ADJUSTING PRODUCT VARIETY OFFERING TO CUSTOMER DECISION MAKING PROCESS

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ABSTRACT

The creation of market simulation models is increasingly widespread as it enables better enterprise planning and optimization of product delivery. In case of mass customization approach, which aims to simultaneously target scores of individual customers, understanding customer behavior under growing market stratification conditions is critical. This paper describes development of a market simulator in which individual customers are represented as software agents, behavior of which is based on a set of predefined rules. Parameters in those rules can be either fixed or randomly follow some probabilistic distributions. Customers/agents operate in a market which offers them a line of products. These products have a set of customizable features, presumably addressing the needs of customer population. The paper describes in detail the decision process of an agent, market fragmentation design, and presents some sample results which can be used to determine desired variation offering of a product.

KEYWORDS

Product variety, decision making, customer satisfaction.

1. INTRODUCTION

How many variations of a product or service should a firm offer? This is a fundamental issue for producers defining portfolio of their products aimed at any particular market. General market trend over the past 20-30 years indicates a growing number of offerings available to the customers (Cox, 1998). From an individual firm's perspective competing in a saturated market requires differentiation, and that directly leads to increased variety in the market offerings. Simplistically, more available variety satisfies more customers.

There are, however, costs associated with introducing more variety, such as, for example: manufacturing costs, handling costs, and the costs of space in the store that sells the product. The economic decision about the optimal number of product variations offered should be determined as a tradeoff between these costs and the customer satisfaction. While increased product variety may lead to increased sales, too many product variations will drive up firm's expenses due to increased complexities of: (1) inventory control and handling, (2) manufacturing processes, and (3) after-sale product support. In general, the number of products N in a family can be roughly determined by the following simplified formula (Koren, 2005), from

$$N = V^C \qquad (1)$$

where C is product complexity (expressed by the available number of product features), and V is a number of product features that create the variations (it exponentially increases the total number of available products). It can be shown that if the total market size has an upper boundary, and the cost increases linearly with the number of product variations, then a point in which profits reach maximum can be calculated (see Figure 1). Past that point, even though revenues can grow further, additional costs associated with handling the variation exceeds the sale derivative, and therefore it is not economical to offer larger variety. This reflects the effects of the Law of Diminishing Returns.

A similar, economic-based argument can be made to justify the introduction of multiple new models of a product family to address niche market needs. It verifies the variety-based feedback loop in the mass customization case (Koren, 2005).

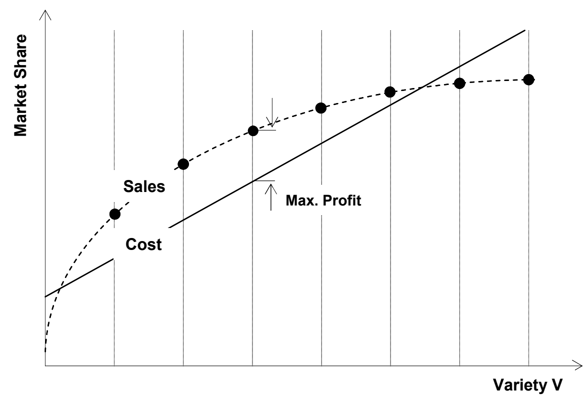

Figure 1. Market share as a function of number of product variations.

While economic arguments can precisely determine amount of product(s) variety that need to be offered to the market by an enterprise, given that the information about the market behavior is fairly accurate. However, recent research on individual decision making (Iyengar, 2005; Schwartz, 2004) indicates that decision-making behavior of individuals under conditions where choice is abundant is sometimes surprisingly counterintuitive. More choices, instead of better fulfilling customer needs, and hence increasing their satisfaction, lead to unanticipated effects, such as choice of no selecetions at all! It seems that the effort of making a choice decision not only carries its own costs (e.g., collection and analysis of necessary information necessary to make an informed decision), but also is influenced by various psychological effects which depend on the emotional profile of the individual (e.g., maximizers vs. satisficers). Thus from the psychological decision making point of view, there also exist an "optimal" amount of variety that a customer can emotionally and computationally handle (see. Fig. 2) (Schwartz, 2004).

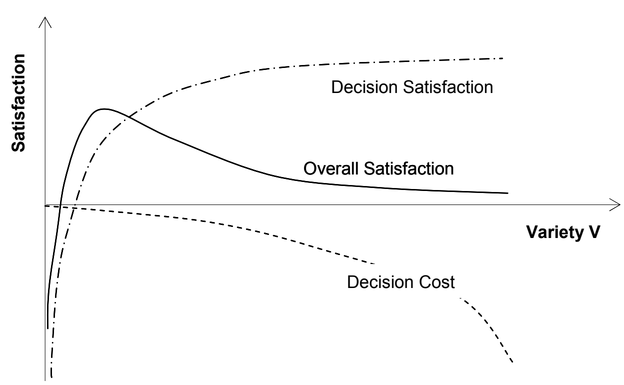

Figure 2. Individual choice satisfaction

In this paper we attempt to quantify how the combined effects of individual decision making under abundant choice conditions impact the model defining optimal variety on the firm's level in an effort to integrate the information flow between product design and marketing. We argue that these phenomena on an individual consumer level accelerate the effects due to the Law of Diminishing Returns mentioned earlier, and quantify their impact.

2. RELATED WORK

Individual consumer choice processes and their models are a source of continued interest, in particular in the areas of marketing and product line (portfolio) development. Most of the existing models are based on the choice axiom (Luce, 1959), which in principle is a multinomial logit model, a special case of a random utility model.

A growing interest over the past decade in the mass customization approach (Pine, 1999; Tseng, 2003) underscores the importance of the individual consumer choices, in terms of both their structure and parameters. However, the industrial mantra of "more is (choice) better," derived from the times when the mass production paradigm reigned, does not seem to hold true anymore as many recent studies of consumer psychology indicate (Iyengar, 2005; Schwartz, 2004). The drive for availability of more choices is tempered by increasing complexity of potential choice decisions, connected unavoidable compromises, and psychological side effects. All of these cause the consumers to either delay (sometimes indefinitely) their decisions, or limit themselves to conservative selections.

Since market surveys and comprehensive studies are usually expensive to conduct (not to mention that may also be unable to deliver answers to the burning questions), a natural solution is to turn towards modeling and simulation of consumer behavior. While early modeling approaches relied on presenting aggregate consumer behaviors, recent developments in software have significantly accelerated transition to modeling individual consumers using agent-based concepts. The commercial market offers now a wide range of software tools enabling development such models (Arena, AnyLogic, Simulink, etc.).

3. MODELING APPROACH

Our model is based on an imaginary market which operates under the conditions of a single manufacturer monopoly. The market population can be divided into a multitude of specific subsegments (niches), ranging from one (uniform market) to as many as there are individual customers. Therefore, on one hand, there are a number of customers in the market under consideration, who may look for product(s) satisfying their needs, on the other – there is a producer who offers a line of products aiming to satisfy these needs.

Customer Behavior Model

The decision process of each agent follows the state chart in Figure 4. After activation each agent enters the *Freeze* (idle) state, and remains there until it is told to proceed (a Boolean value of *Freeze* is then set to FALSE). The agent then moves to the first branch (circle marked B1), and subsequently decides which product to purchase, if any. Next it follows to the second branch, where, if it has purchased a product it goes to the *Owned Product* state and if it hasn't it travels to the *No Product* state. If no product is purchased, the agent will run through this process again to see if any new products have become available. If a product is purchased, the agent will use the product until it expires (determined in the user interface), then it will repeat the steps of looking for a new product to buy. It continues until the Boolean value of Freeze is set back to TRUE and all activity stops.

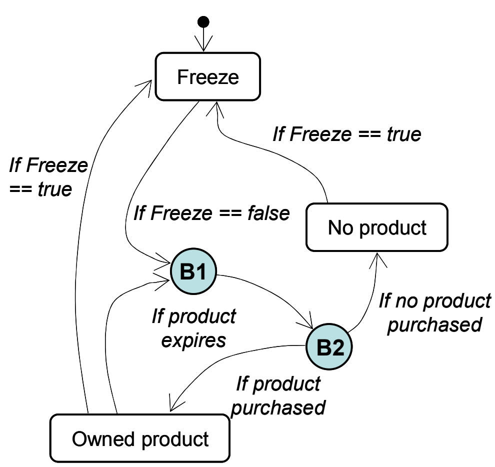

Figure 3. Decision flow in an agent

The model was set up this way primarily to enable potential interruptions in the middle of an experimental run (e.g., for adjustment of parameters). Without this enhancement the structure of the model is fairly simple: if an agent doesn't own a product, it repeatedly tries to buy the one that best matches its criteria; if no match is found, the agent tries over and over again. If a product owned by an agent expires (either wears out of reaches the end of its useful life), the agent initiates an attempt to buy another product as a replacement.

User Interface

The model was designed to mimic the market of almost any simple product. In such a market several groups of consumers and up to 10 products can be created and their characterirtics defined. The primary limitation here is the amount of real estate on the user interface, but nominally the number of products can be infinite. The consumers/agents, given their predefined parameters, will choose a product that best fits their needs.

The three edit boxes in the upper left hand corner of the animation control the largest aspects of the model. The *Groups of People* box determines how many different groups or types of people will be in your model. This is used for populations with non-uniform distributions to people, such as, for example, a population consisting of two groups: a group of very tall people and a group of very short people.

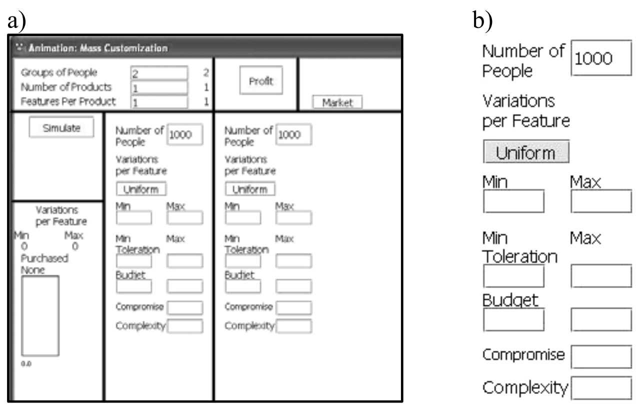

Figure 4. Simulator interface: setup for consumer groups

A screenshot of the interface with added black lines around each section is shown in Figure 4a. Figure 4b shows setup details for just one group of consumers. Each group can independently have any number of agents, a uniform or normal distribution over their preferred feature values (such as width, weight, length, color, etc). The values that affect their decision making can also be independently changed for each group.

The tolerance parameter controls an individual consumer's willingness to buy products that are close to, but not exactly what they want. This is used to distinguish between consumers that would only be willing to buy an item that was exactly what they want or someone who will buy only the best-suiting item from available selection, even if it's far from what they really want. The budget determines the maximum amount that an agent will consider to spend. The compromise value determines how much consumers value a cheaper item with worse fit over a more expensive item that is closer to or matching their original preference. The complexity value is used to determine how much consumers can not make up their minds when more options are available to them.

Up to 10 different products with 7 different features each can be set up in the simulation. Each product has its own cost, durability (life-span) range, and functional features. The durability range can follow either uniform or normal distribution. The durability determines how long each item will last from the moment of purchase. The durability is ser as an integer value representing any value of time and is expressed in relative terms (to other products); see Figure 5.

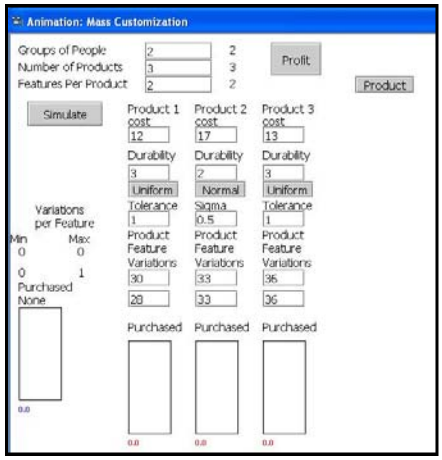

Fig. 5 Simulator interface: setup for products.

Fig. 6 Simulator interface during a run.

After the setup and parameter data entry, a simulation run can be started. Resulting data are collected at every timestep. The simulation run can be suspended at any time. During the pauses, new products can be added or old products can be modified. This gives the user flexibility to explore a broad range of possible products and the agent's reactions. Figure 6 shows what a simulator interface looks during the run.

The agent decision process

The driving force behind the simulation is the decision-making-process of the agents. Each agent first narrows down which products it will consider by looking at the available budget. If the agent's budget is greater (or equal) than the price of the product, then the product is taken into consideration. A special case can also be setup with zero budget – price considerations are then excluded from the decision process. All considered products are compared using the agent's tolerance and perceived choice decision complexity. A product is considered (for purchase) using the following equation:

$$\prod_k (1 - | P_k - P_{dk} | / R_C) \geq 1 - T\, C^n \qquad (2)$$

where k is equal to the number of features a particular product may have, P_k is value of the considered product k, P_{dk} is value of the desired product k, R is the range of product values, T is customer's tolerance for product deviation from desired, C is a measure of decision complexity for the consumer (value between 0 and 1), and n is a number of products.

This particular form of the decision function was used for several reasons. First, it allows the tolerance to have a value between 0 and 1, which gives the functional independence from product values. It also considers all the features of a product together. If a product has many features that are slightly different than desired by an agent, it may be just as desirable to the agent as a product that has one feature moderately or significantly different than desired product. The complexity factor reflects consumers expectation to find something closer to what they want if more options are available. It should typically have a value close to 1, so that when raised to a significant power it would not have an extremely significant effect.

It is worth noting that increase in the number of products also increases the complexity of agent's decision making, which in turn reduces number of products bought in a market. This can be clearly seen in Figure 7 showing these effects for a market with two products and varying levels of consumer–perceived complexity.

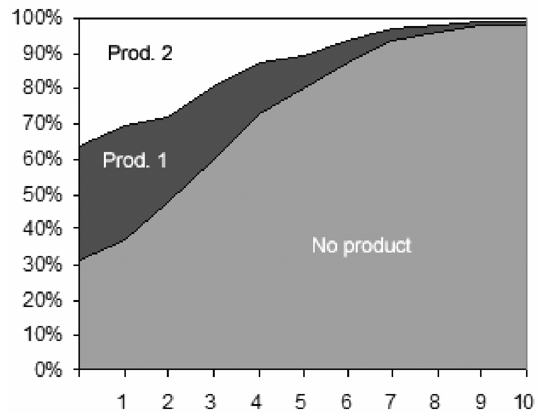

Fig. 7 Impact of consumer's decision making complexity on product market share

4. AN ILLUSTRATIVE EXAMPLE

An application of the developed approach might be considering a market for consumer product, e.g, pants. Each product is characterized by two distinct features (length and waist size). Let's assume that the consumers in such a market can be classified into two distinguishable groups, each with its own set of preferences, and that three different products are available on the market. The summary of the market and product characteristics is given in Tables 1 and 2. See Figures 8 and 9 for an example of how a setup for such a scenario would look like.

Table 1: Summary of the Market Segment Characteristics

Parameter	**Group I**	**Group II**
Size	1000	1000
Length Preference	Uniform 28-36	33
Waist Size Preference	Uniform 30-36	33
Tolerance	0.25-0.75	0
Max. Budget	Uniform $10-19	Uniform $15-25
Compromise Ability	1	1.5
Complexity	0.3	1

Table 2: Summary of the Product Characteristics

Parameter	Product I	Product II	Product III
Cost	$12	$17	$13
Durability	Uniform 2-4	Normal $\mu = 2$, $\sigma = 0.5$	Uniform 2-4
Length	30	33	36
Waist Size	28	33	36

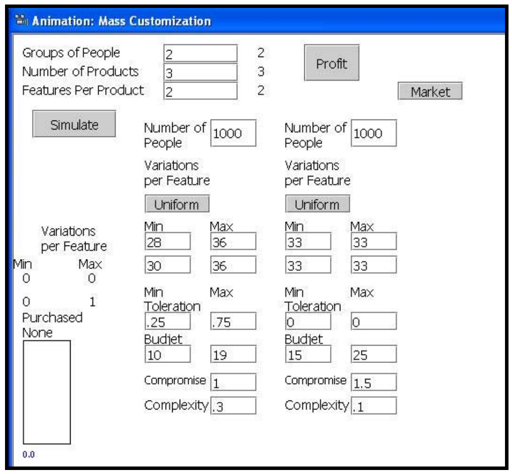

Fig. 8 Market segments setup for the example.

Figure 9. Product parameter setup for the example and simulation results

5. EXPLORATION OF THE CONSUMER BEHAVIOR

The simulator offer and opportunity to explore potential market behavior over a wide range of conditions, reflecting both the variety of consumer behaviors and their response to variety of product supply in the market. Obviously, there are coupling effects present between the two and such a simulation tool can help understand potential implications.

The impact of the customer tolerance of the mismatch between the product that is desired and the product that is actually available can be readily explained using Figure 10. Tolerance is expressed as a fraction of the available product feature range (e.g., $T = 0.1$ means deviation of $\pm 10\%$ of the product range is acceptable to an individual). The tolerance parameter is given in terms of lower and upper limits. Within the lower limit bounds (e.g., $\pm$lower limit) it is assumed that all consumers would buy the not-quite-fitting product. Within the remaining range (to upper limit) is assumed that only 50% of consumers would make a buying decision.

Similarly, the impact of the complexity parameter can be explored. One example of its impact is shown in Fig. 7. This result implies that even though more choices are available to consumers, the effort of making an informed decision is greater (e.g., it is harder to decide) and many may be expected to make no decision at all, thus reducing the number of potential sales.

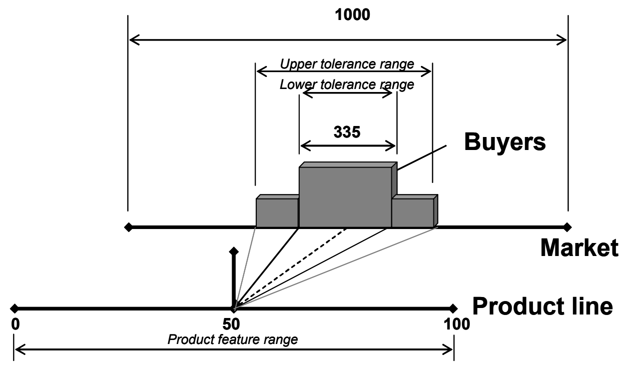

Figure 10. Impact of customer tolerance to desired product mismatch on the number of buyers

6. SUMMARY AND FUTURE WORK

The paper describes a market simulation model intended as an aid in exploring the issues related to consumer decision making under the mass-customization conditions. These conditions are primarily characterized by increased pressure on the customer decision making by abundance of potential choices. A significant negative coupling effect can be observed, which reduced impact of the available product option on the potential market share of the manufacturers.

Implementation of the market model for mass-customization promises better understanding of the coupling effects between product line offered on the market, types of consumers, and their decision preferences. The next step in the process is to explore the impact these factors have on the economic performance of the enterprise. In particular, how careful design of the product line can influence optimization of profits and how enterprises can develop strategies of product introductions into the market under such conditions.

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