

# Performance Evaluation of Vietnamese Apparel Enterprises: An Application of DEA Approach

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*Abstract:* - A continued robust growth of Vietnamese apparel enterprises has showed that they do not play the auxiliary but the main role in the national industry. However, in general, the apparel industry in Vietnam has not met the practical requirements. In order to provide overall performance evaluation and how to achieve efficiency systematically, this study utilizes DEA approach to determine the performance levels of 15 Vietnamese apparel industry enterprises and assess their efficiency. Specifically, we have applied output oriented model, which aims to maximize outputs while the inputs proportions remain unchanged to realize DEA efficiency analysis. CCR-based and BCC-based models are utilized to get overall technical and pure technical efficiencies. The findings show that having business transactions with foreign partners, good labor cost management and effective inventory management are the most prominent factors in distinguishing between efficient and inefficient enterprises in Vietnam's apparel industry. The study may be a useful tool for managers to improve their performances and effectively allocate resources.

*Key-Words:* Performance evaluation, Vietnamese garment industry, Data envelopment analysis, BCC, CCR

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## 1. Introduction

Textile and garment industry is often associated with the early stages of economic development and plays a key role in the process of industrialization in many countries. This industry can create many jobs for the economy, give opportunities to accumulate capital as a premise for the development of other industries, contribute to raising living standards and stabilizing socio-political situation. In Vietnam, the garment industry has been the largest manufacturing-based export sector since its integration into the global economy. Its growth has been rapid, with an export turnover has reached nearly 40 billion USD in 2019.

However, the development still faces several difficulties and challenges including lack of funds, equipment and modern technologies, the low localization ratio (i.e., processing and raw materials still depend on imports) and the high competitiveness. These pressures forced many Vietnamese garment

industry enterprises to change corporate strategies in order to reduce operating costs while maintaining or improving the quality of their products. However, manufacturing decision makers have to deal with a large volume of reports and metrics for evaluating the performance of manufacturing systems. In addition, the metrics provide different and at times conflicting assessments. Therefore, it is difficult for the managers to track and improve overall manufacturing system performance [1].

A number of different approaches can be used to assess the manufacturing industry enterprises. Each of them is used to obtain a different aspect of efficiency measures. The most important two approaches are the production evaluation and the investment evaluation. The DEA (Data Envelopment Analysis) technique is an efficient method to analyze industry efficiency because of the followings: (1) efficiency based on the non-parametric approach method can be derived solely from the quantity observation data of input/output factors; (2) DEA uses the non-

parametric methodology which is not based on functional assumptions and (3) DEA analysis results not only enable the analysis of the efficiency level of the relevant company, but also recognize best practice firms that can become a model for inefficient companies seeking to transform into efficient ones. Also, there is increasing interest in fully ranking the performance of organizational decision-making units (DMUs) with multiple inputs and outputs. DEA can assess the comparative or relative efficiency of homogeneous operating DMUs such as schools, hospitals, or sales outlets. The DMU assessment uses a set of resources referred to as input indices which are transformed into a set of outcomes, referred to as output indices. Usually the weighted sum of outputs divided by the weighted sum of inputs is defined as the efficiency of the transformation process. DEA divides DMUs into two groups including efficient and inefficient DMUs. The relative efficiency measurement of an inefficient unit is reference to some set of efficient DMUs that are compared with each other. Each DMU in the efficient group is assigned a set of weights or indices so that its relative efficiency score is equal to one. Because of the aforementioned reasons, this research proposes the data envelopment analysis (DEA) model which can integrate the production performance and investment performance and consider the compromise between these two aspects for the Vietnamese garment industry. The study provides an evaluation for the Vietnamese garment industry. In addition, this paper also indicates how to improve production efficiency and/or investment efficiency in order to achieve overall best practice. To our knowledge, this study is among the first studies measuring Vietnamese apparel enterprises, therefore providing a better understanding of manufacturing operations in the context of Vietnam. The rest of the paper is organized as follows. Section 2 provides the literature review related to the application of DEA approach in manufacturing section. Section 3 describes the data, input and output variables. Section 4 gives a brief review of DEA approaches including CCR and BCC model. Section 5 gives the DEA results and several discussions. Finally, our conclusions are presented in Section 6.

## 2. Literature review

The first DEA model was proposed by Charnes et al. [2], which is called CCR (Charnes Cooper and Rhodes). It is used to calculate the relative efficiency of the DMUs based on constant return to scale assumption. In 1984, the second DEA model was developed by Banker, Charnes and Cooper [3], called BCC model which is based on variable return to scale. DEA has considered as a powerful technique for evaluating the relative performance of decision making units (DMUs) that use multiple inputs to produce multiple outputs. The factors in DEA calculations are not subjected to rigid importance weights whereas in conventional techniques, the inputs are given weight in terms of creation only one output. DEA allows finding out the reference set which can act as benchmarks instead of finding one most efficient reference. The DEA approach has been widely investigated and applied to manufacturing enterprises. This model can be applied to evaluate the efficiency of units within a manufacturing enterprise or between different enterprises in the manufacturing industry. Ertay et al. [4] used DEA to evaluate layout configurations in manufacturing systems. Liu and Liu [5] used DEA to compare relative efficiencies of nine production lines in an electronics assembly environment. Narasimhan et al. [6] used a multistage DEA approach to identify the importance of using the different manufacturing flexibilities for achieving tangible firm level performance. Jajri and Ismail [7] analyzed the trends of technical efficiency, technological change and total factor productivity growth in the Malaysian manufacturing sector using DEA. Tahir and Memon [8] evaluated the efficiency of 14 top manufacturing companies in Pakistan. Different DEA approaches were utilized to find the overall efficiency, technical efficiency and scale efficiency. There were two input variables (total expenses and total assets) and two output variables (sales and profit before tax). The finding showed showed that only one company is considered technically efficient while the average overall technical efficiency varies from 0.64 to 0.99. Teng et al. [9] adopted DEA method to inter-industry analysis of the manufacturing cost and provide effective assessment. The inputs were manpower, working hours, fees and other

manufacturing costs. The output was the best permutation combination of improvement. The study finding can be used to reduce manufacturing costs and also upgrade operational efficiency, and improve industry competitiveness. Düzakin and Düzakin [10] recommended appropriate inputs and outputs to measure firms' performance under different perspective. They analyzed 500 major industrial enterprises of Turkey through DEA. The model allowed getting a ranking of efficient firms.

Some previous studies have also used the DEA model to evaluate the performance of garment enterprises, in which the input and the output parameters were selected differently. Kayali [11] measured technical efficiency, pure technical efficiency and scale efficiency of 29 textile companies among Fortune 500 companies listed in 2007. The study used number of employees, shareholders' equity and net assets as inputs, and net sales and net profits as outputs. The result of the analyses indicated that efficiency score of textile sector was equal to 57%. It was indicated that utilization of the resources was inefficient in the sector. Bayrak Ozcan, Anil and Emre [12] evaluated the efficiency level of 25 textile companies in Istanbul. Employees, shareholders' equity and net assets were used as inputs, and turnover, profit before tax and export revenue were used as outputs. The results confirmed that only five companies were efficient, and seven of the rest had an efficiency ratio above 50%, while 13 companies had an efficiency ratio below 50%.

Kayalidere and Kargin [13] investigated the efficiency of companies in the textile and cement sectors that were listed in the Istanbul Stock Exchange in 2002. Two analyses were conducted. In the first analysis, they used the number of employees and total assets as inputs, and net sales and net profit as the outputs. In the second analysis, number of employees and tangible assets were considered as inputs, and net sales and net profit were considered as the outputs. According to the findings, it was identified that how much inefficient companies should improve their input-output amounts to be efficient and productive compared to the efficient companies in the sector by calculating potential improvement rates.

Gozu [14] evaluated the technical and scale efficiencies of 19 manufacturers for 2001 and 2002 that performed in the textile, leather and apparel industry, quoted by Istanbul Stock Exchange. The number of employees, tangible assets, paid-in capital and stocks were utilized as the inputs, and net sales and net profit as the outputs for the input-oriented DEA model. For the years 2001 and 2002, it was indicated that average efficiency score was 0.894 and 0.797 in terms of constant return to scale, while it was 0.940 and 0.932 in terms of variable return to scale respectively; and therefore it was concluded that the companies had generally efficient operating cycles in both years. Finally, it was advised for the manufacturers that were efficient in 2001, but did not have scale efficiency in 2002 to revise their scales, as well as their input and output levels.

### 3. Data

Productivity measurement involves comparing trends in output with trends in inputs. In this study, there are four inputs and two outputs.

#### *Identification of input variables*

The average number of employees per month (X1): The firm size is influential on the relationship between intellectual capital and corporate financial return and performance [15]. The size of a company differentiates the relationship between a capital structure and the growth of debt much stronger on emerging than on developed ones [16].

The wage fund (X2): It was indicated that that wages depended on the relative amounts of capital available for the payment of workers and the size of the labor force. Payment of a fixed basic wage or variable basic wage depends on the qualification of an employee and the size of an enterprise. The higher the qualification is, the bigger the chance is that an employee will receive a fixed wage rather than a variable basic wage. It is considered to be in accordance with the efficiency of the work [17].

Total capital (X3): Capital refers to the amount invested in the company so that it can carry on its activities.

Total cost (X4): Total cost in manufacturing firms may consist of material, production costs, cost of procurement specification and acquisition.

### **Identification of output variables**

Total revenue (Y1): Total revenue is the amount of money that a manufacturing firm earns by selling its products during a period of time.

Gross profit (Y2): It is the total sales of the firm minus the total cost of the goods sold. Gross profit is the profit a manufacturing company makes after deducting the costs associated with making and selling its products.

### **Data Sources**

The data were collected through an enterprise survey related to the garment industry, by the General Statistics Office of Vietnam in 2019. Investigating apparel businesses was a part of the enterprise survey. To ensure the collection of high quality data, each survey round was consulted extensively by the relevant agencies about the content of questionnaire and sampling. Results are mentioned in the statistical report and a series of intensive studies is presented to partners and major stakeholders at the stages of draft

report and final report. The important part of this survey report showed the situation of enterprises in the manufacturing and recommendations for the future in order to provide the intensive knowledge of enterprise level trends and the differences among types of enterprises, technology and innovation, thorough studies, lessons learned and the only input for the policy formulation in the development period and the following reformation process of Vietnam.

From the general data set, we selected a group of 15 companies in the apparel industry, which have relatively homogeneous characteristics. Three criteria were used for selection: private enterprise (without state capital contribution); medium size of labor (employing on average from 100 to 200 employees in the year); and have a medium scale of capital (from 20 to 80 VND billion). Table 1 shows the data of the companies selected for the analysis. These companies have the same organizational characteristics which is reflected in the dimensions such as organization structure, work characteristics, and quality management practices.

**Table 1.** Inputs and outputs of the Vietnamese apparel enterprises in 2019 (unit: VND million)

DMU	The average number of labors per year (X1)	The wage fund (X1)	Total capital (X3)	Total cost (X4)	Total revenue (Y1)	Gross profit (Y2)
VGE1	122	11158	41583.5	28206	28532	334
VGE2	122.5	11194	26862	16834	21780	11
VGE3	123.5	10983	24609.5	33238	37314	60
VGE4	124	7274	53771	70118	85531	328
VGE5	125.5	8570	29626	36568	49516	738
VGE6	134	7508	28888.5	10071	10046	5678
VGE7	156	8465	83081	28595	11167	1887
VGE8	167.5	22201	20588	32000	33972	29
VGE9	180	9639	37145	15469	17380	339
VGE10	180	10459	20183	13684	17777	101
VGE11	189	16612	46177.5	39586	43800	1622
VGE12	190	13076	22932.5	33639	39157	1667
VGE13	192	15276	84872	60080	75049	111
VGE14	192.5	12239	41128.65	26706	38994	1537.2
VGE15	195.5	14802	85216	78120	91487	3717

## 4. Methodology

The two basic DEA models including the CCR model and the BCC model have become standards in the literature of performance measurement under the assumptions of constant and variable returns-to-scale respectively. In this study, the CCR and BCC models have been utilized to performance evaluation of Vietnamese supporting industry enterprises. Both models can be either input- or output oriented. In input-oriented models, inputs are minimized and outputs are maintained at current levels. In output-oriented models, outputs are maximized based on a given number of inputs. As this study measures firm export performance and thus identifies maximum export revenues, the output oriented model was utilized.

### 4.1. CCR DEA Model

The CCR - DEA method [2] was developed to define a relative measure of the efficiency of the decision-making units in situations when a large number of output and input variables are available. The relative measure of efficiency using the DEA method is determined by the ratio of weighted output values and weighted input values for each observation unit individually. The DMUs are compared with each other by the use of a linear programming model. The efficiency frontier is composed of DMUs with best business practice, while the efficiency of all other units is determined on the basis of the distance from the defined efficiency frontier. DMUs at the frontier are considered relatively efficient, while those out of the frontier are relatively inefficient. A set of efficient DMUs is considered as a reference point for proposing improvements to relatively inefficient DMUs [18].

Suppose we have  $n$  DMUs and that each  $DMU_j$ , ( $j = 1, 2, \dots, n$ ) has  $s$  outputs with different values,  $y_{rj}$  ( $r = 1, 2, \dots, s$ ), using different  $m$  input values of the same type,  $x_{ij}$  ( $i = 1, 2, \dots, m$ ).

The objective CCR - DEA model is to solve for each  $k$ -th decision-making unit

$DMU_k$  ( $k = 1, 2, \dots, n$ ) the optimization task of the relationship between the virtual output and the virtual input, in order to determine the weight coefficients for the output and input variables to which the value of the relationship will be maximized:

$$(\max) h_k = \frac{\sum_{r=1}^s u_r y_{rk}}{\sum_{i=1}^m v_i x_{ik}} \quad (1)$$

with constraints as follows:

$$\frac{\sum_{r=1}^s u_r y_{rj}}{\sum_{i=1}^m v_i x_{ij}} \leq 1, \quad j = 1, 2, \dots, n$$

$$u_r \geq 0, \quad r = 1, 2, \dots, s$$

$$v_i \geq 0, \quad i = 1, 2, \dots, m$$

where,  $h_k$  - the relative efficiency of the  $k$ -th decision-making unit;  $n$  - the number of decision-making units;  $m$  - the number of inputs;  $s$  - the number of outputs;  $v_i$  - weight coefficients for input  $i$ ;  $u_r$  - weight coefficient for output  $r$ ;  $x_{ij}$  - the amount of input  $i$  for the  $j$ -th decision-making unit, ( $DMU_j$ );  $y_{rj}$  - the amount of output  $r$  for the  $j$ -th decision-making unit, ( $DMU_j$ ).

### 4.2. BCC - DEA Model

All DMUs at the frontier of efficiency are considered to have full overall technical efficiency that includes both pure technical efficiency and efficiency of scale. In order to measure the pure efficiency, BBC-DEA model [3] was derived from the basic CCR-DEA model. BCC model provides an assessment of pure efficiency, excluding the effect of the business scale. This is achieved in a way that the observed unit is compared only with other units of similar size. The decision on whether the additional variable will be included in the numerator or the denominator depends on whether the general form of the BCC model is

transformed into a linear programming model with output or input orientation. The purpose of the additional variable introduction is to set up a constraint on returns to scale and to provide that referent set is formed on the basis of a convex combination of decision-making units. The BCC-DEA model is given by:

$$(\max) h_k = \frac{\sum_{r=1}^s u_r y_{rk} - u^*}{\sum_{i=1}^m v_i x_{ik}} \quad (2)$$

with following constraints:

$$\frac{\sum_{r=1}^s u_r y_{rj} - u^*}{\sum_{i=1}^m v_i x_{ij}} \leq 1, \quad j = 1, 2, \dots, n$$

$$u_r \geq \varepsilon, \quad r = 1, 2, \dots, s$$

$$v_i \geq \varepsilon, \quad i = 1, 2, \dots, m$$

The mathematical formulation of the BCC model, unlike the CCR model includes an

**Table 2.** Evaluation of overall and pure technical efficiency of Vietnamese garment industry enterprises in 2019

DMU	CCR efficiency score	Rank	BCC efficiency score	Rank
VGE1	0.733456	14	1	1
VGE2	0.886098	11	1	1
VGE3	0.903415	9	1	1
VGE4	1	1	1	1
VGE5	1	1	1	1
VGE6	1	1	1	1
VGE7	0.369228	15	0.388034	15
VGE8	0.967137	7	1	1
VGE9	0.769482	13	0.87395	13
VGE10	0.895529	10	1	1
VGE11	0.809179	12	0.845948	14
VGE12	1	1	1	1
VGE13	0.935684	8	1	1
VGE14	1	1	1	1
VGE15	1	1	1	1

According to the presented results, it is noted that, from the point of view of overall

additional variable  $u^*$ . When the CCR model is used, we can solve one model and give either interpretation. If we solve the BCC input model, we can only give an input interpretation and we must solve the BCC output model for an output interpretation. Another difference between the BCC and CCR models lies in the scalar transformations of all data for a given DMU. The efficiency measure in the CCR model is unchanged by scalar transformations, since the efficiency ratio of the scaled DMU is unchanged. On the other hand, the scalar transformations of a given DMU change the scalar size and could easily affect the efficiency measurements from the BCC model.

## 5. Empirical Results and Discussions

### 5.1 Empirical results

The Excel VBA was utilized to implement BCC – DEA and CCR – DEA. The efficiency score and its equivalent rank of each DMU is presented in Table 2.

technical efficiency, the best scores were obtained by the DMUs: VGE4, VGE5, VGE6,

VGE12, VGE14, VGE15. The efficiency coefficient value for these DMUs is 1, indicating that these enterprises have reached total technical efficiency within the observed set of enterprises and that they represent a reference set on the basis of which the relative efficiency of other enterprises is assessed. Slightly lower efficiency scores are achieved by VGE8 (0.967137) and VGE13 (0.935684), followed by VGE3 (0.903415), VGE10 (0.895529). Other DMUs get lower overall technical efficiency. It should be noted that, at defined output and input variables, VGE7 have proven to be inefficient compared to the reference units. It can be seen that the implementation of the input-oriented CCR model would give the same results of the efficiency scores, with the orientation being different.

The results of the assessment of pure technical efficiency for Vietnamese garment industry enterprises show that most enterprises achieved full efficiency. The enterprises that did not achieve pure technical efficiency is VGE9, VGE11 and VGE7.

## 5.2. Discussion

There is a clear distinction of technical performance between two groups of companies: Group 1 (including VGE4, VGE5, VGE6, VGE12, VGE14, VGE15) have the best technical performance and Group 2 (including VGE1, VGE9, VGE11 and VGE7) have the lowest technical performance. When we look at the different aspects of governance between these two groups of companies, we find three important differences as follows: Regarding the commercial transactions (buying and selling goods) with foreign countries: 5 out of 6 companies in group 1 have made international transactions in 2019, in which companies which have earned money from exports include VGE5 (USD 1120 thousand), VGE6 (USD 51.8 thousand), VGE12 (USD 329.9 thousand) and VGE15 (USD 1325 thousand). Meanwhile, all three companies in group 2 did not make any transactions with foreign partners.

Regarding the average cost of wages per employee: companies in the low-performing group (Group 2) have high average cost of wages per employee, for example VGE 11 has an average salary per person of 87.9 million VND, VGE1 with 91.46 million VND per

person, while high-performing companies (Group 1) have low wage cost per employee, 5/6 companies have an average salary from 56 to 68,8 million VND. We can observe a clear difference in wage costs between these two groups of companies.

Regarding inventory management, Group 1 has 4 out of 6 companies without industrial inventories or having low industrial inventory. Industrial inventory means the value of inventory related to work in progress, finished goods, and consignments. Specifically, VGE4, VGE6 and VGE14 have almost no industrial inventories; companies VGE5 and VGE12 have very low inventories. Meanwhile, companies in Group 2 have high industrial inventories, VGE7 has an average inventory of VND 7.3 billion, VGE9 with VND 28.02 billion and VGE11 is VND 2.86 billion in 2017.

Thus, it can be concluded that having business transactions with foreign countries, good labor cost management and effective inventory management are the three factors that help distinguish between efficient and inefficient companies in Vietnam's apparel industry.

## 6. Conclusions

In this study we evaluate the overall and pure technical efficiency of the Vietnamese apparel enterprises using CCR-DEA and BCC-DEA approaches. The findings show that having business transactions with foreign partners, good labor cost management and effective inventory management the most prominent factors in differentiating between efficient and inefficient enterprises in Vietnam's apparel industry. This study provides evidence of how the advances and recent developments in efficiency analysis can be applied for an effective evaluation of performance issues in manufacturing industry.

The results obtained in this study can be associated with some policy implications. Firstly, business transactions with foreign partners can also bring much benefits to enterprises. It was believed that when conducting business transactions with foreign partners, firms will be more likely to decide to diversify their production in order to capture emerging demands from global market. Cooperating with foreign suppliers or customers on a regular basis will also gain

advantage on the foreign markets. Secondly, good labor cost management can do a lot to creating more efficient and effective enterprises. With the deepening of economic reform, enterprises must pay attention to the management of labor costs and to strengthen the analysis of labor costs, reduce the invalid individuals spending to increase labor productivity, labor costs, and input-output ratio optimization. Corporate profit should be implemented, the cost of human input and output are at higher or lower operating mechanism, and thus the formation of enterprises employing more than can less jobs at higher or lower, and income can be increased to a virtuous cycle can be cut to enhance the vitality ability to adapt with the market and increase market competitiveness. Lastly, the operation of inventory management determines the efficiency of enterprises. An effective inventory management system leads to the success and cost reduction of the firm's expenditure necessitate improved supply chain performance.

Despite its intended contributions, this study is not without limitations. This study is focused on measuring apparel enterprises, due to the lack of data, aspects like the quality of the products or the quantity of products provided by the enterprises were not taken into account, both key aspects in the definition of efficiency.

The results and limitations of this study may suggest several future research directions. Other factors such as investment in product quality and production characteristics should be included in the research. The following research questions are proposed for future research: (i) Does there still exist other factors that distinguish effective and inefficient businesses? (ii) Is the garment industry typically labor-intensive? and (iii) Is labor cost management a factor that distinguish efficient and inefficient businesses in garment industry?

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