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Dynamic decision making in mass customization

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ABSTRACT

Mass customization requires proper production strategy to balance uniqueness, fashion, and price. Out of its principle to meet consumers' demand quickly, it requires flexible and dynamic strategies to adapt to cases. This research provides a production selection strategy in dynamic environment. We employed a stated preference survey and logit model to give out product configuration strategy and the base for following analysis. Then we adopt a sensitivity analysis based on Monte Carlo to evaluate the performance of product configuration and find out the most beneficial production strategy on the base of a modified logit model. Furthermore, we provide analysis to find out the most stable strategy in a dynamic environment. We choose apparel industry as a case, and the result shows our model can efficiently address the key issues in different types of markets. Furthermore, it helps decide which aspect to enhance the complex market.

1. Introduction

Gradually, the pursuit of meeting customers' needs at lower cost has been increasingly growing, especially based on large-scale production techniques. Mass customization, providing products with uniqueness with appropriate price, caters to companies. Mass customization takes advantages of both Economies of scale and Economies of scope. It has been widely used in the manufacturing industry to meet individual customers' needs and achieve productivity and efficiency improvement. Under such a situation, MC's aim is to provide consumers with adequately diversified products and services while ensuring reasonable prices. Accordingly, making better production decisions and balancing consumers' needs and costs are the key issues in mass customization.

Techniques have been developed to help companies achieve that. The advances in manufacturing technologies, such as flexible manufacturing systems (FMS) (Brettel, Friederichsen, Keller, & Rosenberg, 2014; Stump & Badurdeen, 2012), computer-aided design/manufacturing (CAD/CAM) (Satam, Liu, & Lee, 2011), and just-in-time (JIT) (Zhong, Dai, Qu, Hu, & Huang, 2013), have changed the ways organizations produce and make order system qualified for mass customization. (Cavusoglu & Raghunathan, 2007).

While these techniques enable firms to provide dramatically various products, however, to control cost, firms are not able to provide all possible products. In reality, firms often customize according to a limited set of attributes along with customers' preferences (Cavusoglu & Raghunathan, 2007), so the production strategy is an important part of mass customization techniques. Furthermore, for a dynamic market like apparel, customers may turn to other products after only several months, over supply may increase cost strikingly. (MacCarthy, Brabazon, & Bramham, 2002).

Our research aims to provide an analysis of mass customization production strategies under dynamic circumstances, especially for the industry facing continuous changes. First, we provide a prediction of sale, profit, and ROI. On the basis, we maximize the ROI to choose the most profitable production strategy. Second, based on the production strategies, we analyze their profit change under different environment and show a way to find out the key factors facing the change. Meanwhile, a case study in the clothing market was conducted to compare the model with other decision-making methods, to reveal its performance on the ROI and its weaknesses.

Our paper contributes to the extant literature in several ways. First, we show a way to find out a proper production strategy that outperforms a previous way using an infrequent survey, based on the key factors, to build connection between customers and production strategy. Second, our research provides a way to analyze their performance under dynamic environment. Meanwhile, we also show the factors that production strategies can diversify.

2. Literature review

Mass customization allows companies to provide customers uniqueness and meet personalized demand with reasonable cost. Ideally, mass customization aims to produce customized products at a cost near mass production (Pine, 1993). It requires not only flexibility but also

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close connection between production and consumers' demand. Companies need a few techniques and several key factors (Pollard, Chuo, & Lee, 2016) to achieve success. In Future Shock, Toffler (1990) creatively envisaged in 1970 to meet customers' specific needs with the cost and time required for standardized production. Davis (1987) called this idea Mass Customization for the first time in Future Perfect. As global supply chain does not bring companies much cost advantages anymore, mass customization (MC) is applied gradually as a new mode of production (Daaboul, Da Cunha, Bernard, & Laroche, 2011).

Sophisticated order management technique is crucial to understand costumers' demand and enhance the connection between costumers and the products (Pollard et al., 2016). One of the key issues that mass customization faces is the strategy constancy under the fierce competition in the rapidly changing, or even turbulent market (Fogliatto, Da Silveira, & Borenstein, 2012). That requires the production strategy models account for market change while maximizing profit.

A production strategy includes two sides: the cost side and the revenue side. The cost side is usually an optimization problem. Algorithms balance all costs and figure out the key cost for further optimization. Tseng, Chang, and Chang (2005) adopted a tree algorithm to help configure product features and analyzing cost including material cost, machining expenses, and deduction cost. Heradio, Perez-Morago, Alférez, Fernandez-Amoros, and Alférez (2016) focused on detecting critical features to enable better product configuration, reduce lead-time, and shorten costs. As the features are essential and dispensable, the perception of feature reusability increases. Such researchers make a great effort in better feature selection methods or optimization algorithm.

On the revenue side, some researchers focus on attracting customers and pay attention to consumers' subjective feeling (Bardakci & Whitelock, 2003; Jo Anderson-Connell, Ulrich, & Brannon, 2002; Trentin, Perin, & Forza, 2014). Others conduct studies in process modeling, including modular design of production processes practice and feature decisions (Hong, Dobrzykowski, & Vonderembse, 2010; Liao, Deng, & Marsillac, 2013; Yao, 2013) which can both increase MC ability directly or indirectly.

Also, some researchers focus on the product configuration based on both sides (Cavusoglu & Raghunathan, 2007; Huang, Zhang, & Lo, 2007; Novshek & Thoman, 2006). Helms, Ahmadi, Jih, and Ettkin (2008) rely on customers to design products while Shao, Wang, Li, and Feng (2006) cluster consumers first according to their demand. Two-step methods are used by Zhang and Tseng (2007) and Kang and Hong (2009) to analyze configuration step by step. From a more systemic and adaptive view, Ng, Scharf, Pogrebna, and Maull (2015) identified business opportunities about products and consumers in complexity. In a flexible, standardized platform, they mined consumer demands from personal data and combined them with the product selection mechanism, which allows the maximization of consumers' value as well as profit.

Besides their research connecting consumers' demand and product design, it is crucial to work continuously in the rapidly changing market (Fogliatto et al., 2012). Based on our sensitivity analysis, we will give an approach to consider consumers' demand in product configuration while the market is dynamic.

This paper would go further in production plan selection based on user preference and its change. We will talk about a production plan selection method according to user demand. This method includes the customer order postponement decoupling point, consumers' change, and how to keep competitive in a highly dynamic market.

3. Design and methods

3.1. User preference

Analysis of user preference plays an important role in the study of personalized demand, which mainly refers to the preferences when consumers purchase. Inevitably, when enterprises provide goods or services, there will be some characteristics or laws underlying product factors, which affects users' purchasing decisions and willingness to pay. Meanwhile, those features also affect the costs. Therefore, the strategy is to maximize the return on investment. Particularly in the MC model, besides traditional cost factors, customization will also influence purchasing decisions and commodity costs. In other words, the non-traditional industrialized elements of customization should be taken into consideration.

By investigation, we denote the coefficient of Customer Requirements (CR) as W_j. In general, the model measuring the best ROI by customer demands and preferences is mainly composed of costs and sales, so we calculate the cost and obtain the optimal solution based on the correlation matrix. This model will use quantitative user preferences, cost and changes in sales volume to evaluate the impact of user preference on cost and revenue.

3.2. General model

3.2.1. Circumstance, assumption and definition

The participants we choose come from big cities in China. Aging from 20 to 30, well-educated, they begin to pursue fashion, uniqueness while also care about price. Comparably, the older generation, who should pay more attention to brand and quality in developed countries, usually live a more frugal life because of poverty in their childhood and youth. They care about prices more than quality and brand, especially brand. Additionally, as the education cost booming and the return on real estate rising, they are more likely to save money and spend less on clothing. The younger generation, chosen in this research, growing up with more attention to fashion and uniqueness, begin to pursue brand, quality, etc. With limited savings, they care about price, as well as brand, fashion, and uniqueness. Therefore, they are right the target of apparels customization.

There are already some business practices of mass customization in China's apparel industry. Traditional customization provides tailor-made choice, style choice, cloth choices, etc. some mass customization shops, including online and offline, have a few pre-made T-shirts or dresses, and customers can decide the figures, logos, and select stereotype, cloth from given options. Others would provide several options such as the lace style, the waist shape, on pre-designed dresses. In this research, we select several common factors and CODP used in mass customization based on these business models.

In this research, we assume the amount of demand per consumer is elastic, although the number of options in the survey is not elastic. Each participant was asked to choose an option when given a screen. The number of options chosen by a participant is fixed. However, it is not the demand. Some options chosen will be at a loss, so that is a virtual option that will never exist, and not contribute to the demand.

We use the probability to purchase each product to evaluate the demand. The revenue of each product is proportional to the probability to purchase, the demand. For example, if the probability to choose Product A priced $8 is 0.6 and for Product B priced $10 is 0.4, the price∗demand ratio of these two would be 4.8/4.0.

Based on this assumption, we regard the revenue of sales (price∗demand) is proportional to the probability of purchasing. That is to say; we get revenue from each product's purchasing probability and its price. At the same time, the total cost of each product is influenced by the revenue of sales, so the amount of sales is also proportional to the probability of purchasing. What's more, the time value is not considered in this model, so we simply note investment same with cost.

$$revenue = probability{*}price{*}population\,(\text{fixed} \tag{1}$$

$$ROI = \frac{profit}{investment} = \frac{revenue-cost}{cost} = p{*}\frac{price}{cost}-1 \tag{2}$$

Using these two formulas, we get the revenue and cost of each