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Management and forecast of dynamic customer needs: An artificial immune and neural system approach

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ABSTRACT

The twenty-first century is marked by fast evolution of customer tastes and needs. Research has shown that customer requirements could vary in the temporal space between product conceptualization and market introduction. In such cases, the products generated might not fit the consumer needs as companies originally expected. This paper advocates the proactive management and forecast of the dynamic customer requirements in bid to lower the inherent risk in developing products for fast shifting markets. The research identified the principles of artificial immune and neural systems as a solution to the problem. A customer requirements analysis and forecast (CRAF) system is defined in this paper to address the issue. The system aims to support product development functions with quantitative and qualitative customer requirements information, in the pursuit of generating products for near future markets. A case study is presented in this article to illustrate the functions of the system.

1. Introduction

While uncertainties in businesses can be managed to produce competitive advantages, they are also threats if left unaccounted. In the twenty-first century, many new product development (NPD[1]) businesses face the uncertainties of highly turbulent market. Blocker and Flint [1] found that the changing needs and rapidly evolving preferences of customers represent the key drivers of market turbulence. It is therefore sound to assert that customers are the key source of information in the bid to reduce uncertainties inherent in NPD projects [2].

Meeting or exceeding customer requirements is the ultimate target of total quality management [3], and this class of market information is an important capital for capturing product markets in competitive environments. The management of customer requirement information is generally concerned with requirement elicitation, analysis and specification [4]. While the processes of requirement management in product development have been relatively well-investigated, there have been only few studies that considered the temporal dimension of the critical information. The status is similar in the industry. Studies have shown that companies in general have neglected this aspect in product development [5,6]. In volatile markets, for instance the cellular phone market, it is imprudent for one to comment on the validity of customer requirement data without making any reference to the frames of time. As the issue of dynamic customer requirements is increasingly valid due to such factors as consumer sophistication and competition, it is urgent and critical to recognise the issue in both practice and research.

2. The issue of dynamic customer requirements

Requirement is the basis of product development, and it can vary with time. The variation of customer satisfaction attribute weights along the temporal dimension was elucidated in a longitudinal study performed by Mittal et al. [7]. Calantone and Sawyer [8] demonstrated the instability of market segments, which manifested the changing of consumer needs over time. Prior to ramping up production, design specifications are by necessity frozen. In cases where customer requirements shift substantially during the period between design freeze and market introduction, the final products may not satisfy the customers as intended. Factors that affect the variation of requirements include the length of production period, market volatility and competition intensity. Product developers, if unwary of the variable, may end up generating products not wanted by the customers. In another scenario where organizations react to changing requirements by modifying design specifications, undesirable delays in schedules can be resulted. The situation was identified in a study by Kärkkäinen and Elfvengren [9] as self-reinforcing "vicious" cycles in product development processes.

2.1. The significances of dynamic customer requirements

There has been research that indicates the implications of shifting customer requirements on NPD successes. It was found in an

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[1] A list of acronyms is provided in the appendix (Table A).

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empirical analysis that a series of managerial problems could be resulted when the assessment of future customer needs has not been given adequate attention [9]. Design specifications based on customers' future needs can reduce design iterations and reworks, as indicated by Kärkkäinen et al. [5]. The selection of research and development (R&D) projects requires foresight and good grasp of the market dynamics. When future customer needs could not be clearly identified, the return of investment of R&D projects would be of higher uncertainty, which might in turn undermine the overall NPD efforts [6]. In a similar vein, it is important for marketers to understand the evolving markets. Revision of marketing strategies, such as product repositioning and advertising appeals revamping [8] may be called for as the responses to the shifting market needs. In the manufacturing context where customer requirements are in the state of permanent flux [10], production planning is an extremely difficult task [11]. As shown by various studies, the dynamism of customer requirements bears implications on product development successes, ramified through such functions as design, marketing, production and R&D. Research in the area of dynamic customer needs will therefore be of considerable significances to the multi-disciplinary aspects of NPD.

2.2. A review of the current solutions

Research of requirement management to date has preliminarily considered the temporal dimension of the information. Studies that have focused on or at least considered the time-based variation of customer requirements have offered two classes of solutions in general. The first approaches the problem by advocating sensitivity to the dynamic needs, while the second proposes methodologies that forecast future needs.

2.2.1. Sensitivity to the changing needs

As customer requirements are in many cases dynamic, researchers deemed that customer satisfaction should be measured and assessed regularly. Reichwald et al. [12] proposed a distributed mini-factory organization that can improve firms' sensitivity to requirement changes, essentially by the virtue of close proximity to customers. Apart from physically moving closer to the customers, Internet has been a common tool proposed for customer relationship management [13]. Modern technology makes it incredibly straightforward for companies to gather vast amount of data concerning individuals and their habits on daily basis [14,15]. Such data can be employed for pattern and trend tracking to gain competitive advantages. For instance, information on the usages of credit cards and supermarket loyalty cards is flowing in a continuous manner, and timely analysis would require a dynamic system [14]. Gunasekaran et al. [16] proposed a web-enabled quality function deployment (QFD) model that facilitates the continuous communication of customer needs information across geographical dispersed supply chain. A patent [17] describes the idea of having microprocessors embedded in products for bilateral communications between product developers and customers. The patent claims that changing customer requirements can be sensitively detected based on the method [18]. Wu and Shieh [19] proposed the application of Markov chain model on QFD to monitor the dynamism of customer requirements from probabilistic viewpoint. Similarly, a dynamic QFD (as opposed to the traditional static versions) was proposed to handle the constantly evolving customer needs [20]. The paradigm of agile manufacturing advocates continual assessments of customer requirements, as well as production flexibility that can response effectively to requirement changes [10].

2.2.2. Forecasting of changing customer needs

Reichwald et al. [12] commented that traditional market research methodologies focus only on current situation and often do not contribute to the correct assessment of future customer requirements. Flores [21] and Shen et al. [22] separately proposed methods that involve seeking consumers' opinions on their future requirements. While such approach is useful when historical data is unavailable for projections, the soundness of the results hinges on the sampled customers' abilities to forecast the population's future requirements.

With historical data, time-series methods can be employed for forecasting. Xie et al. [23] employed the double exponential smoothing technique in projecting the importance levels of the requirements. The method is limited to forecasting quantitative data, and only of linear trend. Wu et al. [24] proposed the use of grey theory in forecasting, which requires only four past data points. Raharjo et al. [25] developed a method that prioritises quality characteristics that have greater confidence in meeting future customer requirements, in the context of the dynamic QFD. The method per se does not generate future customer requirement information, but requires it as input. Chen and Yan [26] analysed customer preferences using radial basis function neural network. While the method does not specifically ascertain future customer needs, it predicts customer preferences over a range of product options. Ha [27] proposed using knowledge engineering technique to analyse and predict the shifting of customers across market segments.

2.3. Moving forward

In the studies of dynamic customer requirements, the intentions were in general to counter the uncertainties that the variable contributes to NPD. A study by Kärkkäinen and Elfvengren [9] recommended companies to develop better abilities to recognize customers' future needs. Having noted that most approaches proposed have been reactive, Blocker and Flint [1] specifically recommended future research to develop tools that forecast the direction and rate of change of market segments. Kahn et al. [28] similarly suggested forecasting (an under-researched area) as a means of addressing uncertainties in product development. In this light, this article defines an approach that forecasts customer needs.

Customer requirement information consists of both qualitative and quantitative aspects [23]. The former represents the types (or objects) of requirements, while the latter represents the degree of importance or preferences. The quantitative dimension has been the variable of interest focused in previous studies (e.g. Refs. [23,24]). Szakonyi [6] recommended that customer future needs should be identified in terms of new product characteristics (i.e. qualitative terms). As such, a solution that can handle both quantitative and qualitative variation will be valuable in addressing the issue.

It is known that new customer requirements emerge while current ones obsolete over time. A common limitation of the current methodologies reviewed above is the necessity of continuous human interventions to update newly emerged needs and to strike out out-dated requirements. For instance, in the case of the dynamic QFD proposed by Adiano and Roth [18], manual reviews of customer surveys are required in the process of updating the matrix. Therefore, a dynamic system that autonomously learns both the quantitative and qualitative aspects of the data will be desirable for the benefits of NPD organizations.

A review of literature of customer requirement management by Jiao and Chen [4] shows that the research of dynamic customer needs has not been addressed. Likewise in the industry, product developers generally paid little attention to identifying future customer needs [5]. Szakonyi [6] highlighted marketers' lack of analytical skills as a plausible impedance to ascertaining future needs. It is clear that the research necessary to produce relevant theories, methodologies and tools has been modest in both areas of marketing [1,7] and engineering [23,26].