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A new importance–performance analysis approach for customer satisfaction evaluation supporting PSS design

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ABSTRACT

Product-service system (PSS) design focuses on customer value and satisfaction more than traditional product or service design, and pays much attention to making improvement strategies due to the immaturity of engineering design methodology. Customer satisfaction evaluation attracts PSS providers' attentions in supporting PSS design. Importance–performance analysis (IPA) as an effective customer satisfaction evaluation tool is revised and used to identify PSS improvement strategies in this paper. The new IPA is proposed for three reasons. First, considering the fact that the attribute performance and importance are not independent variables and attribute performance has a nonlinear relationship with the overall satisfaction, Kano's model is integrated into IPA. Second, to overcome the drawbacks of statistic method and artificial neural network (ANN) in obtaining attribute importance implicitly, e.g. requiring sufficient and confident data, and overlooking the attribute original importance about attribute's contributing level to customer value realization, a set of adjustment models are proposed to revise the attributes original importance according to the Kano quality categories of attributes and the levels of attributes performance. Third, considering the mutual influence relationships among attributes, the proposed IPA takes these relationships into account by decision making trial and evaluation laboratory (DEMATEL). In addition, to deal with the uncertainty and vagueness in evaluation process, vague sets are employed in the revised IPA. A case study is carried out to demonstrate the effectiveness of the developed customer satisfaction evaluation approach.

1. Introduction

The emerging concept of product-service system (PSS) has the potential to drive sustainable production and consumption, and expand companies' competitive space and customers' satisfaction space. For the manufacturing industry, the traditional boundary between manufacturing and services is becoming increasing blurred (Mont, 2002). The new trend is products and services are integrated and provided as a whole set to fulfill customer's requirements, and the product/service ratio can vary in different customer using contexts. The driving force of PSS design is not traditional functional requirements for product design or service design, but a higher requirement level named customer value. Sakao, Shimomura, Sundin, and Comstock (2009) proposed that the target in service product engineering (SPE) was shifted from functions or quality to value, and developed a service model consisting four sub-models: "flow model", "scope model", "scenario model", and "view model".

Continuously satisfying customer value requirements is a critical strategy for PSS design. Therefore, analyzing customer satisfaction and identifying improvement opportunities are important tasks for PSS providers. Furthermore, the PSS engineering design methodologies are still immature, and it makes the continuous improvement in PSS design much more important. Importance–performance analysis (IPA) introduced by Martilla and James (1977) is a simple and effective technique for customer satisfaction evaluation, which can assist practitioners in identifying attributes improvement priorities and making quality-based marketing strategies to achieve advantages over competitors (Abalo, Varela, & Manzano, 2007; Hansen & Bush, 1999). Its main structure is dividing attributes into four groups depending on their performance and importance to customers.

Conventional IPA model has two impractical assumptions (Matzler, Bailom, Hinterhuber, Renzl, & Pichler, 2004): (1) the relationship between attribute performance and overall customer satisfaction is linear, (2) attribute importance and attribute performance are independent variables. For the first assumption, the most famous model to describe that the relationship between attribute performance and overall customer satisfaction is not always linear is the Kano's model proposed by Kano, Seraku, Takahashi, and Tsuji (1984). For the second assumption, the fact that the attribute performance and importance are related has also been suggested (Matzler et al., 2004; Ryan & Huyton, 2002). In

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order to overcome the erroneous assumptions in the traditional IPA model, many revised IPA models have been presented. Their main focuses are revising the method of eliciting attribute importance, because the customer self-stated attribute importance is insufficient for effective IPA analysis.

Two categories of approaches have been used to acquire the attribute importance implicitly: statistical approach and artificial neural network (ANN). Matzler and Sauerwein (2002) applied the multiple regression analysis to correlate the attribute performance with overall satisfaction, and used the regression coefficients as the attributes importance. Matzler, Sauerwein, and Heischmidt (2003) used the partial ranking method to derive partial correlation coefficients as attributes importance. These conventional statistic methods have some drawbacks, e.g. they assume that the attribute performance has a linear relationship with the overall satisfaction. Garver (2002) indicated that ANN can be employed to overcome the constraint of hypothetical problems of conventional statistic method. Deng, Chen, and Pei (2008) used the back-propagation neural network (BPNN) model to establish the function relationships between attributes performance and the integral satisfaction and derive the hidden importance value of each attribute. Deng (2007) integrated the three-factor theory and partial correlation analysis to amend the IPA model considering the nonlinear relationships between attributes performance and the overall satisfaction. These researches have not considered the mutual influence relationships among attributes in IPA, and these relationships have a significant effect on the rationality of analyzing outcome. Hu, Lee, and Yen (2009) integrated BPNN and decision making trial and evaluation laboratory (DEMATEL) to re-establish the IPA model, and DEMATEL was used to analyze the causal relationship among the quality characteristics. The DEMATEL method, originated from the Geneva Research Center of the Battelle Memorial Institute (Gabus & Fontela, 1972, 1973), is especially practical for analyzing influence relationships among elements in a system, and identifying causal group and effect group in the system through a causal diagram.

The revised IPA models based on statistic approaches or ANN have two weak points: (1) the application and success of them depend on sufficient and confidential historical data, (2) the attribute importance does not embody the basic importance of attribute to customer value. In the setting of this paper, historical data are deficient in the early phase in the PSS companies, thus the statistic approaches and intelligent approaches lack effectiveness in deriving attributes importance. Hu, Lee, and Yen (2009) and Hu, Lee, Yen, and Tsai (2009b) proposed a KD-IPA method to obtain attribute importance through modifying the original attribute importance based on Kano's model and DEMATEL. However, the unavoidable uncertainty and vagueness in the evaluation process is not considered in KD-IPA.

It is more rational for customers to adopt imprecise linguistic terms to express their judgments in IPA. Therefore, how to deal with linguistic information is critical to the effectiveness of evaluation. Fuzzy set theory is commonly used in dealing with linguistic terms. However, it supports the favoring evidences only, and just reveals the positive preference degree associated with decision maker's (DM's) subjective judgments. A single membership degree provides little information about its uncertainty. Consequently, fuzzy set theory has some shortcomings in dealing with vagueness information. Recent years, vague set theory proposed by Gau and Buehrer (1993) gains its popular in decision-making in many areas, e.g. idea-screening in new product development (Lo, Wang, & Chao, 2006), engineering schemes selection (Ye, 2007), and supplier selection (Boran, Gen, Kurt, & Akay, 2009; Zhang, Zhang, Lai, & Lu, 2009). Vague set theory supports both the favoring and opposing evidences in dealing with DMs' linguistic judgments by means of membership function and non-membership function. Therefore, it is superior to fuzzy set theory in capturing uncertainty and vagueness that exists in IPA analysis.

This paper proposes a new IPA approach based on vague sets for customer satisfaction evaluation. Kano' model and DEMATEL are employed in the new IPA to consider the nonlinear impact of PSS quality attributes and causal relationship among these attributes, respectively. The original attribute importance is acquired from customers to express the importance of this attribute contributing to customer value requirements. At the same time, the original attribute importance can reflect the attribute expectation level to some degree. The attribute original importance is modified twice. First, it is modified according to the Kano quality category the attribute belongs to and the level of the attribute performance. Three adjustment models for modifying attribute original importance are proposed aiming at three different Kano quality categories, and these models are based on the comparison and similarity calculations between attribute performance and attribute original importance. Second, it is modified by the difference level of the attribute impacting others and being impacted by others driving from DEMATEL. The remainder of the paper consists of the following sections. Section 2 gives out a description of the proposed problem and approach, and reviews the relative literature. Section 3 gives out a description of the first modification of attribute original importance based on Kano's model and vague sets. Fuzzy Kano analysis to determine the Kano quality category of attribute and the three adjustment models are presented. Section 4 presents the second modification of attribute importance based on DEMATEL with vague sets. In Section 5, the proposed approach is applied in a real world case of customer satisfaction evaluation supporting PSS design for a company providing pump products and services. Conclusions are then presented in Section 6.

2. Problem description and literature review

The researches on PSS design are immature and on the way of searching. Most of the early studies on PSS design were primarily conducted from the viewpoint of marketing and management, such as case study approach (Manzini and Vezzoli, 2003) and industry PSS initiatives research at the empirical level (Williams, 2007). Engineering methods and tools have been developed gradually to support the realization of PSSs, such as life-cycle engineering for technical PSS development (Aurich, Fuchs, & DeVries, 2004; Aurich et al., 2006), PSS representation approach based on IDEF0 (Morelli, 2006), and service engineering based on computer-aided design tool (Sakao & Shimomura, 2007; Sakao et al., 2009). Satisfying customer is the design objective pursued unceasing for PSS providers. Evaluating customer satisfaction to identify improvement opportunities of PSS design gets much more important in practice.

Extracting critical customer perception attributes of PSS is the fundamental step in evaluating customer satisfaction. Questionnaire survey is an effective way to collect objective information. The quality characteristics generated in the PSS conceptual design can be combined with the data in customer relationship management in offering fundamental information to design questionnaire for eliciting critical customer perception attributes. After acquiring customer perception PSS attributes, the rest task is identifying the management strategies of these attributes based on IPA.

IPA is a two-dimensional grid based on customer-perceived importance and performance of attribute analyzed. The x-axis and y-axis presents attribute performance and attribute importance, respectively. These two axes divide the IPA grid into four quadrants. The graphic representation provides an understandable guide for identifying the crucial product or service attributes in terms of their need for managerial action. IPA has been widely used in customer satisfaction analysis for improving service quality in many fields, e.g., tourism management (Enright & Newton, 2004;