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An evaluation approach to logistics service using fuzzy theory, quality function development and goal programming

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ABSTRACT

Logistics customer service is an important factor in the success of supply chain management. The aim of this study is to propose a novel approach for customer service management. For the improvement of logistics service operations, the proposed method integrates quality function development (QFD), fuzzy extended analytic hierarchy process (FEAHP), and multi-segment goal programming (MSGP). The advantage of the method includes the consideration of various logistics goals and the flexibility of setting multi-aspiration levels of evaluation criteria.

1. Introduction

Almost two decades ago, some studies had highlighted the significant role of logistics and customer service in achieving competitive advantage (Bailey, 1996). Since then, customer service has become increasingly important while brand advantage and the product's technical characteristics are no longer the exclusive factors to attract customers. While directly related to customer service, logistics management aims to increase the operational efficiency by facilitating greater collaboration and coordination with business partners (Celebi, Bayraktar, & Bingol, 2010). Furthermore, as a global trend, outsourcing of the logistics function has become increasingly important that the logistics service providers (LSPs) have been well positioned to turn into the indispensable links in the chain of commerce.

Whereas businesses need to expand the breadth of logistics services (Bottani & Rizzi, 2006), its design determines if the actual operations will ensure customer satisfaction and lifetime value. Therefore, understanding customers' requirement for providing the right solution is essential. Same as physical products, customers evaluate service by comparing their perceptions with their expectations; therefore, a gap in between can be a synthetic measure of customer satisfaction (Bottani & Rizzi, 2006; Robledo, 2001).

This paper proposes a novel approach for designing the logistics customer service by integrating quality function development (QFD), fuzzy extended analytic hierarchy process (FEAHP) and multi-segment goal programming (MSGP). QFD is implemented as an analytical framework to integrate FEAHP and MSGP. FEAHP not only handles the inherent uncertainty of the human judgment, but also provides the flexibility for the decision makers to comprehend the problem-solving process. MSGP is devised to address the decision-making problem which involves multi-segment aspiration levels of evaluation criteria.

The remainder of this paper is organized in the following order. Section 2 reviews the studies on logistics service for defining customer service requirements (CSRs) and logistics operation requirements (LORs) from the respective perspectives of customers and service providers. Section 3 introduces the basics of QFD, FEAHP and MSGP. Section 4 presents the procedure of the proposed method and Section 5 provides a practical case study to demonstrate its application. Section 6 provides the concluding remarks.

2. Logistics and customer service

From customer perspective, Franceschini and Rafele (2000) suggested the requirements of logistics service include lead-time, regularity, reliability, flexibility, completeness, correctness, harmfulness and productivity. Bottani and Rizzi (2006) considered lead-time, flexibility, reliability, accuracy, fill rate, frequency,

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organization accessibility and complaints management as the logistics service factors, while Spekman, Kamauff, and Myhr (1998) and Gourdin (2006) provided similar lists concerning logistics service.

In contrast, from the service provider's perspective, logistics management refers to analyzing, designing, and controlling the internal and external functions of the logistics system, including supplying materials, transforming materials and distributing finished products or services to customers, while maintaining consistency with the logistics strategy (Gourdin, 2006; Spekman et al., 1998). According to (Andersson & Norrman, 2002; Boyson, Corsi, Dresner, & Rabinovich, 1999; Dornier, Ricardo, Fender, & Kouvelis, 1998; Stank & Daugherty, 1997), the goals of logistic management include efficiency, reliability, controllability, flexibility, sustainability, and environmental friendliness. In more specific terms, the performance criteria may include short delivery times, minimum stock levels, minimum costs, damage free, vehicle and load tracking, and waste handling and transport.

In recent years, the concept of just-in-time (JIT) has been borrowed from manufacturing to streamline logistics service via the efficient flows of materials and information, thus is able to consistently deliver the right product to the right place at the right time (Bottani & Rizzi, 2006). The performance of logistics service is reflected by stable service quality, forecasting accuracy, fault diagnosis capability, responsiveness, information technology, profit/risk sharing and mutual trust with business partners (Bagchi & Virum, 1998; Langley, Allen, & Tyndall, 2002; Lynch, 2000; Tam & Tummala, 2001). In addition, warehouse management, including warehouse location and layout, order picking, items storage/retrieval operations, customer relationship management has significant impacts on logistics performance (Bottani & Rizzi, 2006).

According to the above review, we summarize those performance factors into Table 1 (customer service requirements, CSRs) and Table 2 (logistics operation requirements, LORs), which represent respectively WHAT customers require and HOW the service provider should operate.

3. Basics of QFD, FEAHP and MSGP

3.1. Quality function development (QFD)

QFD is a systematic method that provides a means of translating customer requirements into technical requirements for each stage of product development (Bhattacharya, Sarkar, & Mukherjee, 2005; Karsak, Sozer, & Alptekin, 2002; Tseng & Lin, 2011). The successful QFD application may result in greater customer focus, shorter lead times, and knowledge preservation (Liu, 2009). QFD can be applied to practically any manufacturing or service industry, including logistics service (Baki, Basfirinci, Murat, & Cilingir, 2009; Behara & Chase, 1993; Bottani & Rizzi, 2006; Lapidus & Schibrowsky, 1994; Stuart & Tax, 1996; Tu, Chang, Chen, & Lu, 2010).

As a systematic method, QFD has a twofold implication. First, it supports product planning on the basis of the customer's voice by a stepwise analysis and deployment of customer requirements (Akao, 1990). Second, it requires the collaboration between different business areas as a prerequisite for the design tasks (Bottani & Rizzi, 2006).

As the basis of QFD, the customer requirements planning matrix (a.k.a. "House of Quality", HOQ) consists of seven components: (1) customer requirements (CRs), (2) importance of customer requirements, (3) engineering characteristics (ECs), (4) relationship matrix for CRs and ECs, (5) correlation among ECs, (6) benchmark analysis, and (7) prioritization of design requirements (Chan & Wu, 2002; Tseng & Lin, 2011). By developing the HOQ (Fig. 1), the design team transforms the customers' requirements (WHATs) into the engineering characteristics (HOWs) of the product or service.

3.2. Fuzzy extended analytic hierarchy process (FEAHP)

The analytic hierarchy process (AHP) (Saaty, 1980) has been widely used to address multi-criteria decision-making (MCDM) problems, which is about evaluation and ranking a set of competing alternatives according to multiple criteria involving subjective judgment of hierarchical structure (Cho & Cho, 2008; Liao & Kao, 2010; Önü & Soner, 2008). The AHP consists of six essential steps (Lee, Kang, & Chang, 2009; Murtaza, 2003): (1) define the unstructured problem, (2) develop the AHP hierarchy, (3) perform pairwise comparison among decision factors, (4) estimate the relative weights of the decision factors, (5) check the consistency property of matrices, and (6) obtain the overall rating for the alternatives.

Whereas fuzzy set theory has proven advantages to approximate uncertain, imprecise and vague information, the fuzzy AHP approach is the fuzzy extension AHP (FEAHP) to handle the fuzziness of data involved in the MCDM problems (Bozbura, Beskese, & Kahraman, 2007; Cheng, 1999; Lee et al., 2009; Liao, 2011; Murtaza, 2003; Önü & Soner, 2008).

A fuzzy set is characterized by a membership function that assigns each object a grade of membership ranging from 0 to 1. In this set, general terms such as "large", "medium", and small" are used to capture a range of numerical values. Among various representations, triangular fuzzy numbers are most popular for applications (Chan & Kumar, 2007). As shown in Fig. 2, if n_1, n_2 and n_3 denote the smallest possible values, the most promising value and the largest possible value that describe a fuzzy event, respectively, then the triangular fuzzy number can be denoted as a triplet (n_1, n_2, n_3) where $n_1 \leqslant n_2 \leqslant n_3$. In Fig. 2, triangular fuzzy number $\widetilde{M}$ is represented by (n_1, n_2, n_3), and the membership function can be defined as

Table 1
Customer service requirements.

Service requirements ("**WHATs**")	Description
Lead-time	Time period passing from customer's order until receipt
Flexibility	Capability to modify orders in terms of due date and quantity when required by customers
Reliability	Capability to deliver orders within the due date
Regularity	The dispersion around the mean value of the delivered lead-time
Completeness	Capability to deliver full orders when required by customers
Accuracy	Avoidance of mistakes and damages in orders delivered process
Fill rate	The percentage of units available when requested by customers
Correctness	Avoidance of mistakes in orders delivered
Harmfulness	Avoidance of damages in orders delivered process
Productivity	Number of item produced in a given time period
Frequency	Number of deliveries accomplished in a given time period
Organization accessibility	Customer's opportunity to establish a contact with firm's staff
Complaints management	Process subsequent to the recognition of some errors in service provided, that allows service quality standards to be reestablished