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A fuzzy-based decision-making method for evaluating product discontinuity at the product transition point

Jeongsu Oh [a], Jeongho Han [b], Jeongsam Yang [b,*]

[a] PDEM Development Group, Samsung SDS, Yoksam-dong, Kangnam-gu, Seoul 135-918, Republic of Korea
[b] Department of Industrial Engineering, Ajou University, San 5, Wonchun-dong, Yeongtong-gu, Suwon 443-749, Republic of Korea

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ABSTRACT

Companies have been striving to achieve product innovation and cost savings to keep up with a rapidly changing manufacturing environment, as well as to deliver new products just in time and earlier than their competitors. Their strategic goals include effective decision making with regard to product life cycles, predicting market demand, and timing new product launches through the optimization of demand and supply of products. However, most products that enter a decline stage experience a decline in sales, which in turn causes an increase in warehouse costs, and a decline in competitiveness, owing to a delay in the release of new products. In this paper, we propose a fuzzy-based decision-making method to effectively evaluate products to be discontinued at the product transition point after taking into account market uncertainties and characteristics of businesses in companies. Therefore, we conduct the matrix analysis and the Pareto analysis for quantitative evaluation of four stages of the product life cycle based on market demand information for target product groups, apply the results of this analysis to the fuzzy-based qualitative evaluation model, and subsequently infer the discontinuity priority for product models that are expected to be replaced by new products. Furthermore, we develop the PTP portfolio system to identify a list of product models to be discontinued, as well as to review their percentage of sales contribution with respect to the overall product sales of the company.

1. Introduction

Product complexity is consistently increasing, while product life cycle (PLC) is rapidly declining. This is especially true of high-tech products with short PLCs that are delivered to markets in order to secure high profits, an extended market share, and an enhanced brand value. High-tech products are designed to ensure that old products tend to become obsolete soon and are unable to compete in terms of function, design, and cost. Therefore, companies need to establish a product transition plan strategically to enhance sales and maintain control over the market continuously (Fig. 1). If there is a delay in determining a product's transition point, there is a danger of an overproduction of stock. This results in a decline in the cash flow of a business, which in turn causes a decline in its profits and brand image, owing to excessive discount-based sales. Consequently, the delivery of new products to the marketplace gets prolonged, further threatening their future in the marketplace.

In general, determining when an old product is replaced by a new product by analyzing the demand forecast of the old product, is accompanied by various uncertainties. It is very difficult for a decision-maker to predict how long he or she needs to retain old products in the market even if a new product has been released, or when he or she has to switch from an old product to a new one. Since most products that enter the decline stage undergo a decline in sales, an increase in warehouse management costs, and prolonged new product delivery, companies have been making concerted efforts to determine the product transition point. This is especially true of companies manufacturing high-tech products. Even though their pre-delivery into the market is a crucial factor in acquiring a competitive edge, it is difficult to arbitrarily adjust market variables surrounding uncertainty. For instance, if a product's percentage contribution to the overall product sales of a company is small, it needs to be discontinued. In addition, if a product remains in a warehouse for an extended period of time owing to low demand, it incurs higher inventory management expenses, which calls for immediate product transition. However, in some special cases, a company has to continue to produce a product upon request by business partners, although overall demand for that product is low in the market. This specific business

* Corresponding author. Tel.: +82 31 219 1879; fax: +82 31 219 1610.
E-mail address: jyang@ajou.ac.kr (J. Yang).

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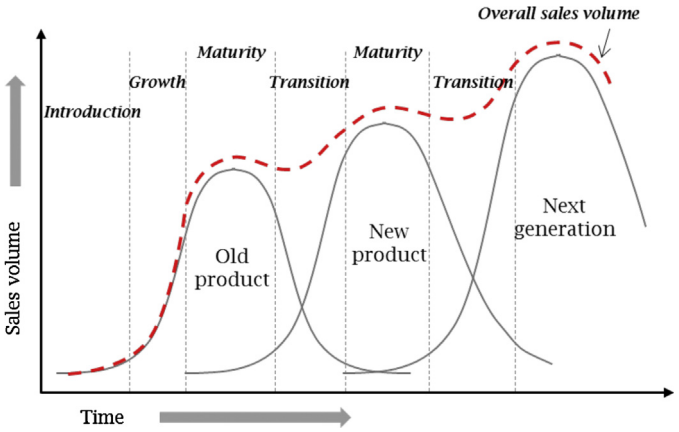

Fig. 1. Trend of the accumulated sales volume at a product transition point.

situation cannot be predicted by quantitative evaluation using sales and inventory information alone, but by using a combination of qualitative and quantitative evaluation methods.

In this paper, we propose a fuzzy-based decision-making method that evaluates product discontinuity by taking into consideration market uncertainties and characteristics of a company's business, and subsequently apply the results of the evaluation to the fuzzy logic model and the fuzzy inference procedure to effectively determine when a product needs to be discontinued. Hence, we carried out a quantitative evaluation of a product group by using three end-of-life (EOL) analysis methods: PLC analysis, Pareto analysis, and matrix analysis. We also suggested a fuzzy inference evaluation model based on current market demand and sales volumes, and subsequently inferred the discontinuity priority for products to be discontinued or replaced by new products. Not only can users access a list of discontinued products intuitively through the PTP portfolio system developed for this study, but they can also determine how much these products contribute towards the overall sales of a company. As a result, a decision maker is able to determine a product's transition point by considering a product mix in terms of a unified strategic portfolio.

2. Related works

2.1. Market and technology uncertainties

A company must optimize its portfolio management strategy for delivering new products to the market just in time by analyzing market trends such as past sales data, current customer demands, and PLC [1]. This strategy will determine when an old product needs to be replaced by a new product, besides analyzing risk factors, to overcome market and technology uncertainties. For the successful entry of new products into the market, Cooper [2] suggested that the strategic marketing integration of the old product and the new one during the decline stage of the old product was an important element of the product mix.

Simchi-Levi et al. [3] clarified that an incorrect estimate of market demand may lead to an increased risk of bad inventories due to excessive purchases of long-term delivery materials. Further, it is difficult to predict product discontinuity during the maturity stage of a product's life cycle due to market uncertainties. To resolve this problem, they suggested the integration of a company's supply chain and logistics information at the product planning phase itself. In addition, McGrath [4] studied the problems arising from the cannibalization effect, where old products are forced to compete with new ones due to an incorrect estimate of the product transition time. Cui et al. [5] suggested a system dynamics modeling method that formalizes the adjustments of launch scale according to actual market conditions and the dynamic interactions among launch scale and various tactical elements of product launch. While this method may be useful for directly developing inventory management strategies during market uncertainties, its applicability to evaluating product transition point and cost is limited. On the other hand, Chang and Park [6] studied how a pioneer product's brand strategy and transition into a successive generation product would affect consumer preferences for the latter at different levels of technological uncertainty.

Milliou and Petrakis [7] examined how product market competition affects the timing of adoption of new technology by firms, and whether there are sufficient market incentives for this adoption. It demonstrates that the timing of adoption differs not only among symmetric firms, but also among markets with varying features. They found that differences in market features, such as product substitutability or mode of competition, lead to significant differences among firms' technology adoption patterns. McNally et al. [8] attempted to reconcile conflicting notions regarding the relationship between speed to market and product quality, their joint impact on product profitability, and their mediation role in the effects of product development expenses and cross-functional integration on product profitability. In addition, they highlighted that identifying factors that contribute to a new product's success are of vital management concern because successful new products lead to a significant improvement in financial and market performance and may indicate undiscovered business opportunities.

2.2. Managing product discontinuity

Early market delivery of a new product does not always evoke a positive response from the market. In addition, if the product is a drug on the market, then product management costs may be incurred, resulting in declining profits. Therefore, if a delivered product is considered to be a drug on the market, it is better to discontinue it immediately. Wallace and Stahl [9] considered sales and operations planning (S&OP) as a five-step business process (executive meeting, pre-meeting, supply planning, demand planning, and data gathering) that enables companies to maintain their demand and supply balance. Macchi et al. [10] addressed innovation in enterprise operations by integrating people, processes, business systems, and information throughout the PLCs and across extended enterprises in terms of PLC. Marchetta et al. [11] extended the reference framework for PLC management to include a business process model, a product information model, and an architecture of applications based on modern technologies, particularly intelligent agents. This framework provides a suitable model for expanding the participation of a product throughout its lifecycle.

Using knowledge base models, Bufardi et al. [12] defined the various parameters necessary for evaluating discontinued products and determining when a product needs to be discontinued. Doria and Shpitalni [13] classified product information items primarily based on PLCs and suggested a knowledge based ontology model to manage PLCs, from product planning and design to EOL. Recently, Oh et al. [14] proposed a decision-making framework that uses a fuzzy expert system in portfolio management for dealing with the uncertainty of the fuzzy front-end of new product development. They also developed fuzzy inference-based portfolio evaluation models for items that are too ambiguous to be numerically evaluated.

3. EOL analysis for product discontinuity

3.1. Overview of EOL analysis

At the product transition point, it is important to determine the key parameters associated with product discontinuity, identify the