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Demand-oriented multi-objective planning method for electronic product technology development

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ABSTRACT

In this study, a demand-oriented multi-objective planning method is proposed for electronic product technology development. The proposed method uses the analytical hierarchy process to analyze the relative importance of each customer demand. Subsequently, quality function deployment is used to analyze the relationships between customer demands and product technologies, as well as for evaluating the customer satisfaction level for each electronic product that is being implemented. By using a model to identify the life-cycle stage of the product technology, each electronic product technology is classified in order to determine how to obtain the technology. A multi-objective evaluation model of planning strategies is obtained for electronic product technology development to evaluate the performance of different planning strategies. A multi-objective genetic algorithm is utilized to help companies efficiently establish an optimal planning strategy for electronic product technology development with the maximum customer satisfaction level and minimum product development cost. Finally, a case study of a green smart phone development project is provided to demonstrate and verify the practical contributions of the proposed method.

1. Introduction

Listening to the voices of customers and understanding their real needs are the cornerstones of successful new product development. However, not all customer needs are equal. Thus, product development managers must constantly trade-off the level of customer satisfaction against the cost of developing or purchasing the technologies needed to meet their requirements. Therefore, companies must realize the relative importance of each customer need. The customer needs from the target market are related directly to product technology selection, so the uncertainty associated with electronic product technology development planning can be reduced by analyzing the relationships between customer needs and product technologies [1].

Formulating a planning strategy for electronic product technology development involves a series of complex analysis, evaluation, and decision-making activities. To devise these strategies, product development managers must evaluate customer needs,

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analyze the relationships between customer needs and electronic product technologies, estimate the customer satisfaction level for each electronic product technology, decide how to obtain electronic product technologies, and determine the optimal electronic product technology combination. To address these challenges, a demand-oriented multi-objective planning method for electronic product technology development is proposed in the present study. First, this method utilizes the analytical hierarchy process (AHP) method to evaluate the relative importance level of each customer need. Quality function deployment (QFD) is then employed to analyze the relationships between customer needs and electronic product technologies. In addition, QFD is used to measure the ability of each electronic product technology to satisfy customer needs.

Of course, if a company can successfully acquire the innovative product technologies that satisfy customer needs, the company can significantly boost its competitiveness, which may lead to higher profitability. Furthermore, product technologies can be acquired through either in-house development or patent licensing. This decision depends on the current life-cycle stage of the technology, and the tradeoff between cost and time that is required to acquire this product technology. In some cases, multiple product technologies may be available to satisfy the same specific customer need. Hence, different electronic product technology combinations can be used. To achieve an optimal planning strategy, companies must simultaneously consider the customer satisfaction level and the total development time and cost for a technology. Therefore, a multi-objective planning model must be established to help firms to evaluate the performance of a variety of planning strategies for use in electronic product technology development. In this study, we apply an efficacious multi-objective genetic algorithm (MOGA) to help electronic product development managers to determine the best planning strategy for electronic product technology development.

In summary, the objective of this study is to provide a demand-oriented multi-objective planning method for electronic product technology development. The advantages of this method can help companies to objectively identify real customer needs and to assess the potential of each electronic product technology for satisfying customer needs by using customer satisfaction based on QFD. A model for identifying the life-cycle stage of a product technology can be used to categorize each technology to support managers when deciding the most appropriate method for acquiring an electronic product technology (i.e., in-house development or patent licensing). Moreover, a multi-objective assessment model of planning strategies for electronic product technology development can be used to analyze the performance of various planning strategies. Using the MOGA can help product development managers to formulate the optimal planning strategy for electronic product technology development with the maximum customer satisfaction level and minimum technology development cost.

2. Literature review

Product technology development planning can have profound impacts on the competitiveness of new products and it is generally considered to be a multi-criteria decision problem. Some previous studies have used the AHP method to help product development managers with product technology development planning. Kengpol and O'Brien [2] used the AHP method as a decision support tool to select advanced technologies and facilitate rapid product development. Lee et al. [3] employed the fuzzy AHP model to rank hydrogen energy technologies to support technology development planning. Cho and Lee [4] employed the Delphi method to identify the main factors and to formulate a hierarchical framework during the evaluation of new product technologies. In addition, Cho and Lee [4] used the fuzzy AHP method to establish a model for selecting product technologies for machinery companies. Hadidi and Khater [5] noted that AHP is a common multi-criteria decision-making method, which is used to systematically visualize a decision-making problem by creating a hierarchical structure of evaluation criteria and for analyzing the relative importance of each criterion. Hence, the AHP method is used to evaluate the relative importance of each customer need in the present study. In contrast to the pairwise comparison method, Kalbar et al. [6] applied the technique for order preference by similarity to ideal solutions (TOPSIS) to rank wastewater treatment technologies. To address the uncertainties embedded in the selection problem, Oztaysi [7] improved TOPSIS and developed TOPSIS-Grey to rank content management systems. Vinodh et al. [8] integrated fuzzy AHP and TOPSIS to evaluate and select the best alternative among various plastic recycling methods. Data envelopment analysis (DEA) has also been applied to technology selection problems. For example, Amin and Emrouznejad [9] utilized a DEA model to select the most efficient advanced technology. To obtain more objective and reasonable weightings for evaluation criteria, Yu and Lee [10] combined AHP and DEA to select the optimal promising emerging technology. However, these methods can only screen out a single technology, whereas electronic product technology development planning must be performed from an entire product perspective to select all of the technologies required to develop a new product.

To consider overall product development, some previous studies have focused on customer needs to develop technology evaluation and selection methods. Zhai et al. [11] developed a rough set based QFD approach for identifying technical requirements to establish a customer needs-based technology development planning method. Lee et al. [12] used a technology roadmap and QFD to establish the interconnections between service devices and technologies to facilitate smart city development by supporting service-device technology development planning. By focusing only on product development, Liu [13] utilized fuzzy QFD to translate the customer requirements into a list of measurable engineering characteristics and they successfully established the relationships between both sets of parameters. Subsequently, a fuzzy multi-criteria decision-making model was established to select the best product design. Shao et al. [14] used AHP to evaluate the relative weights of stakeholder requirements. QFD was applied to determine the relationships between the energy efficiency measures and the requirements, after which potential energy efficiency measures were screened. Finally, the energy retrofit solutions could be obtained by multi-objective optimization. In summary, previous studies have combined AHP, QFD, and genetic algorithms to obtain greater effectiveness. Hence, in the present study, we use these analytical tools to produce a demand-oriented multi-objective planning method for electronic product technology development. Moreover, Dat et al. [15] noted that QFD is a popular and proven method for determining what