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Performance evaluation of SCM using DEA: A review

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Abstract
Over the years we have witnessed the growing importance of supply chain operations and supply chain management (SCM), as supply chains play a major role in every step of the product life cycle. Therefore, this paper will DEA-based performance evaluation approaches for overall supply chain can be categorized. Future perspectives and challenges are discussed.

Keywords: Performance evaluation, Data Envelopment Analysis (DEA), Supply chain management analysis (SCM)

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1 Introduction

Supply chain management (SCM) is one of the most important competitive strategies used by modern enterprises. Many firms have actively engaged in supply chain initiatives, and have achieved superior operational and financial performance [12]. The well-known examples include Wal-Mart's cross-docking strategy, Dell's direct sell business model, Hewlett-Packard's late differentiation strategy, and the POS (point of sale) system to receive early demand signals [10].
Supply chain management creates value for companies, customers and stakeholders interacting throughout a supply chain. The strategic dimension of supply chains makes it paramount that their performances are measured. In today’s performance evaluation processes, companies tend to refer to several models that will differ in terms of corporate organization, the distribution of responsibilities and supply chain maturity.
Data Envelopment Analysis (DEA) is a non-parametric programming technique that develops an efficiency frontier by optimizing the weighted output/input ratio of each provider, subject to the condition that this ratio can equal, but never exceed, unity for any other provider in the data set [2].

Therefore, strengths of DEA:

- DEA easily accommodates multiple inputs and multiple outputs.
- DEA doesn't impose a particular functional form relating inputs to outputs.
- DEA directly compares an observation against one or more actual peers.
- DEA allows inputs and outputs to be measured in very different units.

Research in the past has primarily focused on the performance of transit in which transit efficiency is evaluated through one-stage DEA models ([8]; [17]). In order to make the linkage between economic

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policy and transit industry development, [11] simultaneously evaluated transit efficiency and social efficiency by using a two-stage DEA model. The two-stage DEA models are frequently developed in many theoretical studies and applications ([16]; [4]; [15]; [7]). Therefore, this paper will address a DEA-based performance evaluation approaches from the perspective of the overall supply chain. In this models the supply chain are under the control of a unique decision maker, and the decision maker can determine the optimal prices of intermediate products to maximize the overall performance score. In addition, by compared with other supply chains, the evaluated supply chain can be identified as efficient or inefficient. The inefficiency perspective and corresponding improvement strategies for those inefficient supply chains can be given at the same time.
The structure of this study is listed as follows: Section 1, Introduction; Section 2, supply chain management; Section 3, Methodology DEA-Supply chain; Section 4, Conclusion.

2 Supply chain

Since a supply chain consists of a series of firms, it will perform only as well as its weakest link. The growing trend of outsourcing and globalized manufacturing have further fueled the proliferation of the supply chain processes across business and national boundaries. Thus actions and decision taken by one firm can considerably impact the performance of other firms [19]; minor performance deterioration of a firm can snowball into a disaster for the entire supply chain.
Supply chain measures can help supply chain members focus on primary symptoms at the supply chain level first, and then determine where to perform a more detailed activity analysis for the lower-level and firm-specific operations, Figure 1.

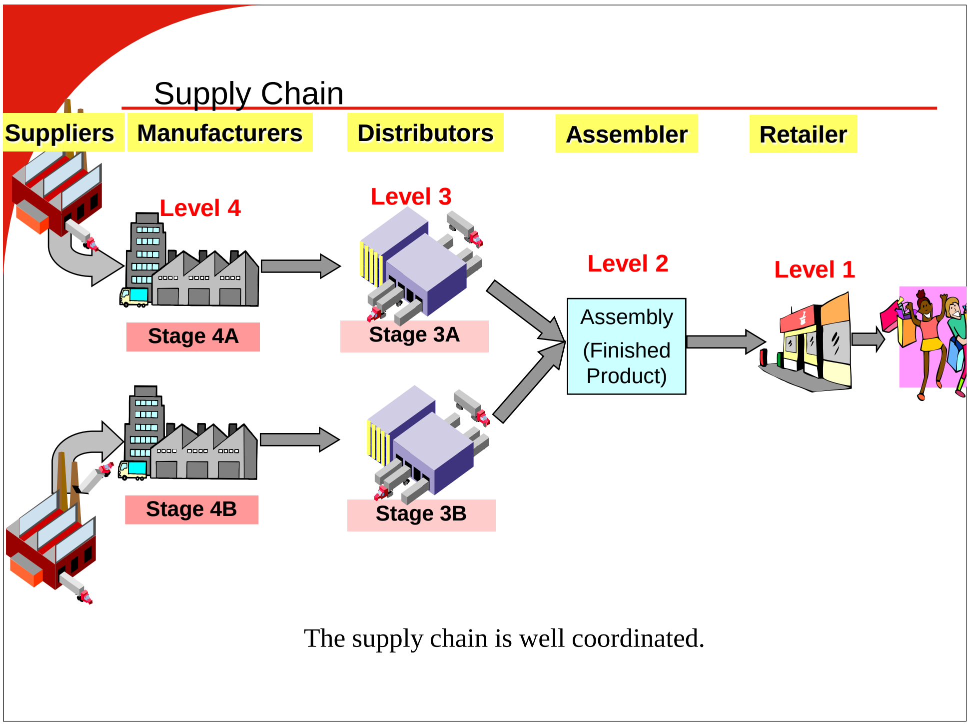

Figure 1. A supply chain

Supply chain (SC) performance evaluation problems cover a wide range from evaluating the performance of independent organizations among supply chains to evaluating the performance of a whole supply chain system. The Supply chain performance evaluation problem is one of the most comprehensive strategic decision problems that need to be considered for long-term efficient operation of the whole supply chain. Traditionally, marketing, distribution, planning, manufacturing and purchasing organizations among the supply chain operated independently. Correspondingly, performance evaluation of supply chain means evaluating the performance of marketing, distribution, planning, manufacturing and purchasing organizations independently [6].

3 The DEA-Supply Chain method

Therefore, this study considers how to optimize the supply chain itself in order to maximize the benefit by DEA. In addition, a signify cant matter is that supply chains have sometimes unbalanced business processes. This means that some particular DMUs on the supply chain have a superiority which maintains efficiency. That is why the other DMUs on the supply chain need to operate in unfavorable conditions. As a result, their operations badly affect the total efficiency of the supply chain. Therefore, the proposed method introduces an adjustment variable to calculate the optimum operation of the supply chain. The utility and effectiveness of the proposed method are shown by numerical experiments, [18].

[1] this paper examines the effectiveness of joint decision making within 87 pairs of buyer-supplier relationships in manufacturing, namely, the efficiency of joint decision making in buyer-supplier relationships,[9]. [5] Provide an efficiency measurement framework for a two-subsystem series system, and three types of efficiency measurements are given.

[20] Advances two definitions of supply chain CRS production possibility set and proves their equipollence. Based on the definitions, a DEA model is created to appraise the overall technical efficiency of supply chains. Traditional DEA CCR model is proven effective to assess the technical efficiencies of peer decision making units, including the suppliers and manufacturers in Figure. 2. The technical efficiency of the d^{th} $(d = 1, . . . , n)$ supplier (the supplier in the d^{th} supply chain) is computed by the following model:

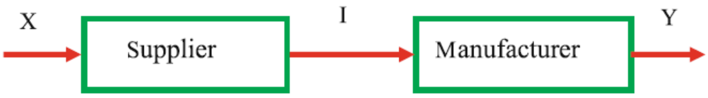

Figure 2. A supply chain

$$
\begin{aligned}
&\theta_d^s = \min \theta^s \\
&s.t. \\
&\sum_{j=1}^{n} \lambda_j^s x_{pj} \le \theta^s \times x_{pd}, \; p = 1,\dots,P \\
&\sum_{j=1}^{n} \lambda_j^s i_{kj} \ge i_{qd}, \; k = 1,\dots,K \\
&\lambda_j^s \ge 0 \qquad j = 1,\dots,n
\end{aligned}
\tag{1}
$$

where W and V denote the output and input weight vectors. The technical efficiency of the d^{th} manufacturer is computed as follows:

$$\begin{aligned} &\theta_d^m = \max \theta^m \\ &s.t. \\ &\sum_{j=1}^{n} \lambda_j^m i_{kj} \le i_{qd}, k = 1,...,K \\ &\sum_{j=1}^{n} \lambda_j^m y_{qj} \ge \theta^m \times y_{qd}, q = 1,...,Q \\ &\lambda_j^m \ge 0 \qquad j = 1,...,n \end{aligned} \tag{2}$$

Denote by θ_d the d^{th} supply chain's DEA efficiency, denote also by $((x^*_{pj}, i_{kj}, y^*_{qj})$ points located at the frontier enveloped by the sub-perfect supply chain CRS production possibility set. θ_d can be computed using Model (3):

$$\begin{aligned} &SC_d = \min \theta \\ &s.t. \\ &\sum_{j=1}^{n} \lambda_j x^*_{pj} \le \theta \times x_{pd}, p = 1,...,P \\ &\sum_{j=1}^{n} \lambda_j y^*_{qj} \ge y_{qd}, q = 1,...,Q \\ &\sum_{j=1}^{n} \mu_j x_{pj} \times \theta^{*s} \le x^*_{pd}, p = 1,...,P \\ &\sum_{j=1}^{n} \mu_j i_{kj} = i^*_{kd}, k = 1,...,K \\ &\sum_{j=1}^{n} \mu_j y_{qj} \times \theta^{m*} \ge y^*_{qd}, q = 1,...,Q \\ &\lambda_j, \mu_j \ge 0 \qquad, j = 1,...,n \end{aligned} \tag{3}$$

Therefore, [14] utilize the slckes- based measure (SBM) of efficiency approach to solve the supply chain performance evaluation problem, and this property is known by names such as "dimension free" and "units invariant." In this paper we introduce SBM model for supply chain performance evaluation by regard intermediate production, where show input excesses, output shortfalls and efficiency or inefficiency supply chain simultaneously.

The SBM model of the d^{th} supplier is computed by the following model:

$$(SBM_{\sup plier})\min \rho_s = \frac{1-\left(1/P\right)\sum_{p=1}^{P} s_p^- / x_{pd}}{1+\left(1/K\right)\sum_{k=1}^{K} s_k^+ / i_{kd}}$$

$$s.t.$$

$$\sum_{j=1}^{n} \lambda_j^s \times x_{pj} + s_p^- = x_{po},\ p = 1,2,\ldots,P \tag{4}$$

$$\sum_{j=1}^{n} \lambda_j^s \times i_{kj} - s_k^+ = i_{ko},\ k = 1,2,\ldots K$$

$$\lambda_j^s \geq 0,\ j = 1,2,\ldots,n$$

$$s_p^- \geq 0,\ p = 1,2,\ldots,P. s_k^+ \geq 0, k = 1,2,\ldots,K.$$

Where s^-_p(p=1,2,…,P) and s^+_k (k=1,2,…,K) denote the input excesses and output shortfalls vectors, and $\lambda_j^s, (j = 1,2,\ldots,n)$ is nonnegative vector. The SBM model of the d[th] manufacturer is computed as follows:

$$(SBM_{manufacturer})\min \rho_m = \frac{1-\left(1/K\right)\sum_{k=1}^{K} s_k^- / i_{kd}}{1+\left(1/Q\right)\sum_{q=1}^{Q} s_q^+ / y_{qd}}$$

$$s.t.$$

$$\sum_{j=1}^{n} \lambda_j^m \times i_{kj} + s_k^- = i_{kd}, k = 1,2,\ldots,K \tag{5}$$

$$\sum_{j=1}^{n} \lambda_j^m \times y_{kj} - s_q^+ = y_{qd}, q = 1,2,\ldots Q$$

$$\lambda_j^m \geq 0,\ j = 1,2,\ldots,n$$

$$s_k^- \geq 0, k = 1,2,\ldots,K. s_q^+ \geq 0, q = 1,2,\ldots,Q.$$

The overall efficiency of the d[th] supply chain is computed by the following model:

$$(SBM_{manufacturer})\min \rho_m = \frac{1-\left(1/K\right)\sum_{k=1}^{K} s_k^{-}/i_{kd} - \left(1/K\right)\sum_{k=1}^{K} s_k^{-*}/i_{kd}}{1+\left(1/Q\right)\sum_{q=1}^{Q} s_q^{+}/y_{qd} + \left(1/K\right)\sum_{k=1}^{K} s_k^{+*}/i_{kd}}$$

$$\begin{aligned} & s.t. \\ & \sum_{j=1}^{n} \lambda_j \times x_{pj} + s_p^- = x_{po},\ p=1,2,\dots,P \\ & \sum_{j=1}^{n} \lambda_j \times i_{kj} = i_{kd},\ k=1,2,\dots,K \\ & \sum_{j=1}^{n} \lambda_j \times y_{kj} - s_q^+ = y_{qd},\ q=1,2,\dots Q \\ & \lambda_j \geq 0,\ j=1,2,\dots,n \\ & s_p^- \geq 0,\ p=1,2,\dots,P.s_q^+ \geq 0, q=1,2,\dots,Q. \end{aligned} \tag{6}$$

And furthermore performance evaluation is of great importance for effective supply chain management. Therefore, DEA can help companies to remove some of the inefficiencies in operational processes in order to become more effective. The current paper develops one approach for determining the DEA projections for inefficient supply chains. Therefore, by using potential DEA slacks in the projections and the [1] model, we have model (1): [3],[13].

$$\begin{aligned} & \theta_d = Min\theta - \varepsilon(\sum_{p=1}^{P} s_p^- + \sum_{k=1}^{K} s_k^+ + \sum_{k=1}^{K} s_k^- + \sum_{q=1}^{Q} s_q^+) \\ & s.t. \\ & \sum\nolimits_{j=1}^{n} \lambda_j x_{pj} + s_p^- = \theta \times x_{pd},\ p=1,2,\dots,P \\ & \sum\nolimits_{j=1}^{n} \lambda_j i_{kj} - s_k^+ = i'_{kd},\ k=1,2,\dots,K \\ & \sum\nolimits_{j=1}^{n} \eta_j i_{kj} + s_k^- = i'_{kd},\ k=1,2,\dots,K \\ & \sum\nolimits_{j=1}^{n} \eta_j y_{qj} - s_q^+ = y_{qd},\ q=1,2,\dots,Q \\ & \lambda_j \geq 0, \eta_j \geq 0, i'_{kd} \geq 0, \forall j,k \\ & s_p^- \geq 0, s_k^+ \geq 0, s_k^- \geq 0, s_q^+ \geq 0, \forall p,k,q. \end{aligned} \tag{7}$$

4 Conclusions

Performance evaluation has been one of the most critical components in management. As production systems nowadays consist of a growing number of integrated and interacting processes, the interrelationship among processes have created a major challenge in measuring system and process performance. Therefore, in this paper establishes the DEA model for supply chain efficiency evaluation based on a two stage supplier manufacturer chain. It is not hard to see that the model can be extended to a more complex and general framework. The main rational of the model construction is the following.

Future research paths might focus on the following questions:

- How would different evaluation model choices affect each of the firms operating within one and the same supply chain in terms of the overall creation of value?
- What is the effect on a chain's performance when each of its actors finds itself at a different level of maturity?
- What happens when new evolution concepts arise?
- What level of competency does a company require to be able to use one or the other of these performance models?

References

[1] Markus Biehl · Wade Cook · David A. Johnston "The efficiency of joint decision making in buyer-supplier relationships" Ann Oper Res (2006) 145:15–34 DOI 10.1007/s10479-006-0023-x.

[2] Charnes, A., Cooper, W. W., Rhodes, E. Measuring the efficiency of decision making units. Europ ean
Journal of Operational Research, 2(6), (1978), pp.429-444.

[3] Chen, Y.,Cook, W.D.,Li, N., & Zhu, J.(2009). Deriving the DEA frontier for two-stage processes. European Journal of Operational Research, 196(1) 1170-1176.

[4] Fare, R., Grosskopf, S., 2000. Network DEA. Socio-Economic Planning Sciences 34, 35–49.

[5] Boaz Golany · Steven T. Hackman · Ury Passy An efficiency measurement framework for multi-stage production systems Ann Oper Res (2006) 145:51–68 DOI 10.1007/s10479-006-0025-8.

[6] Jiuping Xu , BinLi , DeshengWu. Rough data envelopment analysis and its application to supply chain performance evaluation Int. J. Production Economics 122 (2009) 628–638

[7] Kao,C.,Hwang,(2008). Efficiency decomposition in two-stage data envelopment analysis : An application to non-life insurance companies in Taiwan. European Journal of operational Research 185(1).418-429.

[8] Kuosmanen, T., Kortelainen, M., 2005. Measuring eco-efficiency of production with data envelopment analysis. Journal of Industry Ecology 9, 59–72.

[9] Liang Liang · Feng Yang · Wade D. Cook · Joe Zhu DEA models for supply chain efficiency evaluation Ann Oper Res (2006) 145:35–49 DOI 10.1007/s10479-006-0026-7.

[10] Morgan, C. Supply network performance measurement: future challenges. *The International Journal of Logistics Management* 18: (2007) 255-273.

[11] Nolan, J.F., Ritchie, P.C., Rowcroft, J.E., 2002. Identifying and measuring public goals: ISTEA and the US bus transit industry. Journal of Economic Behavior and Organization 48, 291–304.

[12] Jan Olhager, Erik Selldin "Supply chain management survey of Swedish manufacturing firms" Int. J. Production Economics 89 (2004) 353–361.

[13] M.Sanei , S.Mamizadeh-Chatghayeh . Improving supply chain collaborations and performance of inefficient supply chain Iranian Journal of Optimization 4(2010) 211-218.

[14] M.Sanei, S.Mamizadeh-Chatghayeh . Evaluation of Supply Chain Operations Using Slacks-based Measure of Efficiency Int. J. Industrial Mathematics Vol. 3, No. 1(2011) 35-40.

[15] Sexton, T.R., Lewis, H.F., 2003. Two-stage DEA: An application to major league baseball. Journal of Productivity Analysis 19, 227–249.

[16] Seiford, L.M., Zhu, J., 1999. Profitability and marketability of the top 55 U.S. commercial banks. Management Science 45, 1270–1288.

[17] Sheth, C., Triantis, K., Teodorovic, D., 2007. Performance evaluation of bus routes: A provider and passenger perspective. Transportation Research Part E 43, 453–478.

[18] Shingo Aoki · Akio Naito · Ryota Gejima Kazushige Inoue · Hiroshi Tsuji "Data envelopment analysis for a supply chain Artif Life Robotics (2010) 15:171–175 DOI 10.1007/s10015-010-0787-6.

[19] Xu, J.P., Liu, Q., 2008. A class of multi-objective supply chain networks optimal model under random fuzzy environment and its application to the industry of Chinese liquor. Information Sciences 178, 2022–2043.

[20] Feng Yang · Dexiang Wu · Liang Liang · Gongbing Bi · Desheng DashWu Supply chain DEA: production possibility set and performance evaluation model" Ann Oper Res DOI 10.1007/s10479-008-0511-2.