300890	11659
DMU15	3380138	5645821	221379	237333	6408465	311044

Source: synthetic by researcher [15–29].

Table 7: Data of 15 DMUs in 2016 (currency unit: 1,000,000 VND).

DMUs	Inputs				Outputs	
	(I)TA	(I)CS	(I)SE	(I)AE	(O)RS	(O)PT
DMU1	679185	1341165	52198	26851	1478313	42778
DMU2	883468	1336254	46980	148299	1611379	60986
DMU3	1846223	1554546	28942	140127	1887749	81179
DMU4	2707671	3412884	309616	405506	4233351	52540
DMU5	229651	212276	6716	8125	248086	11748
DMU6	533483	926722	19855	48261	1013852	15293
DMU7	1917445	2882242	90013	119504	3198584	71244
DMU8	165293	241046	1623	5724	269649	22368
DMU9	1324281	1540328	39342	84403	1738944	137131
DMU10	88101	110327	11531	13629	152988	9199
DMU11	219244	471021	29763	43920	588614	31616
DMU12	2108020	1771020	52150	90745	2000541	51154
DMU13	718718	700224	9827	46771	798022	25493
DMU14	12562	312154	3744	4664	351044	12562
DMU15	3832596	6622654	266807	259384	7526047	376606

Source: synthetic by researcher [15–29].

correlation; the result is highly reliable. However, if the correlation coefficient is negative or equals zero, the inputs and outputs must be reselected.

Step 9 (DEA analysis (super-SBM-I-V)). The sequence of DEA analysis according to the super-SBM-I-V model is as follows.

Before Alliance. The actual results of the order and business performance of the DMUs serve as a basis for the authors to choose future alliance partner.

After Alliance. From the preunion assessment, the authors select the DMU target as a partner alliance with other businesses. When combining DMU target with 14 other DMUs, the authors use the SBM-I-V model to analyze and obtain 29 plans to compare and evaluate analysis and comments.

Step 10 (partner selection; conclusion). Based on the results of analysis after the alliance, the authors proposed the most appropriate alliance solution in the supply chain of the enterprises, which brings the highest economic efficiency as well as the affiliate groups that are not highly effective in helping the businesses with suitable direction.

2.4. Grey Forecasting Model. Before using the GM (1,1) model, initial data must be tested against the formula [30]:

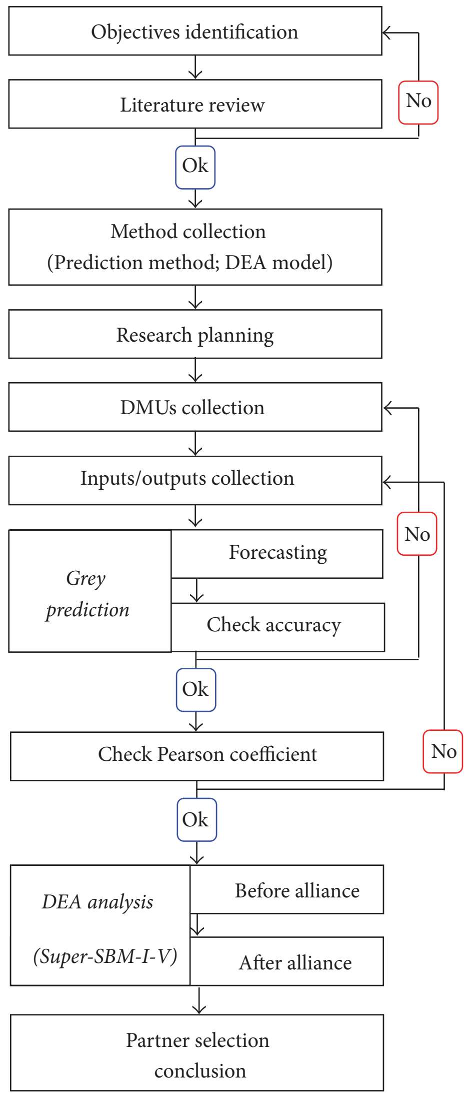

Figure 2: Research process.

$$\delta_i = \frac{x^{(0)}(i-1)}{x^{(0)}(i)}; \quad (i = 2, 3, \ldots, n). \tag{1}$$

If all the δ_i values are within $\delta^{(0)}(i) = (e^{-2/(n+1)}; e^{2/(n+1)})$, we can use the GM (1,1) model to forecast.

The GM (1,1) model is calculated based on the following differential equation [31]:

$$\frac{dx^{(1)}(k)}{dk} + ax^{(1)}(k) = b. \tag{2}$$

Within the equation, a and b are coefficients. The initial data is considered as a value chain as follows:

$$X^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)\right); \quad n \geq 4. \tag{3}$$

In this research, $X^{(0)}$ is the actual business metrics of DMUs recorded from 2013 to 2016. Data after being tested will be calculated using the following steps.

Step 1. Calculate the $X^{(1)}$ by using the cumulative method [31]:

$$\chi^{(1)} = \left(\chi^{(1)}(1), \chi^{(1)}(2), \ldots, \chi^{(1)}(n)\right); \quad n \geq 4, \tag{4}$$

where $\chi^{(1)}(1) = \chi^{(0)}(1), \chi^{(1)}(k) = \sum_{i=1}^{k} \chi^{(0)}(i)$; $k = 1, 2, 3, \ldots, n$.

Calculate series $Z^{(1)}$ (mean value) of adjacent neighbor $\chi^{(1)}$ by [31]:

$$Z^{(1)} = \left(Z^{(1)}(1), Z^{(1)}(2), \ldots, Z^{(1)}(n)\right); \quad n \geq 4, \tag{5}$$

where $Z^{(1)}(\kappa) = 0.5(\chi^{(1)}(\kappa) + \chi^{(1)}(\kappa - 1))$; $k = 2, 3, \ldots, n$.

Step 2. Set the equation for the GM (1,1) model and calculate the $Z^{(1)}$ values [31]:

$$\frac{dX^{(1)}(k)}{dk} + aX^{(1)}(k) = b, \tag{6}$$

where $Z^{(1)}(\kappa) = 0.5(x^{(1)}(\kappa) + x^{(1)}(\kappa - 1))$; $k = 2, 3, \ldots, n$.

Table 8: The grades of MAPE.

MAPE valuation (%)	≤10	10 ÷ 20	20 ÷ 50	≥50
Accuracy	Excellent	Good	Qualified	Unqualified

Sources: [30].

Step 3. Calculate the parameter a and parameter b.

Parameter a and parameter b of the GM (1,1) model are calculated based on the least-squares method as follows [31]:

$$\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix}^T = \left(B^T B\right)^{-1} B^T \overline{Y}_N, \tag{7}$$

where: $B = \begin{bmatrix} -\alpha Z^{(1)}(2) & 1 \\ \vdots & \vdots \\ -\alpha Z^{(1)}(n) & 1 \end{bmatrix}; Y_N = \begin{bmatrix} X^{(0)}(2) \\ \vdots \\ X^{(0)}(n) \end{bmatrix}$.

Step 4. Set the formula to calculate the predictive value of the model [31]:

$$\widehat{X}^{(1)}(\kappa+1) = \left[\chi^{(0)}(1) - \frac{b}{a}\right] e^{-a\kappa} + \frac{b}{a} \qquad (\kappa = 1, 2, 3, \ldots). \tag{8}$$

Then calculate the predicted values of the GM (1,1) model based on the following formula [31]:

$$\widehat{X}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k), \tag{9}$$

where $\hat{x}^{(0)}(1) = x^{(0)}(1)$; $(\kappa = 1, 2, 3, \ldots, n)$.

2.5. Evaluation of Volatility Forecasts. In this paper, we use MAPE, which is a tool to measure the accuracy value in statistics, to identify the grey prediction models with good performance. The MAPE is small; It is called the slacks-based measure of efficiency (SBM) [32].

$$\text{MAPE} = \frac{1}{n}\left[\sum_{i=1}^{n}\left|\frac{A_i - F_i}{A_i}\right| \times 100\right]. \tag{10}$$

The MAPE is divided into our ranks as shown in Table 8.

2.6. Nonradial Super Efficiency Model (Super-SBM). In this section, we propose a model by which we discriminate between such DMUs: it is called the slacks-based measure of efficiency (SBM). Here, a super-SBM is expanded by the addition of the super efficiency to the DEA model with the polarities of the inputs and outputs. The n DMUs with the input/output matrices (X, Y) are used in this model [33], in which $X = (x_{ij}) \in R^{m\times n}$ and $Y = (Y_{ij}) \in R^{s\times n}$. λ is a nonnegative vector in R^n. The vectors $S^- \in R^m$ and $S^+ \in R^s$ represent an excess input and a short falling output, respectively [34]. The SBM model is given by following equation [35]:

$$\begin{aligned} \min \quad & \rho = \frac{1 - (1/m)\sum_{i=1}^{m} s_i^-/x_{i0}}{1 + (1/s)\sum_{i=1}^{s} s_i^-/y_{i0}} \\ \text{s.t:} \quad & \chi_0 = X\lambda + S^-, \\ & \gamma_0 = Y\lambda - S^+, \\ & (\lambda \geq 0,\ X \geq 0,\ Y \geq 0). \end{aligned} \tag{11}$$

Suppose $(p^*, \lambda^*, s^{-*}, s^{+*})$ is the optimal condition of SBM, and (χ_0, γ_0) is SBM efficient of DMU. When $p^* = 1$ so $s^{-*} = 0$ and $s^{+*} = 0$ (or there is no excess input and a short falling output). Hence, a super-efficiency model was introduced for ranking DMUs, and it was defined by the following formula [36]:

$$\begin{aligned} \min \quad & \delta = \frac{(1/m)\sum_{i=1}^{m} \overline{x}_i/x_{i0}}{(1/s)\sum_{r=1}^{s} \overline{y_r}/y_{r0}} \\ \text{s.t} \quad & \overline{x} \geq \sum_{j=1,\neq 0}^{n} \lambda_j x_j, \\ & \overline{y} \leq \sum_{j=1,\neq 0}^{n} \lambda_j x_j, \\ & \overline{\chi} \geq \chi_0, \\ & \overline{\gamma} \leq \gamma_0, \\ & \overline{\gamma} \geq 0, \\ & \lambda \geq 0. \end{aligned} \tag{12}$$

Suppose the denominator is 1, so that the objective function is an orientation input of the super-SBM model. The obtained feedback value of the objective function is larger or equivalent to 1. It is straightforward, then, that the inputs are positive; however, the outputs are able to become a negative value. The proper solution to solve this problem is to use DEA-solver pro 4.1 manual [37], as follows:

Suppose $y_{ro} \leq 0$. It has defined $\overline{y}_r^+$ and $\overline{y}_{-r}^+$ by

$$\begin{aligned} \overline{y}_r^+ &= \max_{j=1,\ldots,n}\left\{y_{rj} \mid y_{rj} > 0\right\}, \\ \overline{y}_{-r}^+ &= \min_{j=1,\ldots,n}\left\{y_{rj} \mid y_{rj} > 0\right\}. \end{aligned} \tag{13}$$

If there is no positive component in the output r, it becomes $\overline{y}_r^+ = y_{-r}^+ = 1$. The element s_r^+/γ_{r0} is instead the following, while the γ_{r0} is unchanged:

Table 9: Data of DMU1 from 2013 to 2016 (currency unit: 1,000,000 VND).

Year	Inputs				Outputs	
	(I)TA	(I)CS	(I)SE	(I)AE	(O)RS	(O)PT
2013	509991	1152459	42110	54446	1306653	30880
2014	588788	1221869	46946	53530	1379742	35119
2015	606216	1309806	51544	53208	1480821	44063
2016	679185	1341165	52198	26851	1478313	42778

Source: synthetic by researcher [9].

$$\text{When } \overline{\gamma}_r^+ > \overline{\gamma}_{-r}^+ \text{ the element is: } \frac{s_r^+}{\gamma_{-r}^+\left(\overline{\gamma}_r^+ - \gamma_r^+\right)/\left(\overline{\gamma}_r^+ - \gamma_{r0}\right)}$$
$$\text{When } \overline{\gamma}_r^+ = \overline{\gamma}_{-r}^+ \text{ the element becomes: } \frac{s_r^+}{\left(\gamma_{-r}^+\right)^2/B\left(\overline{\gamma}_r^+ - \gamma_{r0}\right)}. \tag{14}$$

Here, B represents a large positive value; in the DEA-solver the value of B is about 100.

Given the fact that the denominator is certainly lower than γ_{-r}^+, it increases with the decrease of the distance $\overline{\gamma}_r^+ - \gamma_{r0}$ and vice versa. Hence, this model significantly affects the nonpositive output value. The obtained score is constant, and it is a unidimensional unit for using units of the measurement [35].

3. Results

3.1. Results and Analysis of the Grey Forecasting of the Output Values for All DMUs. The GM (1,1) model is utilized to predict the input and output factors values for each decision-making unit from 2017 to 2020. We used factor total assets (TA) – input 1 of DMU1 in Table 9 to explain calculation procedure in this part.

First, we use the GM (1,1) model for trying to forecast the variance of primitive series.

Create the primitive series:

$$X^{(0)} = (509991; 588788; 606216; 679185). \tag{15}$$

Perform the accumulated generating operation (AGO):

$$\begin{aligned} X^{(1)} &= (509991; 1098779; 1704995; 2384180) \\ x^{(1)}(1) &= x^{(0)}(1) = 509991 \\ x^{(1)}(2) &= x^{(0)}(1) + x^{(0)}(2) = 1098779 \\ x^{(1)}(3) &= x^{(1)}(2) + x^{(0)}(3) = 1704995 \\ x^{(1)}(4) &= x^{(1)}(3) + x^{(0)}(4) = 2384180. \end{aligned} \tag{16}$$

Create the different equation of GM (1,1).

To find $X^{(1)}$ series, the following mean obtained by the mean equation is

$$\begin{aligned} z^{(1)}(2) &= 0.5 \times (509991 + 1098779) = 804385 \\ z^{(1)}(3) &= 0.5 \times (1098779 + 1704995) = 1401887 \\ z^{(1)}(4) &= 0.5 \times (1704995 + 2384180) = 2044587.5. \end{aligned} \tag{17}$$

Solve equations.

To find a and b, the primitive series values are substituted into the grey differential equation to obtain

$$\begin{aligned} 588788 + a \times 804385 &= b \\ 606216 + a \times 1401887 &= b \\ 679185 + a \times 2044587.5 &= b. \end{aligned} \tag{18}$$

Convert the linear equations into the form of a matrix.

Let

$$B = \begin{bmatrix} -804385 & 1 \\ -1401887 & 1 \\ -2044587.5 & 1 \end{bmatrix}; \quad \widehat{\theta} = \begin{bmatrix} a \\ b \end{bmatrix}; \quad Y_N = \begin{bmatrix} 588788 \\ 606216 \\ 679185 \end{bmatrix}. \tag{19}$$

And then use the least-squares method to find a and b:

$$\begin{bmatrix} a \\ b \end{bmatrix} = \widehat{\theta} = \left(B^T B\right)^{-1} B^T y_N = \begin{bmatrix} -0.0734 \\ 520724.6709 \end{bmatrix}. \tag{20}$$

Use the two coefficients a and b to generate the whitening equation of the differential equation:

$$\frac{dx^{(1)}}{dk} + 0.0734 \times x^{(1)} = 520724.6709. \tag{21}$$

Table 10: Data of 15 DMUs in 2017 (currency unit: 1,000,000 VND).

DMUs	Inputs				Outputs	
	(I)TA	(I)CS	(I)SE	(I)AE	(O)RS	(O)PT
DMU1	721814.76	1413714.89	55627.68	25296.03	1546318.61	48544.08
DMU2	1053997.39	1403749.17	67264.71	169108.78	1720725.30	62130.40
DMU3	2294455.62	1881264.48	32380.04	165411.22	2268702.20	100498.51
DMU4	3130664.07	4143249.39	371956.57	502950.15	5121472.13	57986.82
DMU5	281200.84	192406.24	6729.79	7154.80	225963.51	3242.28
DMU6	475353.42	816765.35	19381.36	50028.24	895875.88	7694.20
DMU7	2302526.94	3212821.85	100626.19	148225.35	3579094.18	76730.92
DMU8	200487.46	293300.49	1885.72	5316.81	321723.30	25020.34
DMU9	1424974.01	1844619.97	40822.27	98235.86	2007490.91	166631.40
DMU10	94367.97	102522.46	10619.72	13686.16	145006.42	11240.91
DMU11	225439.67	454380.31	38423.52	55629.26	598318.91	45151.67
DMU12	2453736.30	1978048.44	53396.32	94910.26	2250200.03	51258.86
DMU13	1046331.33	901189.93	8305.48	55816.79	1008742.38	29953.18
DMU14	17985.77	388587.67	3557.42	6423.83	435973.52	17985.77
DMU15	4397864.35	7798797.34	287608.15	296483.83	8786351.84	418309.95

Sources: calculated by researcher.

Find the prediction model from equation

$$\begin{aligned}\widehat{X}^{(1)}(\kappa+1) &= \left[\chi^{(0)}(1)-\frac{b}{a}\right]\times e^{-a\kappa}+\frac{b}{a}\\ &= \left[509991-\frac{520724.6709}{(-0.0734)}\right]\\ &\quad\times e^{-(-0.0734)\kappa}+\frac{520724.6709}{(-0.0734)}\\ &= 7604289.363\times e^{0.0734\times k}\\ &\quad-7094298.363.\end{aligned} \tag{22}$$

Substitute different value of k into the equation

$$\begin{aligned}&X^{(1)}(1)=509991 \quad k=0;\\ &X^{(1)}(2)=1089144.30 \quad k=1;\\ &X^{(1)}(3)=1712406.71 \quad k=2;\\ &X^{(1)}(4)=2383137.67 \quad k=3;\\ &X^{(1)}(5)=3104952.43 \quad k=4;\\ &X^{(1)}(6)=3881741.61 \quad k=5;\\ &X^{(1)}(7)=4717692.14 \quad k=6;\\ &X^{(1)}(8)=5617309.83 \quad k=7;\end{aligned} \tag{23}$$

derive the predicted value of the original series according to the accumulated generating operation and obtain

$$\begin{aligned}&\widehat{x}^{(0)}(1)=x^{(1)}(1)=509991\\ &\widehat{x}^{(0)}(2)=\widehat{x}^{(1)}(2)-\widehat{x}^{(1)}(1)=579153.30\\ &\widehat{x}^{(0)}(3)=\widehat{x}^{(1)}(3)-\widehat{x}^{(1)}(2)=623262.42\\ &\widehat{x}^{(0)}(4)=\widehat{x}^{(1)}(4)-\widehat{x}^{(1)}(3)=670730.95\\ &\widehat{x}^{(0)}(5)=\widehat{x}^{(1)}(5)-\widehat{x}^{(1)}(4)\\ &\qquad=721814.76\text{—Result forecast of 2017.}\\ &\widehat{x}^{(0)}(6)=\widehat{x}^{(1)}(6)-\widehat{x}^{(1)}(5)\\ &\qquad=776789.18\text{—Result forecast of 2018.}\\ &\widehat{x}^{(0)}(7)=\widehat{x}^{(1)}(7)-\widehat{x}^{(1)}(6)\\ &\qquad=835950.53\text{—Result forecast of 2019.}\\ &\widehat{x}^{(0)}(8)=\widehat{x}^{(1)}(8)-\widehat{x}^{(1)}(7)\\ &\qquad=899617.69\text{—Result forecast of 2020.}\end{aligned} \tag{24}$$

As with above process, we have the result of all DMUs from 2017 to 2020, respectively, in Tables 10, 11, 12, and 13.

In this study, the authors use MAPE to check the accuracy of forecasts to ensure appropriate predictive methods and as a basis for highly reliable assessments. The results are shown in Table 14.

This research uses a model-based forecasting approach (an approach to obtain information for the future with modeling tools); through resimulating the past and comparing values, the forecast is calculated by actual data and the model; if the error is within the allowable limits, then the model is reliable and usable. As shown in Table 14, average MAPE of 15 DMUs is less than 10%. Based on rules, as shown in Table 8, the predicted results in this study have a high level of accuracy (average MAPE of 15 DMUs is

Table 11: Data of 15 DMUs in 2018 (currency unit: 1,000,000 VND).

DMUs	Inputs				Outputs	
	(I)TA	(I)CS	(I)SE	(I)AE	(O)RS	(O)PT
DMU1	776789.18	1480059.07	58572.89	19300.11	1599270.79	53131.91
DMU2	1226468.27	1481143.18	96220.54	190968.19	1840070.14	62373.71
DMU3	2813720.28	2178272.62	33076.22	186161.97	2608027.98	122708.61
DMU4	3495299.88	4781494.65	430700.05	604322.45	5878474.45	47705.47
DMU5	324822.64	174740.33	6797.49	6498.75	207884.79	1380.11
DMU6	452735.10	734911.71	18797.32	51732.30	804655.10	4497.72
DMU7	2863522.13	3562321.21	104426.16	177677.19	3962721.45	80419.71
DMU8	240420.59	342986.29	2096.21	4894.19	367301.15	25358.17
DMU9	1532556.94	2270676.18	39861.49	118106.13	2376926.55	209816.16
DMU10	103714.56	93407.36	8711.68	13795.21	135247.46	14709.18
DMU11	220517.09	431990.09	48542.73	68926.94	596408.96	63025.78
DMU12	2824812.20	2235788.48	53686.99	101400.69	2541235.71	54332.00
DMU13	1559205.34	1176387.15	7680.31	63932.10	1284240.82	34505.81
DMU14	24530.38	480066.86	3645.25	8464.64	536697.39	24530.38
DMU15	5041317.17	9198794.29	318016.79	335956.54	10293643.64	474013.17

Sources: calculated by researcher.

Table 12: Data of 15 DMUs in 2019 (currency unit: 1,000,000 VND).

DMUs	Inputs				Outputs	
	(I)TA	(I)CS	(I)SE	(I)AE	(O)RS	(O)PT
DMU1	835950.53	1549516.73	61674.04	14725.40	1654036.27	58153.32
DMU2	1427161.42	1562804.22	137641.17	215653.21	1967692.42	62617.97
DMU3	3450501.19	2522171.46	33787.36	209515.89	2998106.11	149827.14
DMU4	3902405.69	5518058.16	498720.94	726126.87	6747368.91	39247.05
DMU5	375211.34	158696.43	6865.88	5902.85	191252.51	587.46
DMU6	431193.01	661261.18	18230.88	53494.41	722722.69	2629.18
DMU7	3561200.02	3949840.06	108369.64	212981.01	4387468.04	84285.84
DMU8	288307.62	401088.98	2330.18	4505.17	419335.92	25700.56
DMU9	1648262.18	2795139.59	38923.33	141995.57	2814348.88	264192.82
DMU10	113986.88	85102.67	7146.46	13905.12	126145.28	19247.55
DMU11	215701.99	410703.18	61326.93	85403.31	594505.11	87975.68
DMU12	3252005.51	2527112.08	53979.24	108334.98	2869913.27	57589.39
DMU13	2323471.75	1535621.61	7102.19	73227.30	1634980.85	39750.40
DMU14	33456.42	593081.58	3735.26	11153.81	660691.70	33456.42
DMU15	5778913.76	10850110.93	351640.51	380684.49	12059510.17	537133.97

Sources: calculated by researcher.

4.08%). This confirms that the GM (1,1) model used in this study is suitable with highly reliable predicted results and analysis.

3.2. Pearson Correlation. In this study, the authors use the super-SBM-I-V model to analyze and choose a strategic alliance partner for DMUs, where the condition for using DEA is the correlation coefficient, which could not be negative or equal to 0. Hence, before analyzing DEA, the authors used the Pearson correlation coefficient to determine the data used in this study, which is in accordance with the DEA standards. Correlation coefficients are always in the range of (−1) to (1); if this factor is as close to (1), it is a perfect linear relation [37]. The results are shown in Tables 15, 16, 17, and 18.

Results of the Pearson correlation coefficient from Tables 15 to 18 show that the factors used in this study have a strong linear relationship, which is consistent with the conditions of DEA and can be used for analysis. In the super-SBM-I-V model, strategic partners will be selected for DMUs in the future.

3.3. Analysis Alliance

3.3.1. Analysis before Alliance. To identify and select the target DMU for alliance with other DMUs in the future, the authors

Table 13: Data of 15 DMUs in 2020 (currency unit: 1,000,000 VND).

DMUs	Inputs				Outputs	
	(I)TA	(I)CS	(I)SE	(I)AE	(O)RS	(O)PT
DMU1	899617.69	1622233.95	64939.38	11235.04	1710677.14	63649.31
DMU2	1660695.01	1648967.54	196892.37	243529.08	2104166.24	62863.20
DMU3	4231393.77	2920363.98	34513.79	235799.54	3446527.55	182938.84
DMU4	4356928.06	6368085.31	577484.45	872481.62	7744694.24	32288.35
DMU5	433416.69	144125.61	6934.96	5361.60	175950.92	250.06
DMU6	410675.94	594991.68	17681.50	55316.53	649132.88	1536.91
DMU7	4428862.42	4379514.24	112462.04	255299.58	4857741.34	88337.82
DMU8	345732.79	469034.41	2590.28	4147.07	478742.33	26047.57
DMU9	1772702.95	3440739.56	38007.25	170717.17	3332269.41	332661.92
DMU10	125276.61	77536.33	5862.46	14015.91	117655.67	25186.19
DMU11	210992.04	390465.21	77477.97	105818.21	592607.33	122802.45
DMU12	3743802.81	2856395.20	54273.08	115743.46	3241101.23	61042.07
DMU13	3462354.10	2004555.83	6567.59	83873.95	2081511.77	45792.13
DMU14	45630.44	732701.61	3827.48	14697.32	813332.68	45630.44
DMU15	6624428.33	12797862.80	388819.25	431367.35	14128309.73	608660.09

Sources: calculated by researcher.

Table 14: Average MAPE of 15 DMUs.

DMUs	Average MAPE (%)
DMU1	3.51
DMU2	1.79
DMU3	5.36
DMU4	7.72
DMU5	5.29
DMU6	3.01
DMU7	3.78
DMU8	4.85
DMU9	3.59
DMU10	4.13
DMU11	3.90
DMU12	2.40
DMU13	3.28
DMU14	7.38
DMU15	1.27
Average MAPE of 15 DMUs	4.08 (%)

Source: calculated by researcher.

use actual business data of the DMUs and the analytical applications from the super SBM-I-V of DEA to evaluate the business situation of DMUs before the alliance. The results are shown in Table 19.

3.3.2. Analysis after Alliance. Based on the actual performance of the business in 2016 and the results of business analysis obtained from the super-SBM-I-V software, the authors establishe DMU5 as the alliance target for the business. If we choose low-rated and performance DMUs, it will be difficult to persuade other DMUs to join the alliance. When combing DMU5 to other 14 DMUs, the authors have 29 combinations. The authors used software of a DEA-solver pro 8.0-super-SBM-I-V model and obtained the results, as shown in Table 20.

In this study, DMU5 was chosen as the target DMU for alliances with other enterprises in the textile supply chain because DMU5's business performance in 2016 was ineffective (specifically $DMU5_{Rank} = 14$ (14/15 DMUs); $DMU5_{Score} = 0.9998$). Hence, the DMU5 management team needs to boldly change the strategy and choose an alliance solution with other DMUs to improve their business efficiency. On the other hand, DMU5 (Ha Dong Textile J.S.C), established in 1956, has a long history in the textile industry, with a large market and modern technology, and can easily persuade other DMUs to join their alliance.

Based on the ranking and efficiency score at Table 20, we can separate into two groups good alliances cooperative and inappropriate alliances as follows.

Group 1. After strategic alliances, the DMUs get good business efficiency, make the relationship among the coalition parties better, and expand market share. Candidates need to own good characteristics and necessary consistency with one's desire in business. There are 13 DMUs (DMU14, DMU8, DMU9, DMU3, DMU1, DMU13, DMU7, DMU10, DMU6, DMU11, DMU4, DMU2, DMU15) in this group, which help DMU5 to improve results after the strategic alliance. Alliances DMU5 + DMU14, DMU5 + DMU8, DMU5 + DMU9, DMU5 + DMU3, DMU5 + DMU1, DMU5 + DMU13, DMU5 + DMU7, DMU5 + DMU10, DMU5 + DMU6, DMU5 + DMU11, DMU5 + DMU4, DMU5 + DMU2, DMU5 + DMU15 receive a score of more than 1. These are shown in Table 21.

Group 2. In this group, DMU12 combined with DMU5 shows no any progress after alliance. Thus, this combined will not be priority with selection of a strategic alliance partner in the future, as shown in Table 22.

Table 15: Correlation of inputs and outputs in 2013.

	TA	CS	SE	AE	RS	PT
TA	1.0000	0.9077	0.8869	0.9286	0.9176	0.8134
CS	0.9077	1.0000	0.8977	0.9064	0.9985	0.9108
SE	0.8869	0.8977	1.0000	0.9218	0.9168	0.8809
AE	0.9286	0.9064	0.9218	1.0000	0.9245	0.8329
RS	0.9176	0.9985	0.9168	0.9245	1.0000	0.9175
PT	0.8134	0.9108	0.8809	0.8329	0.9175	1.0000

Source: calculated by researcher.

Table 16: Correlation of inputs and outputs in 2014.

	TA	CS	SE	AE	RS	PT
TA	1.0000	0.9322	0.8973	0.8745	0.9429	0.8528
CS	0.9322	1.0000	0.8894	0.8028	0.9984	0.9176
SE	0.8973	0.8894	1.0000	0.9104	0.9086	0.7912
AE	0.8745	0.8028	0.9104	1.0000	0.8316	0.6814
RS	0.9429	0.9984	0.9086	0.8316	1.0000	0.9181
PT	0.8528	0.9176	0.7912	0.6814	0.9181	1.0000

Source: calculated by researcher.

Table 17: Correlation of inputs and outputs in 2015.

	TA	CS	SE	AE	RS	PT
TA	1.0000	0.9328	0.8608	0.8601	0.9425	0.8548
CS	0.9328	1.0000	0.8774	0.8203	0.9983	0.9284
SE	0.8608	0.8774	1.0000	0.9376	0.8999	0.7319
AE	0.8601	0.8203	0.9376	1.0000	0.8517	0.6716
RS	0.9425	0.9983	0.8999	0.8517	1.0000	0.9185
PT	0.8548	0.9284	0.7319	0.6716	0.9185	1.0000

Source: calculated by researcher.

Table 18: Correlation of inputs and outputs in 2016.

	TA	CS	SE	AE	RS	PT
TA	1.0000	0.9404	0.8370	0.8303	0.9463	0.7818
CS	0.9404	1.0000	0.8667	0.7728	0.9987	0.8835
SE	0.8370	0.8667	1.0000	0.9300	0.8873	0.6227
AE	0.8303	0.7728	0.9300	1.0000	0.8031	0.5075
RS	0.9463	0.9987	0.8873	0.8031	1.0000	0.8714
PT	0.7818	0.8835	0.6227	0.5075	0.8714	1.0000

Source: calculated by researcher.

3.4. Discussion of Alliance Partner Selection. DMUs include DMU14, DMU8, DMU9, DMU3, DMU1, DMU13, DMU7, DMU10, DMU6, DMU11, DMU4, DMU2, and DMU15. But these DMUs would not be willing to combine with DMU5 because some companies have a score after an alliance, and ranking is reduced before an alliance.

In alliances that bring high performance in group 1, DMU9 (Saigon 3 garment joint stock company, GATEXIM), before alliance, has a ranking at 3 (3/15 DMUs); however, after the alliance, its ranking is at 8 (8/29 DMUs). Hence, the effect given is immensely good; specifically, DMU5 in Hanam (the large economic center in the northern region of Vietnam) specializes in the textile industry and the DMU9 in Ho Chi Minh City (the largest economic center in the south of Vietnam) specializes in the garment industry. Thus, in terms of expertise, these two companies joined the alliance between textile and apparel enterprises when the parties signed the main agreement, which helps to build the supply chain by eliminating intermediaries between suppliers and consumers and shorten the length of the channel consumption. Joining

Table 19: Rank and score before alliances.

Rank	DMU	Score
1	DMU14	4.9495
2	DMU8	2.1602
3	DMU9	1.4468
4	DMU10	1.3776
5	DMU1	1.1660
6	DMU3	1.1542
7	DMU7	1.0303
8	DMU11	1.0262
9	DMU13	1.0251
10	DMU6	1.0241
11	DMU4	1.0183
12	DMU2	1.0105
13	DMU15	1.0000
14	DMU5	0.9998
15	DMU12	0.8677

Source: calculated by researcher.

Table 20: Performance ranking of virtual DMUs.

Rank	DMU	Score
1	DMU14	4.5722
2	DMU8	1.9574
3	DMU10	1.3776
4	DMU5 + DMU14	1.0526
5	DMU1	1.0498
6	DMU9	1.0473
7	DMU5 + DMU8	1.0293
8	DMU5 + DMU9	1.0292
9	DMU5 + DMU3	1.0266
10	DMU11	1.0254
11	DMU13	1.0251
12	DMU3	1.0193
13	DMU5 + DMU1	1.0189
14	DMU6	1.0170
15	DMU5 + DMU13	1.0092
16	DMU5 + DMU7	1.0084
17	DMU15	1.0067
18	DMU2	1.0043
19	DMU7	1.0042
20	DMU5 + DMU10	1.0040
21	DMU5 + DMU6	1.0032
22	DMU4	1.0026
23	DMU5 + DMU11	1.0024
24	DMU5 + DMU4	1.0019
25	DMU5 + DMU2	1.0006
26	DMU5 + DMU15	1.0000
27	DMU5	0.9998
28	DMU5 + DMU12	0.8802
29	DMU12	0.8533

Source: calculated by researcher.

the alliance helps businesses ensure that the factors of supply and consumption remain stable. In terms of geographic location, enterprises can deploy and expand their distribution network so that they can take advantage of the available network and human resources of their partners. This not only helps to save cost but also reduces time entering a market to the fullest. Besides, joining alliances also can increase the customer base by leveraging each other's customer systems. Because every business has its own characteristics matching its inherent potential, alliances will have their own advantages to exploit and complement each other. Hence, in order to survive, compete, and develop, an alliance is inevitably a trend because it gives firms greater value-added alliance than standing alone. Hence, in order to survive, compete, and develop, an alliance is inevitably a trend because it gives firms greater value-added alliance than standing alone, to gain greater economic benefits on a larger scale, to increase prestige and brand name, to reduce costs, to maximize business advantages of parties involved, and to develop the customer base and distribution network. This will help strengthen the position and competitiveness in the market and improve business efficiency.

4. Conclusions

With what has been happening in the textile and apparel industry, the need for linking is becoming increasingly urgent. In this study, the authors provide a method for finding and selecting the right strategic partner for textile and apparel enterprises. The selected plan is to promote the internal strength of all participating enterprises while promoting the strength of the alliance in accordance with high volume products, high quality, international quality, timely delivery, and competitive price needs. Authorities can rely on these research results to make the correct and appropriate strategic decisions in helping Vietnam's textile and apparel industry to develop when integrating with the global economy.

Although the paper shows that GM (1,1) is a flexible and easy model of use to predict what would happen in the future business and DEA is an efficient tool to help businesses find the right strategic partner, we still cannot deny some restrictions about these two methods for further studies. Different DEA models and optimization algorithm can also be tested to reveal more changes, and other industries can be studied by this model in the future [38]. This study only focuses on a quantitative model. The authors will do more research of external environmental factors in the future. The comparisons with other quantitative and qualitative approaches will be a good research direction as well.

Conflicts of Interest

The authors declare no conflicts of interest.

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Table 21: The good alliances.

Virtual Alliance	Target DMU5 Ranking (a)	Virtual alliance Ranking (b)	Difference (a) − (b)
DMU5 + DMU14	27	4	23
DMU5 + DMU8	27	7	20
DMU5 + DMU9	27	8	19
DMU5 + DMU3	27	9	18
DMU5 + DMU1	27	13	14
DMU5 + DMU13	27	15	12
DMU5 + DMU7	27	16	11
DMU5 + DMU10	27	20	7
DMU5 + DMU6	27	21	6
DMU5 + DMU11	27	23	4
DMU5 + DMU4	27	24	3
DMU5 + DMU2	27	25	2
DMU5 + DMU15	27	26	1

Source: calculated by researcher.

Table 22: The inappropriate alliance.

Virtual Alliance	Target DMU5 Ranking (a)	Virtual alliance Ranking (b)	Difference (a) − (b)
DMU5 + DMU12	27	28	(−1)

Source: calculated by researcher.

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