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Selecting Partners in Strategic Alliances: An Application of the SBM DEA Model in the Vietnamese Logistics Industry

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Abstract: *Background:* Strategic alliance is a popular strategic option for business entities to strengthen the competitive advantages of all partners in a partnership. The global logistics industry has witnessed the formulation of several successful strategic alliances. However, the Vietnamese logistics industry seems to grow slowly and lacks long-term inter-firm partnerships. In such a context, it is critical to have a more effective approach to selecting partners in strategic alliances to increase long-term relationships and firm performance. *Method:* Thus, this study proposes using the SBM-I-C DEA model to examine and suggest partners for Vietnamese logistics firms to form strategic alliances. *Results:* Our findings show that integrating technology in managing strategic alliances will foster companies in the alliance to formulate a better strategy with up-to-date information on policies. *Conclusion:* Using the SBM-I-C DEA model, companies can minimize operating costs and optimize delivery time. Thus, companies can better satisfy customers. From the research findings, some implications are proposed for Vietnamese logistics companies.

Keywords: super-SBM-I-C DEA model; strategic alliance; Vietnam domestic logistics companies

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1. Introduction

International commerce has been steadily increasing in recent years due to globalization and economic connectivity among countries, which is deepening and broadening, creating numerous opportunities for import–export enterprises and the country's economy. Logistics services, in particular, are a vital component of international trade. Furthermore, businesses in wealthier countries are rapidly outsourcing their operations to rising regions such as Southeast Asia to reduce manufacturing costs. In addition, with urbanization rates increasing at a massive pace, population densities in cities are on the rise, and supplying those urban areas with goods in a sustainable manner is becoming more and more challenging (Nitsche, 2021, Logistics) [1]. Due to its vast natural resources, low raw material costs, and labor wage, Vietnam is considered one of the most desirable emerging markets. Additionally, our country's topography is suitable for encouraging geographical and political advantages in developing logistics infrastructures such as deep-water harbors, international airports, the Trans-Asian railway system, and international transport hubs.

The logistics industry in Vietnam is considered an emerging market and has an increasing role to play in the development of Vietnam's economy. According to the Vietnam Association of Logistics Service Enterprises, along with the GDP growth rate, industrial production value, import–export turnover, and retail value of goods and services, in recent years, Vietnam's logistics has had a relatively high growth rate of 12–14% [2]. The total import and export turnover of goods since 2010 has increased by 3.6 times. Meanwhile, the GDP has increased by 2.4 times, from USD 157 billion in 2010 to USD 544 billion in 2020, of which exports have increased at an average rate of 4.5%/year, becoming a vital driving force of economic growth. In the past two years, the COVID-19 epidemic has had a strong impact on the economy, facing unprecedented difficulties in all aspects from economy, culture, and tourism to people's lives globally, especially putting heavy pressure on production capacity as well as the global supply chain. However, the import and export sector still has positive double-digit growth. The total import–export turnover of goods reached USD 600 billion, recognizing the uptrend of 22.3% over the same period, of which exports were nearly USD 300 billion. This result positively contributes to Vietnam's logistics industry as a supporting factor in the transshipment of goods. Logistics enterprises have managed to ensure the regular operation of Vietnam's supply chains in the most challenging times, helping to transship large volumes of import and export goods [3].

Despite the positive growth rate, Vietnamese logistics companies have fewer strategic benefits and face multiple difficulties in size, capital, infrastructure, warehousing, equipment, information technology application, management capacity, and human resources [4]. According to the Ministry of Industry and Trade's Vietnamese Logistics Report 2021, most logistics businesses in Vietnam are still small- and medium-sized in terms of capital, labor, and technology. Moreover, the financial potential is still limited (80% of existing companies have registered capital of VND 1.5–2 billion). In addition to capital problems, Vietnam's logistics are still inexperienced and have limited competitiveness, so it has not had the opportunity to reach the market with huge demand. In addition, there is a lack of synchronous linkage between enterprises and between different stages of logistics activities. Nevertheless, logistics services in the direction of outsourcing of manufacturing companies (3PL, 4PL services) have been present and have great potential for development in Vietnam [5]. However, to enhance the logistics system significantly, the Vietnamese government has only focused on developing infrastructure to create the most advantageous conditions for the logistics business development, as evidenced by different national modal transport development plans [3].

Furthermore, one of the significant issues in the Vietnamese logistic industry is the high cost compared with other countries such as Thailand, China, and Malaysia. Therefore, cutting costs is an excellent way to achieve better performance. Therefore, this study desires to analyze the effectiveness of strategic alliances in Vietnamese logistics firms to enhance their performance. The collaboration of logistics companies allows small- and medium-sized businesses in Vietnam to obtain finance, cut transportation costs, and increase operating efficiency. Furthermore, this collaboration will assist Vietnamese logistic firms in meeting local demand rates, organizing to connect transport activities, expanding the source of information, and opening more service sectors in this billion-dollar service value chain. As a result, these firms may compete with foreign logistic corporations operating in Vietnam.

For years, strategic alliance has emerged as a popular business strategy for many industries. As a result, numerous transportation companies have identified the potential benefits of forming strategic alliances. Logistics alliance is the logistics model between self-operated logistics and outsourcing logistics. It combines the advantages of self-operated and outsourcing logistics and reduces the risks of the two opposite models. Regarding the new trends in the logistics industry in the coming years, sustainability is a buzzword that will drive industry changes. Strategic alliance is primarily focused on as it is considered one of several ways to promote sustainability in the global supply chain because it helps reduce transportation costs and air emissions.

Furthermore, a strategic alliance in the logistics industry also helps to connect various members in the global supply chain and make it easier for goods transportation worldwide. According to Nitsche (2021), optimization to plan, control or execute the physical flow of goods and the corresponding informational and financial flows within the focal firm and with sustainable supply chain partners helps productivity increase in logistics networks (applied economics) [1].

However, only a few pieces of research on strategic alliances in the logistics industry have been conducted in Vietnam. In this regard, we use the super (SBM-I-C) DEA (Data Envelopment Analysis) model to analyze and evaluate the ability of domestic enterprises to cooperate [6]. Our sample included 16 Vietnamese logistics companies, and data for analysis were obtained for three years, from 2018 to 2021. The primary goal of our research is to validate the application of the SBM-I-C DEA model in selecting strategic alliance partners for logistics firms in Vietnam.

2. Literature Review

2.1. Logistics Industry and Strategic Alliance

Logistics is a service consisting of people, processes, and technology to deliver the right product at the right cost, time, and place in the right quantity and condition to the right customer. Logistics processes manage the movement and storage of goods among the different supply chain partners [7]. Therefore, measuring the performance of the supply chain is fundamental to identifying and addressing deficiencies in logistics activities, and it serves as a good input for managerial decision making. However, logistics is a well-integrated trading and product movement system, not only a transportation system.

According to Glaister (1998), a strategic alliance is described as an "inter-firm collaboration over a given economic space and time for the attainment of mutually defined goals" [8]. Similarly, Taylor (2005) stated that a strategic alliance is an interconnection between multi-business partners that shares resources, managerial control, and rewards in collaboration and makes ongoing contributions in one or perhaps more strategic areas, such as technological or product innovation [9]. It is also an efficient paradigm for assisting organizations in accessing and conserving the resources required for dynamic development innovation and risk sharing. Vyas et al. (1995) and Mockler (1997) established a strategic alliance model that emphasizes the essential traits of a successful partnership, including goal integration, should move towards a similar direction, synergy—joint actions should add more value than the sum of their parts by leveraging the strengths of each partner [10,11].

The logistics alliance concept is formed when we combine the strategic alliance definition and the logistics industry characteristics. A logistics alliance is organized by two or more business entities to cooperate through signing contracts in the long term. The primary purpose of the alliance is to leverage members' advantages to share resources, have complementary advantages, and achieve logistics objectives together. A strategic alliance is characterized by interdependence, cooperation, risk, and benefit sharing among alliance members. 2M, Ocean Alliances, and The Alliance are examples of global carrier shipping alliances that pool resources to expand service offerings and geographic coverage. Collaboration among local transportation and logistics industries is expected to increase their ability to compete against multinational firms significantly.

Some studies on strategic alliances have been conducted in Vietnam. For example, Vu (2019) stated that collaboration and joint ventures are critical strategies for improving the performance of logistics businesses in Vietnam [12]. Thus, the authors also emphasize that many enterprises are not capable of accomplishing it with their strength, so a logistics alliance is a reasonable choice. To achieve the best possible outcome from these criteria, we must examine transportation, human resource systems, buildings, upgrading and extending warehouse systems, loading and unloading equipment, and other support services. Moreover, a logistic company should connect and expand its service network in the country and worldwide to create foreign markets and enhance the professional capacity of officials from there. If domestic firms seek to compete for market share with foreign corporations, these variables will be an enormous difficulty to deal with.

2.2. Data Envelopment Analysis Model and Its Application

Charnes et al. (1978) established Data Envelopment Analysis (DEA), a statistical approach for identifying the impact of a decision-making unit (DMU) [5]. A DMU is a group of entities that receive the same set of inputs and produce the same set of outputs. In cases of one or more inputs or outputs, the DEA is used to determine relative efficiency [13].

DEA has changed over the years as different models have been modified. Non-radial models, such as Tone's (2001), provided slacks-based measures (SBM-I-C) and input excess and output deficit measurement. However, because early models produce the same score (equal 1) for all units in the efficient frontier, they cannot distinguish between efficient DMUs' performance [14]. The need to evaluate efficient DMUs prompted the creation of a number of super-efficiency models. According to Du et al. (2010) the super-SBM-I-C model accomplishes this by calculating the target DMU's shortest distance to the efficient frontier while excluding the target DM [15].

Much research on the use of DEA in various industries has recently been published. Oum et al. (2008) used DEA models to evaluate the strategic and functional productivity of a Spanish airline in 2001 [16]. Furthermore, Das and Teng (2003) and Wang et al. (2016) applied the DEA model in various areas in businesses such as Renault–Nissan, Merck, and AB Astra [17,18]. Liang et al. (2006) used DEA to enhance the feasibility of supply management sectors. In addition, a substantial study has been conducted to measure the efficiency of the logistics industry in specific cities using a variety of inputs and outputs in conjunction with data envelopment analysis (DEA) [19]. For example, Gen and Syarif (2005) researched the logistics industry's efficiency based on the selection of four variables: delivery reliability, delivery flexibility, delivery cycle, and inventory level [20]. Hamdan investigates the efficiency of the logistics industry with a focus on the rate of return, the delayed arrival rate, and the price. Li and Liu (2019) focused on the number of trucks, the transportation and warehousing and fixed postal investment, the urban road area, and the urban road length. The latter consists of the freight volume and the freight turnover [21].

Similarly, Nguyen and Tran (2018) used the DEA model to evaluate the strategic alliance in Vietnamese logistic firms. They concluded that collaboration among local enterprises could boost supply chain integration, making it more productive and increasing the industry's competitiveness. In addition, they analyzed that the contemporary background of Vietnam is that it is a developing country with a lengthy and dynamic geographical structure. Its logistics are likewise in the development process and appear to have a high potential [22]. However, a lack of experience and technology, fragmented operations, severe price competition among local firms, and dominance by global logistics giants are all challenges that may hinder the local sector's growth. Therefore, strategic alliance is a good strategy for Vietnamese logistics firms.

3. Methodology

3.1. Research Methodology

3.1.1. Research Procedure

This research uses a procedure with 7 steps. Each of the steps is detailed as follows:

- Step 1: Data collection.
- The data of DMUs were collected from VietStock, which is a famous stock market in Vietnam [23]. In this research, one DMU was selected and is defined as a target company that is a basic company that selects other companies as partners for a strategic alliance.
- Step 2: Selection of input/output variables.
- Inputs and outputs are the main impact factors used by DEA model to measure the relative efficiency of a DMU to other DMUs.
- Step 3: Selection of DEA model.
- In this step, the super-SBM-I-C was used to measure the efficiency of different DMUs.
- Step 4: Pearson correlation analysis
- DEA was used for incompetency estimation for DMUs by developing a comparative effectiveness score through the change in the multiple foundation data into a ratio of a single virtual output to a single virtual input. Subsequently, correlation testing for collected input and output is quite important. In this research, the Pearson Correlation Coefficient Test was used to check the suitability of selected input and output variables.
- Step 5: Analysis before strategic alliance.

- This step aimed to select one target company and understand its performance before applying strategic alliance with allied members. This helped to understand the performance of the target company after applying the strategic alliance in the next step.
- Step 6: Analysis after strategic alliance.
- This step aimed to analyze the performances of various alliances available for the target company selected in the previous step. From the results available from different alliance strategies, we can identify the best one for a selected target company. The performance of each strategic alliance can be estimated by using the super-SBM-I-C model.
- Step 7: Summary (Partner Selection).
- This step aimed to summarize a suggestion, based on the previous step. Basically, the strategic alliance should result in positive results that can benefit all allied members.
- An overview of the steps is drawn in Figure 1

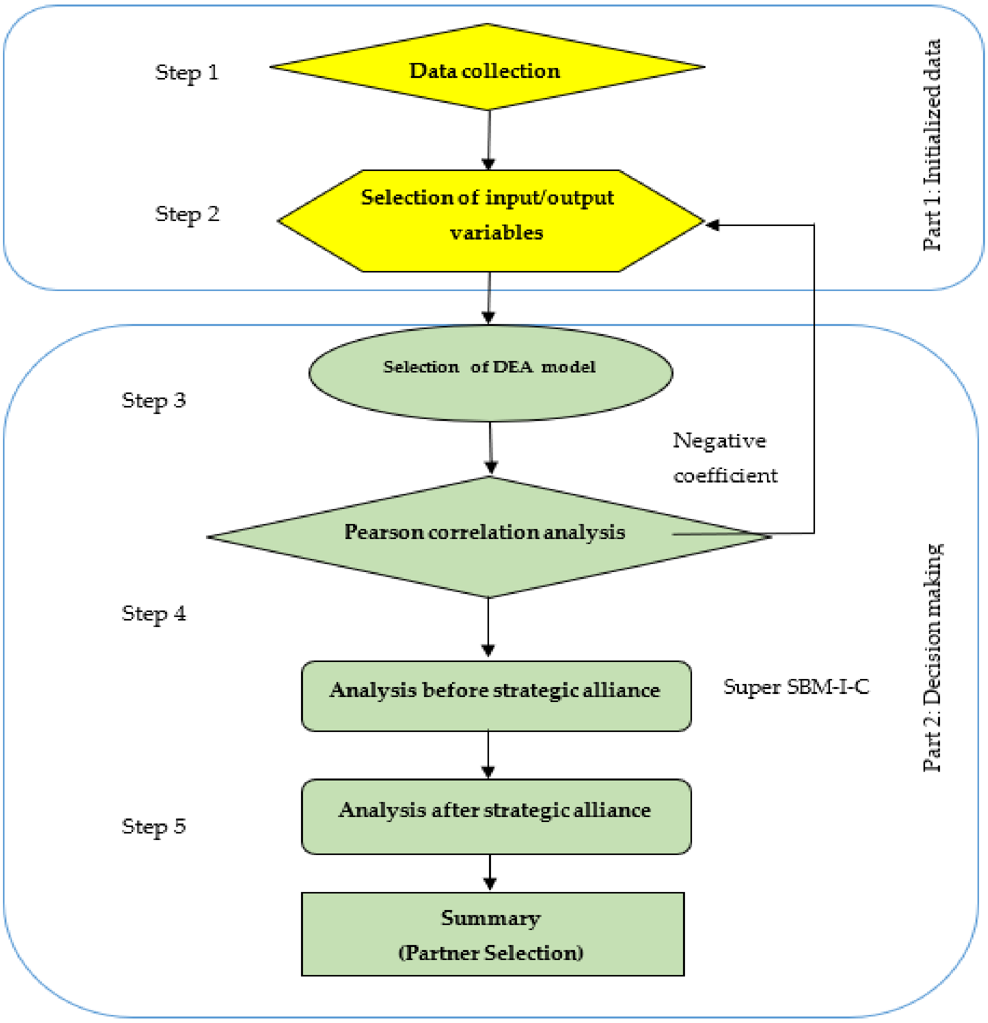

Figure 1. Framework of research.

3.1.2. Non-Radial Super Efficiency Model (Super-SBM)

In this study, the non-radial slack-based measure of super-efficiency (super SBM) of DEA is applied. This model was introduced by Tone in 2001 [14].

In the super SBM model, given n DMUs with the input and output matrices $X = (Xij) \in R^{m\times n}$ and $Y = (Yij) \in R^{8\times n}$, respectively. Let λ be a non-negative vector in R^n.

The vectors $S^- \in R^m$ and $S^+ \in R^s$ indicate the input excess and output shortfall, respectively. This model provides a constant return to scale. It is defined in Equation (1) that subjects to Equation (2).

$$\min\rho = \frac{1 - \frac{1}{m}\sum_{i=1}^{m} S_i^- / x_{i0}}{1 + \frac{1}{8}\sum_{i=1}^{8} S_i^- / y_{i0}} \tag{1}$$

$$s.t\ x_0 = X\lambda + S^-,\ y_0 = Y\lambda - S^+,\ \lambda \geq 0, S^- \geq 0,\ S^+ \geq 0 \tag{2}$$

The variable S^+ measure the distance of inputs $X\lambda$ and outputs $Y\lambda$ of a virtual unit from those of the unit evaluated. The numerator and the denominator in the objective function measure the average distance of inputs and outputs, respectively, from the efficiency threshold. The DMUs $(X_0,\ Y_0)$ is SBM-efficient, if $p^* = 1$. This condition is equivalent to $s^{-^*} = 0$ and $s^{+^*}, s^{+^*} = 0$ if there are no input excesses and no output shortfalls in any optimal solution. The SBM-I-C model is non-radial and deals with input/output slacks directly. The SBM-I-C returns and efficiency measure between 0 and 1.

The best performers have the full efficient status denoted by unity. The super-SBM-I-C model is based on the SBM-I-C model. Tone (2001) discriminated these efficient DMUs and ranked the efficient DMUs by super-SBM-I-C model. Assuming that the DMU (X_0, Y_0) is SBM-I-C-efficient, $p^* = 1$; the super-SBM-I-C model is defined in Equation (3) and subject to Equation (4).

$$\min\delta = \frac{\frac{1}{m}\sum_{i=1}^{m} \overline{X}_i / x_{i0}}{\frac{1}{8}\sum_{r=1}^{8} \overline{y}_r / y_{r0}} \tag{3}$$

$$s.t\ \overline{x} \geq \sum\nolimits_{j=1,\neq 0}^{n} \lambda_j x_j,\ \overline{y} \leq \sum\nolimits_{j=1,\neq 0}^{n} \lambda_j x_j,\ \ \overline{y} \geq x_0\ and\ \overline{y} \leq y_0,\ \overline{y} \geq y_0,\ \lambda \geq 0 \tag{4}$$

The input-oriented super-SBM-I-C model is derived from Equation (3) with the denominator set to 1. The super-SBM-I-C model returns a value of the objective function that is greater or equal to 1. The higher the value, the more efficient the unit.

Suppose that $y_{r0} \leq 0$. It defines $\overline{y}\,_r^+$ and $\overline{y}\,_{-r}^+$ by:

$$\overline{y}\,_r^+ = max_{j=1,\ldots,n}\{y_{rj} | y_{rj} > 0\} \tag{5}$$

$$\overline{y}\,_r^+ = min_{j=1,\ldots,n}\{y_{rj} | y_{rj} > 0\} \tag{6}$$

In the objective function, if the output r has no positive elements, then it is defined as $\overline{y}\,_r^+ = y\,_{-r}^+ - 1$ The term s_r^+ / y_{r0} will be replaced in the following way. (The value y_{r0} of in the constraints has never changed.)

If $\overline{y}\,_r^+ > y\,_{-r}^+$ the term is replaced by:

$$s_r^+ / \frac{y_{-r\ (\overline{y}\,_r^+ - y_{-r}^+)}^+}{\overline{y}\,_r^+ - y_{r0}} \tag{7}$$

If $\overline{y}\,_r^+ = y\,_{-r}^+$ the term is replaced by:

$$s_r^+ / \frac{\overline{y}\,_r^{+2}}{B(\overline{y}\,_r^+ - y_{r0})} \tag{8}$$

where B is a large positive number (in DEA-Solver B = 100).

Furthermore, the denominator is positive and strictly less than $\overline{y}\,_r^+$. Moreover, it is inverse to the distance $\overline{y}\,_r^+ - y_{r0}$. Hence, this scheme concerns the magnitude of the nonpositive output positively. The score obtained is units invariant; it is independent of the units of measurement used.

3.1.3. Data Collection

In this research, 16 companies were recorded as the most notable market logistic organizations. Initial capitalization is targeted at DMUs due to their importance in the logistics industry in Vietnam published in the stock market. The list of 16 companies were included and listed in Table A1 (Appendix A)

3.1.4. Input and Output Variables Selection

In this exploration, some previous research in logistic industries were referred to in order to find suitable variables as inputs and outputs. Input and output are the two most important data for evaluating DMUs. These selected variables should be able to reveal the performance of DMUs. Table 1 below shows the summary of input and output variables used in some past research for the assessment of DMUs.

Table 1. Summary of input and output variables used in previous studies.

Research Title	Input Variable	Output Variable
Raising Opportunities in Strategic Alliance by Evaluating Efficiency of Logistics Companies in Vietnam: A Case of Cat Lai Port Nguyen and Tran (2019) [22].	Total Asset Cost of Goods Sold Liabilities	Net Revenue Operating Profit
Automobile Industry Strategic Alliance Partner Selection: The Application of a Hybrid DEA and Grey Theory Model Wang et al., 2016 [18].	Fixed Assets Cost of Goods Sold Operating Expenses Long-Term Investments	Revenues Total Equity Net Income
Strategic Alliance for Vietnam Domestic Real Estate Companies Using a Hybrid Approach Combining GM (1,1) with Super SBM DEA Wang et al., 2020 [24]	Charter Capital Asset Value Selling Expense General and Administrative Expense	Revenue from Sales of Goods and Services Profit Before Tax

Let an optimal solution for SBM-I-C be $\left(p^{*}, \lambda^{n}, s^{-^{*}}, s^{+^{*}}\right)$.

There are numerous input and output factors that are routinely used to assess the logistics industry's efficiency. The nature of the study and the peculiarities of a certain efficiency evaluation situation determine which input and output variables are used. Based on the theory of "Operational Efficiency" by Lee and Johnson (2013), which emphasizes the relationship between output revenue and the cost of using input resources or the ability to turn input resources into outputs the best in business activities, the input and output variables were selected in this study [25]. Because of logistics operations in Vietnam cost highly compared with other countries such as Thailand, China, and Malaysia, to improve the operational efficiency, cutting down the logistic costs is essential. The input variables include fixed assets, operating expenses, and the cost of goods sold. These are chosen based on the factors occupying the high percentage on Vietnamese logistics costs such as transport cost, warehousing cost, investment in infrastructure, and technology. The output variables are capital, revenue, and operating income. We believe these factors reflect the essential business resources and outcomes of the respective industry. Details of each variable are shown below:

- Fixed assets (I): The assets owned by, leased by, or required for the functioning of any Logistics Group firm, as well as any future expansions thereof [22,26,27].
- Operating expense (I): An operating expense is an expense a business incurs through its normal business operations. Often abbreviated as OPEX, operating expenses include rent, equipment, inventory costs, marketing, payroll, insurance, step costs, and funds allocated for research and development [28].
- Cost of goods sold (I): The total costs incurred related to a shipment from the time a transaction is generated to the end of a transaction for a shipment. For export services, the cost of goods sold includes sea freight for export, lifting fee, warehousing fee, and document fee [29]

- Total equity (O): The amount invested in a company by investors in exchange for stock, plus all subsequent earnings of the business minus all subsequent dividends paid out [18,30].
- Operating income (O): The measurement of a company's profit once operating costs, taxes, interest, and depreciation have all been subtracted from its total revenues [31,32].
- Net profit (O): The measurement of a company's profit once operating costs, taxes, interest, and depreciation have all been subtracted from its total revenues [18,26].
- Data collection
- Data of these input and output variables 2018–2021 collected from the Vietstock Website are presented in Tables 2–5 [23]

Table 2. The data of Vietnam logistics company 2018 (Unit: million dong).

DMUs	Input			Output		
	Fixed Assets	**Operating Expense**	**Cost of Goods Sold**	**Total Equity**	**Account Receivable**	**Net Profit**
VIN	421,660	48,178	48,912	373,161	89,065	39,968
CQN	3,133,283	133,726	143,228	557,619	56,168	57,119
GMD	10,030,889	2,961,152	4,251,303	4,526,885	1,128,059	443,735
VTP	1,031,937	709,803	714,535	361,028	362,985	111,894
CIA	204,238	92,667	140,517	172,763	8533	7206
CCT	380,786	49,644	119,729	275,091	24,786	12,973
CDN	1,037,629	150,786	22,569	819,599	126,312	127,605
PHP	5,093,773	504,735	1,281,066	3,713,079	298,335	598,557
NCT	485,955	49,970	52,807	436,574	53,496	270,304
TCW	671,512	169,707	373,426	268,924	110,043	62,998
VGR	1,354,535	119,846	761,051	594,444	23,399	28,641
DDG	208,304	84,641	113,87	123,955	70,672	7972
HRT	1,166,448	342,559	450,865	801,788	110,755	3012
SAS	1,730,259	562,722	565,677	1,458,192	293,708	234,112
STG	2,261,989	371,940	1,054,811	909,794	308,540	111,455
VOS	4,152,641	710,986	3,609,911	619,432	463,110	359,180

Source: authors' collection from finance.vietstock.com (accessed on 6 March 2022).

Table 3. The data of Vietnam logistics company 2019 (Unit: million dong).

DMUs	Input			Output		
	Fixed Assets	**Operating Expense**	**Cost of Goods Sold**	**Total Equity**	**Account Receivable**	**Net Profit**
VIN	447,734	60,756	60,099	285,476	94,308	43,102
CQN	2,195,616	1,005,622	1,005,622	579,714	933,603	71,083
GMD	11,183,416	2,676,232	4,196,680	4,409,030	1,127,689	581,436
VTP	1,731,850	1,261,370	1,261,789	479,388	478,704	96,946
CIA	408,066	111,440	199,307	235,445	27,514	20,945
CCT	377,979	39,952	115,726	272,473	35,674	89
CDN	1,277,299	230,973	416,488	870,351	103,294	131,566
PHP	5,194,358	498,609	1,228,735	3,799,561	362,605	482,285
NCT	505,987	64,762	69,888	439,106	54,055	272,817
TCW	673,570	180,423	354,667	322,166	127,304	62,766
VGR	1,322,217	205,988	583,166	745,953	44,946	96,102
DDG	274,242	97,665	157,355	133,383	85,718	9427
HRT	1,570,245	552,471	927,021	715,834	105,257	−87,768
SAS	1,863,906	590,035	607,358	1,542,419	134,952	290,322
STG	2,441,307	518,851	956,061	1,192,403	335,709	521,278
VOS	3,778,130	1,018,129	3,225,726	628,765	510,212	10,736

Source: authors' collection from finance.vietstock.com (accessed on 6 March 2022).

Table 4. The data of Vietnam logistics company 2020 (Unit: million dong).

DMUs	Input			Output		
	Fixed Assets	Operating Expense	Cost of Goods Sold	Total Equity	Account Receivable	Net Profit
VIN	487,886	85,444	85,678	286,480	67,731	42,148
CQN	1,487,272	2,223,351	2,223,351	599,673	2,162,228	75,763
GMD	9,918,515	1,564,165	3,455,081	5,552,787	948,717	1,900,250
VTP	2,714,069	2,153,736	2,153,879	664,768	832,320	102,645
CIA	377,700	56,031	95,993	247,964	84,604	−14,800
CCT	384,938	49,644	121,978	263,680	41,849	110
CDN	1,617,220	199,175	401,877	1,224,527	97,310	147,484
PHP	5,418,363	652,653	1,371,405	3,748,771	318,281	515,702
NCT	502,230	65,546	71,122	434,311	70,711	241,000
TCW	607,283	136,597	269,323	340,517	130,234	60,549
VGR	1,227,418	119,846	351,096	889,201	77,333	148,249
DDG	389,042	172,839	255,186	143,461	164,403	10,078
HRT	1,694,083	423,977	1,060,992	718,676	104,342	2,842
SAS	1,873,148	673,938	674,693	1,538,797	169,449	341,114
STG	2,316,457	574,471	724,029	1,370,972	396,061	157,775
VOS	3,509,305	1,231,050	2,990,817	643,346	605,219	17,138

Source: authors' collection from finance.vietstock.com (accessed on 6 March 2022).

Table 5. The data of Vietnam logistics company 2021 (Unit: million dong).

DMUs	Input			Output		
	Fixed Assets	Operating Expense	Cost of Goods Sold	Total Equity	Account Receivable	Net Profit
VIN	525,094	98,172	98,656	286,480	67,159	38,892
CQN	1,693,879	2,568,371	2,568,371	599,673	2,539,666	66,752
GMD	10,041,526	1,828,483	3,552,650	5,269,823	787,249	613,569
VTP	3,346,549	2,426,061	2,426,253	950,869	1,072,975	106,777
CIA	462,628	67,576	76,171	348,855	105,779	70,953
CCT	372,514	16,275	112,946	260,640	42,365	3947
CDN	1,651,329	120,265	308,418	1,353,878	119,947	184,160
PHP	5,727,560	686,801	1,376,894	3,971,822	330,828	502,802
NCT	582,390	64,289	70,945	514,277	63,593	221,379
TCW	623,811	167,919	266,892	359,439	155,129	68,593
VGR	1,103,650	95,060	154,674	966,081	77,626	133,479
DDG	635,811	142,057	481,179	157,663	133,902	14,203
HRT	1,885,436	592,921	1,226,865	732,568	115,576	13,893
SAS	1,959,692	755,567	760,709	1,586,676	159,773	372,606
STG	2,253,882	458,530	574,618	1,566,795	456,497	122,918
VOS	3.029,303	1,176,479	2,412,692	695,755	548,274	51,070

Source: authors' collection from finance.vietstock.com (accessed on 6 March 2022).

4. Result and Discussion

4.1. Pearson Correlation

There are two major factors of the basic DEA data assumptions; they are homogeneity and isotonicity. Basically, the DEA input data and output data need to be isotonic, which means they have a positive correlation. Therefore, we apply the correlation test as an importance step to make sure the input and output data are isotonic. For example, any increase. In this research, we decide to use Pearson correlation to measure the strength of the linear relationship of normal distribution. According to Lo et al. (2001), the correlation coefficient is always between −1 and +1. If the coefficient of correlation is positive, the factor demonstrates an isotonic solid relationship will be put into the DEA model. On the other hand, if the correlation coefficient is negative, showing a weak isotonic relationship, it will be re-examined [16,33].

The results of correlation coefficients between input and output variables are show in Tables 6–9.

Table 6. Correlation of input and output data in 2018.

	Fixed Assets	Operating Expense	Cost of Goods Sold	Total Equity	Account Receivable	Net Profit
Fixed assets	1	0.891	0.872	0.227	0.890	0.894
Operating expense	0.891	1	0.811	0.304	0.791	0.973
Cost of goods sold	0.872	0.811	1	0.167	0.660	0.870
Total equity	0.227	0.304	0.167	1	0.263	0.326
Account receivable	0.890	0.791	0.660	0.263	1	0.779
Net profit	0.894	0.973	0.870	0.326	0.779	1

Source: authors' calculation.

Table 7. Correlation of input and output data in 2019.

	Fixed Assets	Operating Expense	Cost of Goods Sold	Total Equity	Account Receivable	Net Profit
Fixed assets	1	0.884	0.868	0.323	0.902	0.795
Operating expense	0.884	1	0.880	0.357	0.661	0.900
Cost of goods sold	0.868	0.880	1	0.234	0.622	0.822
Total equity	0.323	0.357	0.234	1	0.357	0.197
Account receivable	0.902	0.661	0.622	0.357	1	0.578
Net profit	0.795	0.900	0.822	0.197	0.578	1

Source: authors' calculation.

Table 8. Correlation of input and output data in 2020.

	Total Assets	Current Liability	Account Payable	Inventory	Total Equity	Account Receivable
Total assets	1	0.511	0.758	0.218	0.944	0.348
Current liability	0.511	1	0.834	0.362	0.320	0.885
Account payable	0.758	0.834	1	0.243	0.534	0.696
Inventory	0.218	0.362	0.243	1	0.174	0.108
Total equity	0.944	0.320	0.534	0.174	1	0.216
Account receivable	0.348	0.885	0.696	0.108	0.216	1

Source: authors' calculation.

Table 9. Correlation of input and output data in 2021.

	Total Assets	Current Liability	Account Payable	Inventory	Total Equity	Account Receivable
Total assets	1	0.538	0.758	0.203	0.942	0.263
Current liability	0.538	1	0.881	0.220	0.329	0.875
Account payable	0.758	0.881	1	0.099	0.533	0.687
Inventory	0.203	0.220	0.099	1	0.239	0.013
Total equity	0.942	0.329	0.533	0.239	1	0.114
Account receivable	0.263	0.875	0.687	0.013	0.114	1

Source: authors' calculation.

Tables 6–9 provide positive correlations that mean correlation coefficients between input and output variables have a strong relationship. Hence, these data can be used for the analysis of DEA calculations.

4.2. Analysis before Alliance

The efficiency of the DERMIs is calculated based on the primary data of 2018, and their ranking before alliances are obtained as well. Table 10 summarizes the empirical results.

Table 10. Rankings and scores before alliances.

DMU	Score	Rank	DMU	Score	Rank
DMU 9	3.884	1	DMU 15	0.997	9
DMU 2	2.457	2	DMU 12	0.869	10
DMU 1	2.291	3	DMU 8	0.626	11
DMU 6	1.573	4	DMU 4	0.417	12
DMU 5	1.406	5	DMU 14	0.372	13
DMU 10	1.353	6	DMU 3	0.308	14
DMU 11	1.328	7	DMU 16	0.273	15
DMU 7	1.233	8	DMU 13	0.176	16

In this research, we used the super-SBM-I-C model in order to measure the efficiency of 16 DMUs and rank them before alliance with the data of 2019. The result of the rankings and scores is shown in Table 10, with DMU 9 having the highest performance (with the score = 3.88457). The DMU 13 has the lowest efficiency (with the score = 0.1676). Thus, we choose to target DMU 3, which is in the 14th ranking. These low efficiencies indicated the important of alliance strategy, which will help the target company to raise its performance.

4.3. Analysis after Alliance

The result form Table 10 shows that the inefficiency score is 0.30894 and low rank is 14th/16. This means the target DMU 3 should enhance the operating activity by implementing alliance strategy. Using the software of the DEA-Solver SBM-I-C model, we combine DMU 3 with 15 other DMUs and obtain the total 31 virtual DMUs. By evaluating this new result, we can see an improvement in the firm's performance after the cooperation.

The results obtained in terms of scores and ranking are presented in Table 11.

Table 11. Performance ranking of virtual DMUs after alliance.

Rank	DMU	Score	Rank	DMU	Score
1	DMU 1	1.895	17	DMU 3 + 8	1
2	DMU 2	1.861	18	DMU 3 + 7	1
3	DMU 5	1.743	19	DMU 3 + 10	0.930
4	DMU 6	1.632	20	DMU 3 + 11	0.925
5	DMU 7	1.601	21	DMU 3 + 9	0.924
6	DMU 9	1.574	22	DMU 3 + 5	0.921
7	DMU 10	1.403	23	DMU 3 + 12	0.920
8	DMU 11	1.328	24	DMU 3 + 6	0.915
9	DMU 15	1.297	25	DMU 3 + 1	0.914
10	DMU 12	1.169	26	DMU 3	0.908
11	DMU 3 + 2	1.150	27	DMU 3 + 16	0.895
12	DMU 8	1.026	28	DMU 16	0.873
13	DMU 4	1.097	29	DMU 3 + 13	0.762
14	DMU 14	1.073	30	DMU 3 + 14	0.662
15	DMU 3 + 15	1.052	31	DMU 13	0.567
16	DMU 3 + 4	1.021			

The score of Table 11 indicates that the target DMU 3 performs the highest efficiency when building an alliance strategy with DMU 2, DMU 15, DMU 4, DMU 8, and DMU 7. This represents the new DMU 3 ranking as being the 26th place. This indicates that any results of cooperation greater than 26th place create better alliance than the original DMUs. Otherwise, if the new ranking is less than the 26th place, then the alliance is even worse. Based on this criterion, this study divided the results obtained into two groups. In order to have an easy comparison, we tabulated 10. The rise in the ranking of DMUs after the alliance demonstrates that the target company can receive advantages from an alliance. Table 10 reveals that 12 companies (i.e., DMU 2, DMU 15, DMU 4, DMU 8, DMU 7, DMU 10, DMU 11, DMU 9, DMU 5, DMU 12, DMU 6, and DMU 1) have the desired features, which correlate with the desire of the partners to do business together.

The virtual companies (DMU 3 + DMU 2; DMU 3 + DMU 15; and DMU 3 + DMU 4) have the greatest number of opportunities to achieve the highest and best efficiency when using a strategic alliance business model (score > 1). Thus, these three companies are highly appreciated when considering a strategic alliance. The second group includes the companies in the category of the not-good alliance partnership.

The first group in the Table 12 display an improvement after an alliance of DMU 3 with 12 other DMUs, including DMU 2, DMU 15, DMU 4, DMU 8, DMU 7, DMU 10, DMU 11, DMU 9, DMU 5, DMU 12, DMU 6, and DMU 1. The top three of the highest efficiencies are defined by the difference of target DMU 3 ranking and virtual alliance ranking (DMU 2, DMU 15 and DMU 4). This means DMU 3 should prioritize to choose these three companies to implement the alliance strategy. Especially, DMU 2 has the greatest potential for cooperation because of its largest difference value (15). In contrast, the second group has three enterprises (DMU 16, DMU 13, and DMU 14) which create a worse cooperate strategy. Therefore, the target DMU 3 should not choose those DMUs for alliance strategy owing to the non-benefits for the target company.

Table 12. The good and bad alliance partnerships.

Number Order	Virtual Alliance	Target DMU3 Ranking (1)	Virtual Alliance Ranking (2)	Difference (1)–(2)
1	DMU 3 + 2	26	11	15
2	DMU 3 + 15	26	15	11
3	DMU 3 + 4	26	16	10
4	DMU 3 + 8	26	17	9
5	DMU 3 + 7	26	18	8
6	DMU 3 + 10	26	19	7
7	DMU 3 + 11	26	20	6
8	DMU 3 + 9	26	21	5
9	DMU 3 + 5	26	22	4
10	DMU 3 + 12	26	23	3
11	DMU 3 + 6	26	24	2
12	DMU 3 + 1	26	25	1
2nd group				
1	DMU 3 + 16	26	27	−1
2	DMU 3 + 13	26	29	−3
3	DMU 3 + 14	26	30	−4

Source: calculated from DEA software.

4.4. Partner Selection

The best alliance partnerships are identified in the previous section based on the position of the target DMU 3. Nonetheless, we must conduct additional research into the viability of alliance partnerships and compare situations before and after alliances. There are clearly 12 good partners, as evidenced by the results in Table 10. In contrast, the other three partners should not. In other words, DMU 9, DMU 2, DMU 1, DMU 6, DMU 5, DMU 10, DMU 11, and DMU 7 are already performing well; if no special circumstances exist, they have no need to form an alliance relationship with DMU 3.

Combined with Tables 8 and 9, the efficiency and ranking of all DMUs before and after alliance are reviewed again in Figure 2. The points that are closest to the middle are given a higher ranking. The partnership will assist in the creation of a manufacturing system that reduces waste, adds value to the consumer, and achieves perfection. Aside from that, the organization must improve mutual understanding by finding new collaboration opportunities from less viable partnership partners. In a nutshell, the results and conclusions of this case study contribute to new guidelines for strategic alliances. The readers will immediately recognize Quang Ninh Port Joint Stock Company as a prominent candidate for an alliance strategy (DMU 2, the best efficiency improvement for the target company).

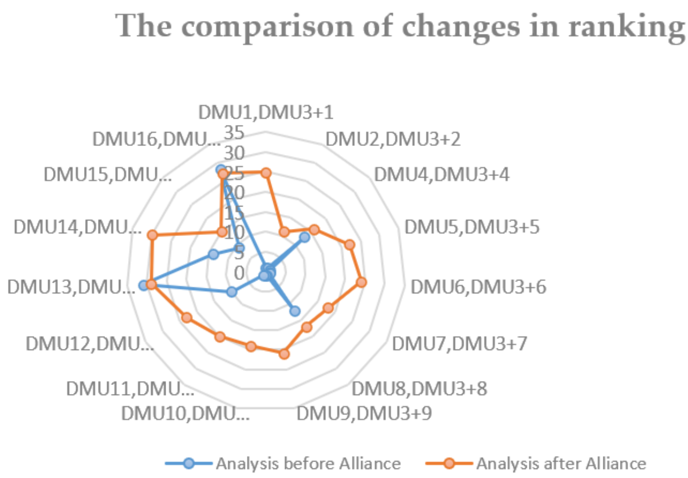

Figure 2. The comparison of changes in ranking.

5. Conclusions

Nowadays, the logistics industry and many other industries face numerous challenges, such as: How to achieve competitive advantage and enter new markets? How to obtain new customers and resources and scale up its business? To solve the above-mentioned problems, this research proposes using the super-SBM-I-C DEA model to analyze and suggest solutions for Vietnamese logistics companies when selecting partners in a strategic alliance.

Based on the public data of 16 Vietnamese logistics enterprises from 2018 to 2021, this study used the SBM-I-C model to evaluate each DMU's performance before and after joining a strategic partnership. In our research, the Gemandept Joint Stock Company (DMU 3) was used as a case study to determine the potential benefits of strategic alliances between firms. The DEA–super-SBM-I-C model was applied to evaluate the efficiency of all real DMUs and virtual DMUs. The empirical analysis showed that 12 candidates are suitable for the Germandept Joint Stock Company to form strategic alliances with, except DMU 16, DMU 13, and DMU 14. However, the Quang Ninh Port Joint Stock Company is feasible for the Gemandept Joint Stock Company. From our findings, this research proposed using the DEA–super-SBM-I-C model as a more accurate, appropriate approach to select partners in strategic alliances by evaluating the performance of logistics companies. The model provides a reference for logistic strategists when choosing alliance partners.

In terms of theory, our study validates the SBM-I-C DEA model in a new context of Vietnam. We found that the model has the greatest number of opportunities to achieve the highest and best efficiency when using a strategic alliance business model. In terms of practice, this study provides a mathematical approach to selecting partners in a strategic alliance in the logistics industry of Vietnam. This approach is our new contribution to the related work in an emerging research context as Vietnam, particularly in the logistics industry, is at its embryonic stage of development.

Nevertheless, this present study has some limitations. Firstly, the DEA is one kind of sensitive method for factor selection. The input/output variables selection could be different, and the results would be impacted. Therefore, a robustness test is necessary. The various input/output variables and removing outliers from DMUs should be re-calculated and re-discussed. For future study, sensitive analysis for different inputs or outputs of DMUs or data of additional years should be included. Moreover, we suggest future research use qualitative methods such as in-depth interviews to verify research results and evaluate the appropriateness of proposed solutions in the actual context of logistics companies. Secondly, the sample size in this study is small. Thus, potential bias in analysis might exist. Expanding the sample to increase the accuracy of analysis results is recommended. Thirdly, this study focuses on data from Vietnamese logistics companies in three recent years, which is limited in terms of timeframe. We strongly suggest that other studies should have a more extended timeframe for analysis to provide more accurate results when using the DEA–super-SBM-I-C model.

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Appendix A

Table A1. List of the 16 logistics companies.

DMUs	Company Code	Company Name	Company's Financial Statement
DMU 1	VIN	Vietnam Foreign Trade Logistics Joint Stock Company	https://finance.vietstock.vn/VIN/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 2	CQN	Quang Ninh Port Joint Stock Company	https://finance.vietstock.vn/CQN/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 3	GMD	Gemandept Joint Stock Company	https://finance.vietstock.vn/GMD/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 4	VTP	Viettel Post Joint Stock Coporation	https://finance.vietstock.vn/VTP/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 5	CIA	Cam Ranh International Airport Service Joint Stock Company	https://finance.vietstock.vn/CIA/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 6	CCT	Can Tho Port Joint Stock Company	https://finance.vietstock.vn/CCT/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 7	CDN	Da Nang Port Joint Stock Company	https://finance.vietstock.vn/CDN/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 8	PHP	Port of Hai Phong Joint Stock Company	https://finance.vietstock.vn/PHP/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 9	NCT	Noi Bai Cargo Terminal Service Joint Stock Company	https://finance.vietstock.vn/NCT/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 10	TCW	Tan Cang Warehousing Joint Stock Company	https://finance.vietstock.vn/TCW/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 11	VGR	Vip Greenport Joint Stock Company	https://finance.vietstock.vn/VGR/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 12	DDG	Indochine Import Export Investment Industrial JSC	https://finance.vietstock.vn/DDG/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 13	HRT	Hanoi Railway Transport JSC	https://finance.vietstock.vn/HRT/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 14	SAS	Southern Airports Service JSC	https://finance.vietstock.vn/SAS/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 15	STG	South Logistics Joint Stock Company	https://finance.vietstock.vn/STG/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)
DMU 16	VOS	Vietnam Ocean Shipping Joint Stock Company	https://finance.vietstock.vn/VOS/tai-tai-lieu.htm?doctype=1 (accessed on 6 March 2022)

Source: authors' collection from [33].

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