Evaluation of Efficiency and Returns to Scale of Resin Chemical Industry Supply Chain using Crisp and Fuzzy Data Envelopment

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Abstract: Supply Chain Management (SCM) is a suitable tool to improve economic, social and environmental performance. SCM assessment is an important task for all types of organizations. The DEA method has been widely used to evaluate SCM. By attention supply chain as network data envelopment analysis (DEA) can calculate the efficiency of supply chain with multiple stages. This study examines the efficiency and returns to scale (RTS) of supply chain management of resin manufacturing companies based on network DEA models. We determine returns to scale of resin manufacturing companies as a two-stage process, with crisp and fuzzy data. Fuzzy DEA model is based on $\alpha - cut$ approach to measure the efficiency and RTS of supply chain. The proposed models are used to evaluate the efficiency and RTS of supply chain of 27 resin production companies. The six companies were network efficient in the investigation with crisp data, while there are three network efficient companies with fuzzy data.

Keywords: Supply Chain Management, Data Envelopment Analysis, Efficiency, Return to Scale Fuzzy Data

Introduction: The supply chain includes all stages that directly or indirectly supply demands and resolve customer needs. Planning, purchasing, production, transportation, storage, distribution and customer service are parts of supply chain which have a major role in the process of running any business. Supply Chain Management (SCM) is an appropriate tool for improving the economic, social and environmental performance of any organization simultaneously; therefore, its evaluation is very important. Data Envelopment Analysis (DEA) is one of the suitable methods for evaluating SCM. The supply chain cannot be evaluated by traditional models of data envelopment analysis due to its network or multi-stage nature, so in this paper apply network DEA is chosen to evaluate SCM. Kao and Hwang (2008) modified the standard DEA model by considering the two-stage series relationship with the overall process, and simulated the efficiency of the whole two-stage process as a result of the efficiency of each stage. Then Chen et al. (2009) proposed another viewpoint. Also, Tavana et al. (2008) measured and analyzed the efficiency of the two-stage fuzzy DEA models using an interval method.

The review of the researches in this area indicate that the consideration of technical efficiency in a two-stage network with environmental impacts is less common in existing literature. Also, in all literature, the issues of return on a scale, which is an economic and important concept in data envelopment analysis, and the maximum output increase per income increase, have been ignored in the supply chain in a two-stage network given the discussion of the two-step technical efficiency. The present research is providing models for determining the efficiency and return to scale of stages and the process of network production in a supply chain, in two states: deterministic and fuzzy data.

Materials and Methods: Firstly, we would measure the technical efficiency of a two-level supply chain using the network data envelopment analysis model. The efficiency of each stage is calculated from the ratio of the weighted output to its weighted input, and the overall efficiency obtained by the

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weighted average efficiency of the stages (Cooper et al. 2007). In this study, we examined the most complete model of two-stage models, which allows for direct inputs and outputs for each stage in addition to the intermediate data between the stages.

Also, Data Envelopment Analysis method can determine the return to scale of decision-making units (DMU). If a DMU has the constant return to scale, each multiplication set of inputs produces the same multiplication of outputs. By assuming constant return to scale, large and small DMUs are compared and generally not efficient rather than each other. In the variable return to scale, any changing of inputs can produce less or more multiplier in outputs. In this research, we measure the efficiency and return to scale (RTS) of supply chain for resin manufacturing companies within the framework of DEA network models; efficiency and return to scale are determined in two states of deterministic and fuzzy data and a model is proposed for evaluating of supply chain management using DEA network with fuzzy data. In evaluating with deterministic and fuzzy data, the supply chain is efficient, if all the stages in the process are efficient. Fuzzy LR numbers are widespread because of reaching good models and good computational performance. In this paper, the fuzzy LR numbers in the fuzzy DEA model is considered, based on the a-cuts approach, and measuring efficiency and determining the return to scale of supply chain of resin companies in Iran. Efficiency and return to scale are calculated on the lower and upper bounds; it is efficient if both bound are efficient $(E_O)_\alpha^L = (E_O)_\alpha^U = 1$.

Results and Discussion: The proposed models have been used to assess the efficiency and RTS of the supply chain of 27 resin production companies in Iran. This supply chain is considered as two-levels, the supply sector as stage 1 and the manufacturing sector as stage two.

Inputs in stage of supply are annual cost, annual turnover of personnel, and environmental costs. The number of products from supplier to manufacturer and partnership cost in green production plans are considered as the intermediate data (inputs for second stage and outputs of firs stage), and outputs of the production stage are the number of trained personnel in the fields of job, safety, and health, number of green products and revenue. In the evaluation of the deterministic data, 6 companies (Alborz Chalk, Fajr Petrochemicals, etc.) are network efficient, with different kinds of RTS, constant, increasing and decreasing return to scale. While, considering fuzzy data, 3 companies are just network efficient.

Conclusion: The proposed models in this paper are methods for determining the efficiency and returns to scale of the supply chain with two deterministic and fuzzy data approaches. We consider the supply chain of 27 resin companies as a two-stage network, and according to the DEA network-related techniques and theories, in addition to identifying efficient and inefficient companies, the determination of an increasing, constant, and decreasing RTS of the supply chain stages with two kind data, deterministic and fuzzy data. Because in many environmental factors, we encounter data that are inaccurate or ambiguous, or our knowledge about the production process is inaccurate, so the proposed model provides more useful information to organizations and industrial activities. Six companies with deterministic data and 3 companies with fuzzy data are efficient in network. These companies have managed and coordinated flow of materials between several organizations and within the organization in the best possible way and with environmental concerns.

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