Evaluating the efficiency of 3PL logistics operations

Amer Hamdan*, K.J. (Jamie) Rogers1

Industrial and Manufacturing Systems Engineering Department, Box 19017, The University of Texas at Arlington, Arlington, TX 76019, USA

Received 2 April 2006; accepted 18 May 2007
Available online 24 July 2007

Abstract

This paper introduces data envelopment analysis (DEA) as a tool to evaluate the efficiency of a group of third-party logistics (3PL) warehouse logistics operations. DEA is a linear programming technique used to evaluate the efficiency of decision-making units (DMUs) where multiple inputs and outputs are involved. The paper starts with a general review of the DEA models and basic definitions, and then provides a review of warehousing functions and performance measures. First, a basic (unrestricted) DEA model is applied to a group of homogeneous warehouses that have similar inputs and outputs. Then, a revised (restricted) DEA model with additional constraints is presented; the revised model incorporates weight restrictions and value judgment. The relative efficiency scores for the warehouses used in the study were analyzed before and after the use of weight restrictions. As a result, we were able to determine the impact of each input and output on the efficiency of each warehouse, and also, we were able to examine specific warehouse characteristics and develop a set of recommendations for assisting managers and engineers in the improvement and design of more efficient operations.

Keywords: 3PL; Warehousing; Logistics performance; DEA

1. Introduction

In this research, a new warehouse efficiency model is presented to evaluate the overall efficiency of a group of third-party logistics (3PL)-operated warehouses at the enterprise level where multiple inputs and multiple outputs are involved. This model is developed using data envelopment analysis (DEA) as a multi-factor productivity model for measuring the relative efficiencies of a homogeneous set of decision-making units (DMUs), or in this case, the set of warehouses used in the study, where the relative efficiency score of each warehouse is calculated in the presence of multiple inputs and multiple outputs. The new model that was developed from the basic (unrestricted) DEA model originally presented by Cooper et al. (2000) incorporates (through additional constraints to the original model) strategic thinking that stems from the organization’s goals and objectives as well as expert opinion. In a related study by Hackman et al. (2001), the authors offered a DEA model that examines specific characteristics of warehouses; although the study provided valuable characteristics of warehouses, it used warehouse data for a wide range of products that included auto parts, electronics, fine paper, mail order apparel, photographic

*Corresponding author. Tel.: +1 817 375 5744.
E-mail addresses: amerhamdan@yahoo.com (A. Hamdan), jrogers@uta.edu (K.J. (Jamie) Rogers).
Tel.: +1 817 272 2495.
supplies, and other products. This wide range of products indicate that these warehouses have different processes and handling techniques and equipment, whereas one of the basic requirements of DEA models is to ensure that all DMUs are to be homogeneous.

2. Warehousing

A warehouse is a location where a firm stores or holds raw materials, semi-finished goods, or finished goods for a varying length of time (Keebler and Durtsche, 2001). The core processes for the warehouses used in this study include all inbound, outbound, and inventory control activities. These are as follows:

1. Receiving: A set of inbound activities that start with unloading goods and materials on the receiving dock, staging, and checking and verification of materials’ quality and quantity.
2. Put-away: The physical and logical movement of materials to designated storage locations.
3. Picking: The disbursement of materials from storage location or picking location to fill customer orders.
4. Packing: Packaging, pricing, labeling, scanning individual items or cartons, and other customer instructions.
5. Shipping: Staging materials on the shipping dock for verification of order quantity, visible damage, order/invoice accuracy, and loading materials on the designated truck.
6. Other processes: Cycle counting, physical inventory, and value-added services (VAS) (Hamdan and Rogers, 2004; Schefczyk, 1993).

3. Measuring performance

According to Keebler and Durtsche (2001), in the case of logistics performance measurement, five recent studies published by the Council of Supply Chain Management Professionals (CSCMP), formerly known as the Council of Logistics Management (CLM), indicate that most firms do not comprehensively measure logistics performance, and even the best-performing firms fail to realize their productivity and service potential available from logistics performance measurement. In addition, logistics competency will increasingly be viewed as a competitive differentiator and a key strategic resource for the firm.

Traditionally, warehouse performance measures were mostly financial measures such as the total cost per order, warehousing cost per unit, etc. While these bottom-line measures may be considered in many cases as good indicators of whether or not logistics strategy is being properly implemented and executed, they do not improve the performance of a process, and they are usually captured and tracked at high levels without providing visibility to those who are accountable for the process. Non-financial measures, on the other hand, such as inventory accuracy, order fill rate, and space utilization rate, are tangible measures that are driven by the organization’s vision and goals. Non-financial measures include customer satisfaction, quality, flexibility, and productivity.

4. DEA

In 1978, Charnes et al. demonstrated fractional programming techniques as an extension to Ferrell’s (1957) single productivity efficiency measure to solve multiple input and multiple output problems. This technique is called DEA. DEA is a non-parametric linear programming technique used for the evaluation of DMUs when multiple inputs and multiple outputs are involved. DEA identifies the “best”-performing or the most efficient DMU and measures the efficiency of other units based on the deviation from the efficient DMU.

DEA is also defined as a quantitative technique that derives the utilization efficiency of a specific unit’s use of inputs (resources such as labor hours, space, and materials) relative to specified outputs. It computes, through iterative processes, the “efficiency score” of each unit evaluated. It also ranks and compares each unit’s performance relative to the other units, where each DMU represents an entity with multiple inputs and multiple outputs. DMUs may include hospitals, banks, libraries, universities, and other profit and non-profit organizations. Generically each DMU is regarded as the entity responsible for converting inputs into outputs and whose performances are to be evaluated.

The CCR (Charnes, Cooper, Rhodes) model is originally a fractional programming problem solved to obtain values for weighted inputs \( v_i (i = 1, 2 \ldots m) \) and weighted outputs \( u_r (r = 1, 2 \ldots s) \). The objective here is to obtain weights \( (v_i) \) and \( (u_i) \) that maximize the ratio of \( \text{DMU}_o \) being evaluated, while satisfying