

A STUDY ON THE EFFECTS OF CONSUMER PREFERENCE ON PROFITABILITY IN A MASS CUSTOMIZATION SUPPLY CHAIN MODEL

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In a bid to improve their competitiveness, there is a rapid growth in the number of firms adopting the “customer-is-king” philosophy by embedding mass-customization into their goods and services delivery network. The adaptation of essentially generic products to suit customer needs results in goods passing through the same production line having varying prices depending on the specificity of the products. In this paper, we discuss a model for studying the effects of consumer behaviour as indicated by their preference indices on the available products and variation in their purchasing power, on the profitability of a firm. This market-based framework gives a monetary-based insight into some issues like innovation, competitive advantage window, customer disposition to premium prices, etc, which planners consider during mass-customization of products. Results from simulations based on Market-Oriented Programming are presented.

Keywords: Market-Oriented Programming (MOP), Mass-customization, Supply Chain, Multi-Agent Simulation, Profitability

1 Introduction

In time past, the concept of innovation for most firms basically revolved around product improvement but recently, diversity in the needs of customers have forced OEMs to explore the arena of innovation for customer satisfaction. Hence, it has become expedient for production engineers to coordinate their activities with product marketers who are closer to customers in the production supply chain. Already, manufacturing industries are with the dilemma of allocating resources optimally in their supply chain for maximum competitiveness. Now, they are confronted with satisfying the diversities in the needs of customers.

Mass-customization techniques have been developed by firms to cope with the peculiarities of customer wants. A production supply network meant for the production of a particular product now have to be adapted for the manufacture of the same good coming in a legion of varieties. Postponement strategies in a supply network¹⁾ have proven to be of immense benefit in mass-customization of products. However, there is still need to be able to measure the effects of customized product distribution on optimal resource allocation in a supply network.

We present a resource allocation model based on competitive market mechanism^{2, 3, 4)} to investigate the effects of distribution of demands for customized products on a firm's profitability. We also take a look at how the strength of investments in an economy affects profitability under mass-customization. Simulations have been run based on Market-Oriented Programming (MOP) and the results are herein presented.

Next, we discuss the research methodology after which we show the procedures for running our simulations as well as the simulation parameters used. In the fourth section, we present some results from the simulation and briefly discuss the implications of these results.

2 Research Methodology

First, we briefly introduce the basic theory underlining a competitive market structure. Our model is based on previous works on resource allocation in a walrasian market^{2, 5)}.

We group the various units in our supply network into either the consumer trader class or the supplier trader class. The trading agents are defined as price-taking agents with unbounded rationality. The market mechanism computes the equilibrium price vector of commodities in the market after every bidding process and posts the result on a tote board.

2.1 Agent Formulation

We use the Cobb-Douglas function with constant returns to scale for the utility and technology functions for our consumer and supplier agents respectively.

(i) Consumer Agents:

Given a set of n consumers and m suppliers in an economy with k goods, in order to bid for goods, the consumer solves the constrained optimization problem:

$$\max U^c = R_c \prod_{i=1}^k g_i^{\alpha_i^c} \quad (1)$$

$$\sum_{i=1}^k \alpha_i^c = 1 \quad (1 \leq c \leq n) \quad (2)$$

R_c = returns to scale of consumer c , α_i^c = consumer c 's

preference index for good i , p_i = price of good i , e_i^c =

consumer c 's endowment of good i , and g_i^c = bid of

consumer c for good i .

Subject to a budget constraint given as:

$$\sum_i p_i g_i^c \leq B^c \quad (3)$$

$$p_i \in P > 0 \quad \forall 1 \leq i \leq k \quad (4)$$

Solving the constraint optimization problem the bidding function for a consumer agent is:

$$g_i^c(p_i) = \frac{\alpha_i^c * B^c}{p_i} \quad (5)$$

(ii) Supplier Agents:

A supplier agent also bids for goods in the economy by solving its constraint optimization problem.

$$\max \pi^s(P) = p_s g_s - \sum_{\substack{i=1 \\ i \neq s}}^k p_i g_i^s \quad (6)$$

$$\text{Subject to } g_s(P) = R_s \prod_{\substack{i=1 \\ i \neq s}}^k g_i^{\beta_i^s} \quad (7)$$

$$\sum_{i=1}^k \beta_i^s = 1 \quad (8)$$

Using same method as for the consumer agent problem, we derive the bidding function for a supplier agent as:

$$g_i^s(p_i) = \left(\frac{p_i}{R_s \beta_i^s p_s} \right)^{\frac{1}{\beta_i^s - 1}} \quad (9)$$

Where β_i^s = technology index of good i for agent s

3 Simulation

Our experimental supply network is made up of three layers as shown in figure 2. The first layer is made up of four supplier's supplier, the second layer is made up of three suppliers and the last layer is made up of five consumers. We dissolve the supply network into a walrasian market as explained in [3].

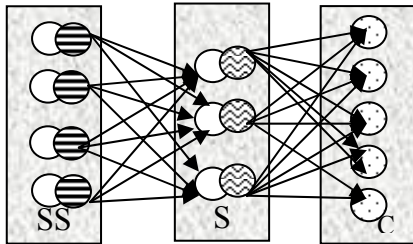


Figure 2: Hypothetical Supply Network

After dissolution of the above network into a walrasian market, we would have seven intermediate goods in the market and two primary factors bringing the total number of resources to nine. There are also five pure consumers, seven neo-consumers and seven suppliers in the same market. We take the outputs of the S layer as the final products in the market. These final products use the same production resources. We represent the mass-customization of these final goods

in terms of the technology used to produce them. Table 1 shows the technology used in producing these final goods.

Outputs Inputs	Technology					
	Supplier 5		Supplier 6		Supplier 7	
	Scale	Index	Scale	Index	Scale	Index
Goods 1(ss1)	5	0.2	5	0.1	9	0.1
Goods 2(ss2)	10	0.3	10	0.26	4	0.1
Goods 3(ss3)	15	0.1	17	0.15	13	0.15
Goods 4(ss4)	10	0.1	15	0.34	7	0.3
Capital	37	0.2	63	0.1	49	0.12
Labour	49	0.1	51	0.05	47	0.23

Table 1: Production Technology for Final Goods

We first ran a resource allocation simulation with an initial endowment to the consumers in the market, then we went ahead to vary the preference of consumers for each of the customized products in the market. We also ran a simulation, varying the endowments of consumers in the market.

Our simulation is based on the Market-Oriented Programming paradigm⁶⁾ which we have confirmed to be more efficient than some other existing algorithm like the scarf algorithm⁷⁾ and the tatonnement algorithm^{6, 7)}.

4 Results and Discussion

4.1 Results

We show results of simulations in figures 3 – 7. Figure 3 shows a plot of price fluctuation as bidding goes on in the supply network. The algorithm is guaranteed to find a market clearing price vector as long as all the axioms of pure competition hold in the market. This is depicted by the level plot for all goods in the market which starts from bidding iteration 10.

Figures 4 and 5 show how prices of final goods in the market and profits generated from turnover of these goods vary with the preference indices of the consumers while figures 6 and 7 show a plot of variation of prices of goods and profits made on them, with changes in endowments of consumers in the economy.

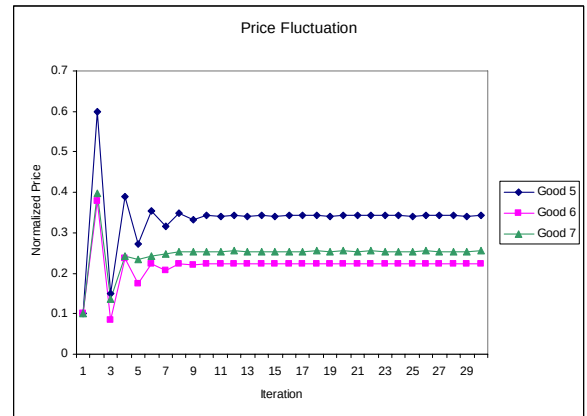


Figure 3: Initial Price Variation for Final Goods

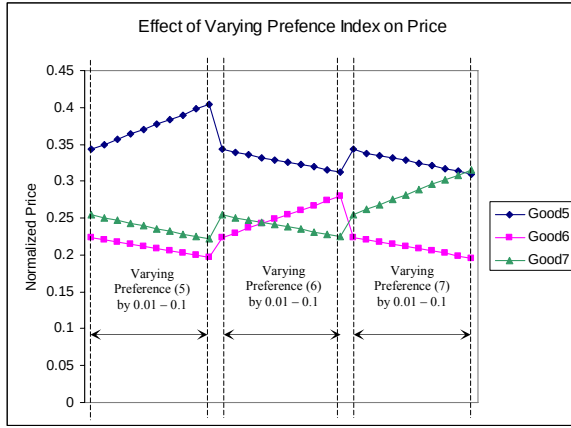


Figure 4: Prices of Final Goods with Varying Preference Indices

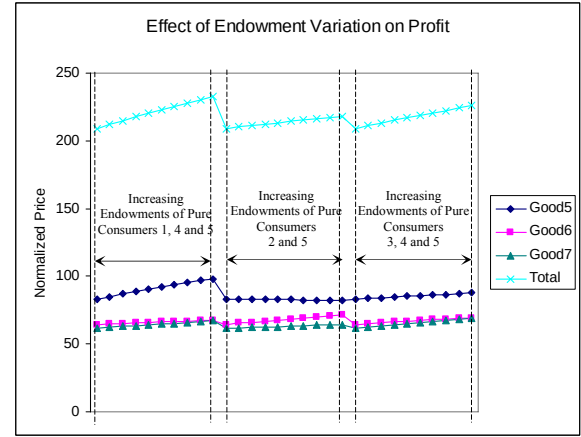


Figure 7: Profits of Final Goods with Varying Endowments

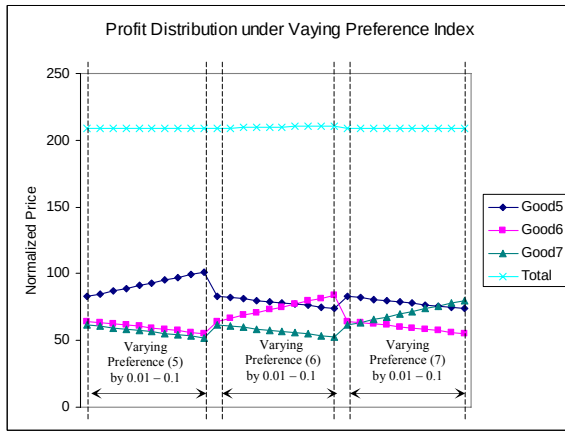


Figure 5: Profits of Final Goods with Varying Preference Indices

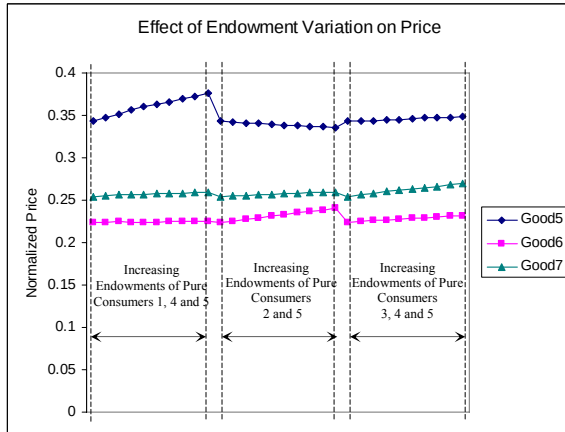


Figure 6: Prices of Final Goods with Varying Endowments

We briefly explain the implications of these graphs in the next section and how the results can be interpreted in the mass-customization domain.

4.2 Discussion

From the results shown in figures 3 – 7, we see that preference redistribution will not have any effect on the overall profit made by a firm if there is no increase in the endowments of the consumers of the product. We also see that customized product five has the highest tendency to improve profits in there is an increase in the endowments of consumers. This is due to the initial preference distribution for the pure consumers which reveals that consumers are more favourably disposed to customized product 6. Another deduction from the results is that even though the price of a product under mass-customization may be high, other external factors may tilt demand in its favour as it is in the case of our hypothetical final products.

5 Conclusion

The main goal of our research is to develop a decision support model which will aid planners working in mass-customization environments to judiciously allocate resources after due consideration of how market situations affect the profit generation drive of a firm. The model enables them to have an insight into the rate of change of customized products profitability in changing market situations.

We have been able to show how consumer preferences and endowments affect price and profit distribution in a mass-customization supply network. It is possible to have a more complex network with more production decision variables incorporated in this framework. Variables in the utility function and the technology functions can be estimated by both marketers and production engineers respectively, thus the need for collaboration between the two groups in a mass-customization environment. It should be noted however, that the model is based on fundamental axioms of computable general equilibrium some of which may overlook resource interdependency conditions which may affect the demand and supply of resources by agents in the economy.

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