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Presenting a New Approach toward Locating Optimal Decoupling Point in Supply Chains

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A R T I C L E   I N F O

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A B S T R A C T

This article attempts to cope with one of the most vital strategic decisions in the supply chain design in terms of manufacturing context. The issue of finding the best position of Customer Order Decoupling Point (CODP) in a production line have been taken into consideration by many researchers in recent years, but locating CODP along a supply chain has not yet been completely investigated. Here we present a novel combined DEA/AHP method to tackle the problem of positioning CODP in a supply chain. Then in order to prove the applicability of the proposed structure in a real case, the model is implemented in a food processing supply chain.

1. Introduction

Today competitive global markets in different industrial and service sectors has highlighted role of customers satisfaction more clearly so far. In this regard, practitioners have focused more severely on the customer requirements. Hence, customer requirements have played a key role in the processes of procurement and delivery of products and services. Upon introduction of customer requirements in the product value chains has emerged evolution of order driven production systems in which no processing and production activities are performed unless an order is received. Similar to other production systems, these systems also suffer some drawbacks, such as longer delivery times and higher production expenses. To cope with these inefficiencies, hybrid production systems were introduced by which systems were benefited from both order driven and production driven competitive advantages. In this regard, concept of customer order decoupling point was introduced as the point in the value chain in which customer orders are linked to the production process. In

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other words, order requirements are taken into account in the process of product/ service processing and delivery after customer order decoupling point of the chain. Activities before this point are forecast driven, while the ones after this point are order driven [1,2]. As the decoupling point closes to the end of production line, delivery time and work-in-process inventories are increased, while line flexibility is decreased due to lower level of possible customization in the processed goods. Therefore, locating optimum decoupling points is a challenging issue in the production facilities delivering customized products and services. This paper addresses this problem in supply chains which include several facilities linking together to provide products and services to end customers. Next section reviews literature body of the decoupling point locating problem. Section 3 includes influential criteria on this strategic problem and the developed hybrid AHP-DEA method towards the considered problem. Finally, numerical results are presented in Section 4 and Section 5 concludes the paper.

2. Literature review

The first research devoted to the locating customer order decoupling point in production lines is the one presented by van Donk in 2001. In his paper, eight criteria were introduced in two categories of “process and stock” and “product and market” in order to determine order decoupling point. Also, his developed model with the introduced criteria were applied in a food industrial company [3]. Olhager developed the model presented by van Donk by extending the criteria in three categories of “market”, “product”, and “process”. He also analyzed reasons of moving the decoupling point foreward and backward in the value chain. Also, two main criteria were introduced in this problem; demand volatility and ratio of production time to delivery time [4]. For the first time, Zaerpour et al. took into account problem of product partitioning (selecting proper strategies for make-to-stock and make-to-order products). In this regard, they developed a hybrid fuzzy AHP-SWOT with sixteen decision criteria in three categories of “product”, “process”, and “production”. They implemented the developed structure in a food industrial company [5]. In another paper from the same authors, product partitioning including hybrid production strategy was studied using fuzzy AHP-TOPSIS [6].

3. Proposed structure

AHP and DEA are two strong methodologies in the fields of management and decision making with numerous applications in different fields. Although these methods have evolved independently, they might be used integrated to compensate their drawbacks. One of the similarities between these two methods is their capabilities in prioritization. In AHP, prioritization is conducted upon pairwise comparisons; however, inputs and outputs of the decision units determine their priorities in DEA method. In the later, decision units are categorized into efficient and inefficient units. In recent days, many applications have been found in which hybrid AHP-DEA methodology were applied. In many applications, AHP was used to quantify qualitative criteria into quantitative ones; then, DEA was used in order to calculate efficiency of decision making units using the quantitative data. Ramanathan first applied DEA to elicit local weights of alternatives using pairwise comparisons performed upon AHP. Also, global weights of alternatives were calculated using DEA method. He proved that the developed method had a superiority over the AHP in deleting any alternatives without changes in the final priorities of the alternatives [7]. Moreover, Sevkli et al. applied hybrid AHP-DEA for supplier selection in a home appliance manufacturing firm. They showed that the developed method had better performance even when the comparisons were inconsistent [8]. This paper addresses problem of locating optimal order decoupling point using AHP-DEA in following steps:

1- Defining alternatives and decision criteria;
2- Conducting pairwise comparisons between alternatives and decision criteria;
3- Calculating local weights of alternatives and criteria using DEA; and
4- Calculating global weights of alternatives.

Alternatives of the considered problem are all steps of the value chain except bottlenecks since locating decoupling point at a bottleneck results in overstock or shortage through the value chain. Also, sixteen criteria are defined in four groups to construct hierarchy of the decision. The related criteria are grouped within four groups of “product”, “process”, “market”, and “supplier”, among which some are elicited from the literature and some are proposed herein in this paper.

Criteria related to supplier

- Supplier flexibility: Since delivering customized products requires more flexible raw materials, more flexible suppliers are needed to deliver MTO products.
- Supplier delivery time: Similar to flexibility, supplier delivery time is an important factor to deliver more flexible products.

Criteria related to market

- Risk of obsolescence: MTO production systems are more compatible with the markets of products which are fashionable. As these products’ markets are always changing, more flexible lines are able to respond to the market changes.
- Demand predictability [9]: Core of any MTS production system is forecasting demand. Hence, more predictable demand patterns of products are compatible with MTS production lines.
- Product customization [4]: In value chains of products with higher levels of customization, MTO production systems are more suitable to cope with the demand flexibility of the customers.
- Customer feedback: In a production environment with dynamic market monitoring, customer feedbacks, customer complaints and satisfaction, more adaptive production lines are required to respond to the required flexibility of the market and customer needs. Therefore, MTO production system is more adaptive to such market conditions.

Criteria related to process

- Process controllability [9]: Since making changes in production line is a prerequisite for implementing MTO production systems, high level of process controllability is required for implementing MTO production system.
- Production time [9]: Longer production times shorten line flexibility. Hence, MTS production systems are more compatible with the longer production times.
- Human flexibility: Processing different products with customization requirements involve human resources in performing different tasks of production. In this regard, flexible human resources are inevitable in delivering more customized products.
- Production flexibility: Similar to human flexibility, production line flexibility is another prerequisite of delivery customized products, since it is required to perform a wide range of production activity to deliver a wide range of products with diverse level of customization.

Criteria related to product

- Unit price: Since MTO production systems involve higher levels of customization and flexibility, they impose higher levels of procurement costs. Hence, higher unit price of products are more compatible with the products processed in MTO production lines.
- Holding cost [9]: MTS production systems yield higher level of in-process inventories. Hence, higher level of holding cost results in shifting the production line into MTO.
- Product perishability [3]: MTS production systems impose some levels of finished goods inventory. Hence, MTO production systems are more suitable for the perishable products.
- Modular design [4]: Modular design helps the line deliver higher level of customization. Therefore, modular design is too appropriate for the MTO production systems.
- Backorder cost: Because customer usually expects to buy MTS products without any delay, backorder cost of such products are relatively high. Therefore, it is better to process the products with higher backorder cost upon MTS production system.
- Transportation cost: On-time delivery is an important cornerstone of MTO production systems, which is accomplished using a suitable transportation system. Hence, it is too important to consider transportation costs in implementing such systems.

After defining decision criteria, 1-9 comparison scale of Saati is used to conduct pairwise comparisons [10]. In Step 3, local weights are elicited using pairwise comparison matrices which are formed as in Figure 1. After solving the DEA model for every pairwise comparison matrix, the obtained local weights are used as the objective function of the DEA model. Other steps are similar to the conventional AHP. Readers are referred to [10].

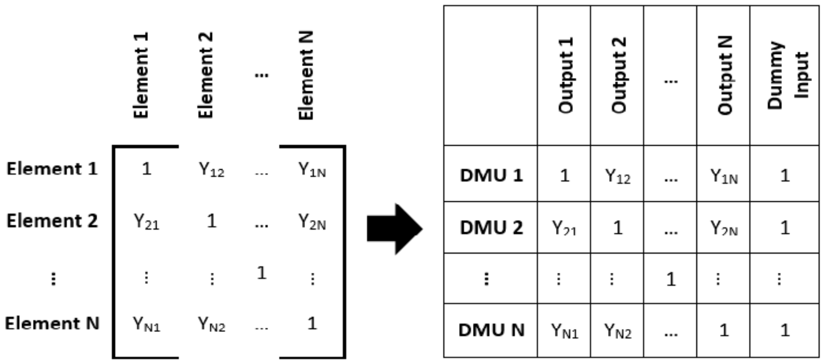

Figure 1- Converting pairwise comparison matrix into DEA model

4. Numerical results

In order to validate the proposed model, the model is implemented in a case study of the food industries. In this regard, the company has decided to reform its strategies upon MTS, MTO or hybrid disciplines throughout its supply chain to cope with market variability in customer customization and maintaining market share.

In the considered company, ten product families are processed for which order decoupling points must be determined. Pairwise comparisons are conducted upon experts' judgments of the firm. Upon the places of production bottlenecks of all product families, alternatives are determined with respect to every product family. For instance, Table 1 shows pairwise comparison matrix of the alternatives for product family 5 with respect to criterion product perishability. Using the developed DEA model, final weights of the alternatives are elicited as compared with those of AHP in Table 2.

Table1- Pairwise comparison matrix for product family 5 with respect to perishability criterion

	O_1	O_2	O_3	O_4	O_5	O_6	O_7
O_1	1	1/6	1/7	1/6	1/7	¼	1/3
O_2	6	1	¼	1	¼	1	1/5
O_3	7	4	1	3	1	3	6
O_4	6	1	1/3	1	¼	½	¼
O_5	7	4	1	4	1	1/6	1
O_6	4	1	1/3	2	6	1	2
O_7	3	5	1/6	4	1	1/2	1

Table2- Comparison of AHP and AHP-DEA for product families

Alternative	AHP	AHP-DEA
O_1	5	6
O_2	2	4
O_3	1	3
O_4	6	1
O_5	3	2
O_6	4	7
O_7	7	5

As is shown in Table 2, obtained priorities from AHP and hybrid AHP-DEA are different. Additionally, some criteria are utilized in comparison of the company performance before and after implementing the developed hybrid algorithm.

Table3- Comparison of efficiency criteria before and after implementing the proposed structure

Criterion	Before	After
No of received orders	26	23
No of accepted orders	22	21
No of on-time deliveries	13	20
Average work in process	19	4

5. Conclusions

Locating supply chain decoupling point as a strategic decision was addressed in this paper. To do so, an AHP-DEA method was developed and the results were analyzed in a company from food industries in order to validate the proposed structure.

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