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Applications of Data Envelopment Analysis in Textile Sector

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Abstract – Interest in Data Envelopment Analysis (DEA) has grown in recent years. This is not surprising since DEA can be used to explore efficiency in organizations whose outputs and inputs cannot be reduce to monetary terms. In a relatively short period of time Data Envelopment Analysis (DEA) has grown into a powerful quantitative, analytical tool for measuring and evaluating performance. DEA has been successfully applied to a host of different types of entities engaged in a wide variety of activities in many contexts worldwide.
For this reason, the textile and garment sector should operate efficiently and increase its productivity. DEA also has different applications in the textile sector. In this study, DEA usage examples and details are given in textile and garment sector. DEA was introduced first, and then the commonly used models and steps of applying these models were explained. Finally, the scope of applications in textile and apparel sector will be examined in detail.

Keywords – data envelopment analysis, decision-making unit, textile, ready-wear, efficiency

I. INTRODUCTION

Competition in today's business life continues to be very contentious. The ability of businesses to keep place with the changing world depends on achieving the highest gain with the most appropriate input component. The proximity to the business market, cheaper business confidence, raw materials, and energy technology has undoubtedly had the advantage. But having all these do not mean that the appropriate input component is provided. Another business with the same resources can use these resources more effectively and efficiently, making it more competitive and profitable.

Data Envelopment Analyses (DEA) is a non-parametric mathematical programming method based on principles of linear programming that can compare relative efficiency levels between organizations in cases of multiple inputs and outputs. In each case, efficiency is measured in terms of a proportional change in inputs or outputs.

In related literature, several studies have evaluated the efficiency of firms in various respects and using several methodologies. The DEA method was been widely used to measure the efficiency of textile and apparel firms. In this study a summary of DEA applications is given related about textile sector.

II. DATA ENVELOPEMENT ANALYSES

The DEA technique aims to determine the efficiency of decision-making units (DMUs) using similar inputs and outputs based on a frontier. Accordingly, DEA identifies a frontier by determining the best input/output combination that produces maximum outputs using minimum inputs for the observation set evaluated. In turn, DMUs in an efficient frontier are determined. Using a relevant frontier as a reference, DMU efficiency is deemed "relative" based on the radial distance to this frontier. In the results of analyze, inefficient DMUs are improved using information on certain variables (input/output) [1].

The mathematical structure of the DEA model was first introduced as a fractional programming model by Charnes, Cooper and Rhoders (1978). DEA is a widely practiced method used for performance benchmarking and comparison, and the first application of DEA technique was performed over the public sector. It is currently a method applicable in many fields (such as schools, public agencies, banks, etc) [2].

Basic DEA models can be divided into CCR and BCC varieties. While the CCR model assumes "constant returns to scale", the BCC model assumes "variable returns to scale". The efficiency value calculated through the CCR model is the "overall technical efficiency" value, whereas the efficiency value calculated through the BCC model is the "pure technical efficiency" value. "Overall technical efficiency" divided by "pure technical efficiency" produces "scale efficiency". Hence, if the CCR model deems a DMU efficient, it will also be deemed efficient through the BCC model. However, DMUs deemed efficient via the BCC model are not necessarily deemed efficient via the CCR model. Hence, the CCR model, which generates overall firm technical efficiency scores, was used in this study [1].

Both models (CCR and BCC) 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 employed [1].

III EXAMPLES OF DEA APPLICATIONS IN TEXTILE SECTOR

There are many studies in which the DEA method is used in the textile sector. In this study, a short summary will be given.

Nearly the first article in the literature is the study of Zhu and Chen (1993). They used the ratio model of DEA to assess the industrial performance of these 35 factories in the consecutive years 1988 and 1989 in order to analyze the technical efficiency, scale efficiency and input congestion [3].

Continuation of this study Zhu in 1996 evaluated the efficiency of the 35 textile factories of the Nanjing Textiles Corporation (NTC) by using both data envelopment analysis/assurance region (DEA/AR) was performed. NTC has been using the Analytic Hierarchy Process (AHP) for some time as an important procedure to systematically evaluate the overall industrial performance of its 35 factories in each year. The results from the AHP to set bounds on the weights, later, in our use of Assurance Region (AR) concepts from DEA. Also, this study measures the returns to scale (RTS) on each of the textile factories [4].

In another research, DEA was used to evaluate the performance of 29 Canadian textile companies in 1994. CCR model was used in DEA. First the efficiency scores were obtain and the results of scale of 29 companies. The efficiency scores were provided the efficiency frontier and the returns to scale by DEA results. Chandra and his friends collected various data from the companies.

The initial input data collected for each DMU is the number of employees, the hourly wage rates (in dollars), the percentage of time of machine breakdown, the average annual investment (in dollars) in the last 10 years, the plant size per worker, the percentage of absentees, the product diversity, the number of process stages, the job classification, and the raw material inventory (in dollars). The data of the 29 Canadian textile companies in 1994 show that most Canadian textile companies did not perform well, with a few being DEA efficient and the rest very poor performers [5].

At the same time period of these articles Cooper and his friends published an article about Chinese Economic Reforms obtained by DEA and Stochastic Frontier Analyses in 1978. Using data obtained from Chinese sources for the period 1966-88, this paper reports results from a study of the impact of the 1978 economic reforms for the period 1966-88 on the Textiles, Chemicals and Metallurgical Industries [6].

When we look at the latest published studies, we recognize that DEA method is used together with other methods or it differs within itself. One of the latest manuscripts in the literature is the study of Jatuphatwarodom et. al. (2018). In this paper a methodology for combined usage of data envelopment analysis (DEA), analytical hierarchy process (AHP) and extended goal programming (EGP) was used in order to provide managerial decision support. The methodology allows the three techniques to be used in a coordinated manner to give an enhanced level of holistic decision support. DEA is first used in a descriptive sense in order to provide information regarding the efficiency of a set of units. The AHP is then used in order to determine the importance of criteria arising from decision problem(s) related to the improvement of unit efficiency. Finally, EGP is used in a prescriptive sense in order to select a set of specific actions for improving unit efficiency. Two specific multi-objective situations arising from the Thai Silk industry are used as case studies for the proposed methodology. [7].

The other latest study of Zhao et al. (2018) analyzed the status of China's textile industry and constructed the evaluation model based on the economical, ecologic, and social benefits. Analytic Hierarchy Process (AHP) and Data Envelopment Analysis (DEA) were used for an empirical study of textile industry. The result of evaluation model suggested that the status of the textile industry has become the major problems in the sustainable development of China's textile industry [8].

Textile supply chains consist of multinational garment retailers (customers), garment manufacturers (suppliers), and ancillary suppliers (suppliers to manufacturers). few studies have used a combination of AHP and DEA methods for tackling the many complex situations within the supplier evalua tion problem (Tone, 1989; Sinuany-Stern et al., 2000; Sueyoshi, 2001; Escobar and Jimnez, 2002; Yang and Chunwei, 2003). For example, the combination of AHP and DEA methodology has been applied for selecting suppliers in the well-known Turkish consumer electronics company, BEKO (Sevkli et al. 2007) [9].

The latest work on this subject carried out in this year, Novairi et al. studied proposes an approach based on data envelopment analysis (DEA) to evaluate the relative efficiency of supply chains with reverse flows in the presence of undesirable factors. The weak disposability assumption is used to handle undesirable factors. To illustrate, a radial DEA model is introduced to determine the efficiency of reverse supply chains while undesirable outputs are present as external factors and reverse flows. The applicability of the proposed approach has been illustrated by a real application in textile industry consisting of seventeen supply chains in this sector. It has been developed to evaluate the technical efficiency within the textile industry in Iran [10].

Cooper et al. (2001) focused on the management performance of the textile industry and automotive industry in mainland China. They took a sample of textile and automotive industry manufacturers from 1981 to 1997, employed the BCC model and Congestion model to assess the management performance of sample vendors, and found that due to the inefficiency of improving management, enterprises could still increase output [11].

Years after this journal Flegg and Allen prepared another study about these two sectors. Congestion refers to a situation where the use of a particular input has increased by so much that output has actually fallen. In this sense, it can be viewed as an extreme form of technical inefficiency. Cooper et al. focus on the problems caused by the employment of excessive amounts of labour in these two industries and they discuss ways in which congestion could be managed without engaging in massive layoffs of workers. Here they demonstrate how output could be enhanced by improving

managerial efficiency, while maintaining the size of the labour force. The aim of Flegg and Allen in this paper was rather different. Instead of focusing on policy issues, they examined the magnitude of the problem of congestion in these two industries and whether it makes much difference how we measure congestion. Although the theoretical issues surrounding the measurement of congestion have been discussed in several recent papers, no consensus has emerged on the most appropriate way to identify and measure congestion [12].

Some of other papers were as follows; Aras (2006) studied find the efficiency and risk analysis of the Turkish Textile and Clothing Industry (TTCI) has been performed for a period of 12 years. Efficiency has been measured with DEA, using 2 different data sets. The research findings indicate that the TTCI has not attained full efficiency for the period under examination, though efficiency improvements in the recent period have been observed [13].

Yenilmez & Girginer (2012) made a study to examine the efficiencies of textile firms' exports in Eskisehir Organized Industrial Zone during the period 2008-2009 by using Data Envelopment Analysis (DEA). The study analyzes 5 firms as a decision making units by applying two DEA models (3 inputs-1 output CCR (Chames, Cooper and Rhoders) models. The results show the scale of the companies for each year's (2008/2009). The study also finds that inefficient companies should decrease their production quantities whereas they have to increase the amounts of the export values [2].

In another study (Sarıcam & Erdümlü, 2012) the efficiencies of textile and apparel companies were analyzed by input-oriented DEA model under variable return to scale assumption. The textile and apparel companies quoted in Istanbul Stock Exchange for the period 2003 and 2008 were evaluated in terms of efficiency level providing a framework for the calculation of input excesses and output shortages.

The analysis revealed that the average efficiency scores of the apparel industry were higher than the textile industry and two industries together. The companies in the apparel industry should overcome the lack of insufficient level of exports whereas the textile industry needs to increase gross value added in order to be more efficient [14].

Saeidi et. al. prepared a paper dealed with the problem of ranking woven fabric defects (WFDs) observed in textile manufacturing with using a data envelopment analysis (DEA) method. The paper showed that the optimal solutions of DEA models for decision making units (DMUs) with multiple inputs can be found without the need of solving the corresponding models. The paper performed a mean–variance analysis for determining the most important statistical factors of WFDs in terms of multiple inputs. The paper introduced a new application for DEA method in textile manufacturing for ranking fabric defects. This is significant in defining rich project in reducing defects through prioritizing of quality specification of fabric defects by Six Sigma experts [15].

The Indian textile industry is one the largest and oldest sectors in the country and among the most important in the economy in terms of output, investment and employment. For inclusive growth and sustainable development most of the Textile Manufacturers has adopted the Cluster Development Approach. The objective is to study the physical and financial performance, correlation, regression and DEA by measuring technical efficiency, peer weights, input slacks, output slacks and return to scale of four textile clusters in India. The methodology adopted is using DEA of Output Oriented BCC model by taking number of units and number of E as inputs and sales and Ex in crores as an outputs [16].

In order to measure the calculated efficiency of industrial sectors more accurately, Three-stage DEA model is presented in the empirical analysis using data from 2007 to 2010 covering 29 manufacturing industries in China. The advantage of using this method is enabling us to separate the managerial factor from external environmental factors and random errors factors on the technical efficiency. This study provides a useful efficiency measurement tool (Three-stage DEA model) to calculate technical efficiency among different industrial sectors. Technical efficiency plays a key role in building the competitiveness of manufacturing industry [17].

In Turkey, there have been three different production systems in the garment industry.

1. Lean manufacturing system (a small production group that produce low number of orders)
2. Mass manufacturing system (a crowded production group with high number of order)
3. Mixed manufacturing system (crowded production group but low number of order)

Illeez worked out the efficiency difference of these systems in her PhD thesis. In this thesis the three types of production methods mentioned above were compared in terms of their performances. Six businesses were selected from each group. 4 inputs (total working period, number of sewing machines, area for used production, and electricity used in sewing band) and 1 output (production number) variable data were collected for 7 months from 18 companies (3 x 6 = 18).

As a result of the investigation with DEA, according to the technical efficiency scores some successful examples of mass production system can been seen but, according to scale efficiency modular production system is seen to be more successful. According to over input costs, modular production system is in the best condition [18].

IV. CONCLUSION

DEA is an effective method for comparing companies with each other. The different models developed and the different inputs and outputs used make it possible to compare companies correctly. Nevertheless, DEA, as a ranking tool, can still be investigated under more favorable conditions. Further research could be conducted, for instance, through redefining a defect as a production system with proper inputs and outputs.

REFERENCES

[1] O. Öztürk and N. Girginer, "The export efficiency of Turkish textile and apparel firms: an investigation employing data envelopment analysis (dea) and analytic hierarchy process (ahp) methods", *Tekstil ve Konfeksiyon*, vol. 25 (1), pp.10-23, 2015.

[2] F. Yenilmez and N. Girginer, "Assessing export performance of textile companies in Eskişehir organized industrial zone by use of data envelopment analysis (dea)", *Tekstil ve Konfeksiyon*, vol. 22 (1), pp.12-17, 2012.

[3] J. Zhu and Y. Chen, "Assessing textile factory performance", *Journal of Systems Science and Systems Engineering* vol. 2, pp. 119-133, 1993

[4] J. Zhu, "DEA/AR analysis of the 1988-1989 performance of the Nanjing textile corporation", *Annals of Operations Research,* vol. 66, pp. 311 – 335, 1996

[5] P.Chandra, W.W. Cooper, S. Li, A. Rahman, "Using DEA to evaluate 29 Canadian textile companies-considering returns to scale", *International Journal of Production Economics*, vol.54, pp.129-141, 1998

[6] W.W. Cooper, S. Kumbhakar, R.M. Thrall, and X Yu, "DEA and stochastic frontier analyses of the 1978 Chinese economic reforms", Socio-Economic Planning Science, vol. 29(2), pp.85-112, 1995.

[7] N. Jatuphatwarodom, D.F. Jones, D., Ouelhadj, "A mixed-model multi-objective analysis of strategic suppy chain decision support in the Thai silk industry", *Annals of Operations Research*, vol. 265, pp.1-27, 2018.

[8] H. Zhao, Z. Lu, T. Yu and Y. Yin, "An evaluation model for sustainable development of China's textile industry: an empirical study", *Journal of Physics: Conference Series*, vol. 989, pp. 1-9, 2018

[9] V. Baskaran, S. Nachiappan, S. Rahman, "Indian textile suppliers' sustainability evaluation using the grey approach", *International Journal of Production Economics*, vol. 135, pp. 647-658, 2012

[10] M. J. S. Noveiri, S. Kordrostami, J. Wu and A. Amirteimoori, "Supply chain performance with undesirable factors and reverse flows: a DEA-based approach, *Journal of the Operational Research Society*, vol70, pp.1-11, 2018

[11] Cooper, W. W., H. Deng, B. Gu, S. Li, and R. M. Thral, "Using DEA to improve the management of congestion in Chinese industries (1981-1997)" *Socio-Economic Planning Sciences* vol. 35, pp.227–242, 2001

[12] A. T. Flegg, D. O. Allen, "Congestion in the Chinese automobile and textile industries revisited", *Socio-Economic Planning Sciences*, vol. 43, pp.177-191, 2009.

[13] G. Aras, "Efficiency and risk analysis of the Turkish textile and clothing industry using data envelopment analysis", *Journal of Global Business and Technology*, vol.2 (2), pp.65-73, 2006.

[14] C. Sarıcam and A. Erdümlü, "Evaluation efficiency levels comparatively: data envelopement analysis application for Turkish textile and apparel industry", *Journal Industrial Engineering and Management*, vol.5, pp.518-531, 2013.

[15] R. G. Saeidi, G. R. Amin, S. Raissi, S. Gattoufi, "An efficient DEA method for ranking woven fabic defects in textile manufacturing", *Internatinal Journal of Advance Tecnologies,* vol.68, pp.349-354, 2013.

[16] E. Bhaskaran, "The productivity and technical efficiency of textile industry clusters in India", *Journal of The Institution of Engineers (India) Series C*, vol. 94 (3), pp.245-251, 2013,

[17] K. Fang, X. Hong, S. Li, M. Song and J. Zhang, "Choosing competitive industries in manufacturing of China under low-carbon economy, a three-stage DEA analysis", *International Journal of Climate Change Strategies and Management,* vol. 5(4), pp. 431-444, 2013

[18] A.A. Illeez, "Development of appropriate production methods for clothing production", PhD Thesis in Textile Engineering of Ege University, İzmir, 2014