ACHIEVING SUPPLIER'S MASS CUSTOMIZATION THROUGH MODULARITY: THE ANTECEDENTS AND THE HEAVY DUTY OF INFORMATION SHARING

Kun Liao, Central Washington University, 20000 68th Ave W, Lynnwood WA 98036,
liaok@cwu.edu, (425) 640-1574 x 3891
Xiaodong Deng, Oakland University, Department of Decision and Information Sciences, School of Business Administration, Oakland University, Rochester, MI 48309-4493,
deng@oakland.edu, (248) 370-4089
Ying Liao, Meredith College, 3800 Hillsborough Street, Raleigh, NC 27607-5298,
liaoying@meredith.edu, (919) 760-8510

ABSTRACT

Mass customization (MC) is the ability of satisfying the diverging needs of customers while maintaining low cost for products. This study applies three-dimensional (3D) concurrent engineering and resource dependency theories to develop a model for achieving MC capabilities through supply chain practices. Mass customization can be achieved by a mechanism including postponement orientation, operational alignment, coordinating information and material flows, and implementing modularity within a supply chain. The data examined in this study were collected from major automotive manufacturer suppliers in China and US. Structural Equation Modeling (SEM) is used to analyze these data. According to the result of the model for suppliers to achieve mass customization, postponement orientation and operational alignment are vital antecedents, and information sharing with the manufacturer takes a heavy duty in coordinating suppliers' modularity practices.

Keywords: Mass customization; Information sharing; Operational alignment; Modularity; Postponement; Automotive

1. INTRODUCTION

Mass customization targets customer values and has become a major business trend because of its responsiveness and cost effectiveness (Pine, 1993; Tu et al., 2004). It is commonly agreed among researchers that mass customization can be achieved through practices that are related to modularity (Pine, 1993; Tu et al., 2004) and postponement (Feizinger and Lee, 1997; Van Hoek et al., 1999; Li et al., 2006). Some studies have examined the implementation of mass customization strategies by combining modularity and postponement (Ernst and Kamrad, 2000; Brun and Zorzini, 2009). However, the models assume a parallel way of postponement and modularity. This study proposes a sequential way of implementing postponement and modality from a strategic perspective, which is establishing a postponement orientation first and then use modularity practices to develop MC capabilities. In addition, operational alignment and information sharing are critical to coordinating material and information flows to increase a firm's MC capability. This study identifies an MC assessment model built on 3D concurrent engineering and resource dependency theory. Testing this model through a large-scale empirical study contributes value to operations literature in that assesses the model's solid theoretical foundations with empirical evidence.

2. THEORETICAL FRAMEWORK AND HYPOTHESES

By definition, modularity allows for the support of many varieties of products while maintaining a low cost of manufacturing for each module. Modularity allows companies to communicate available permutations of products with customers easily and to fulfill orders quickly. In satisfying demanding customers, MC utilizes modularity product design, modularity process design, and supplier segmentation. Modularity product design provides more product varieties for customers. Modularity process design largely increases the flexibility of the manufacturing system. Supplier segmentation is an application of modularity in supply base management. Postponement is a strategy designed to delay the final customization of a product to as close to customers as possible until an actual order is placed. Postponement allows the entire supply chain to lower total inventories and to maintain few or even no final product inventories.

The three supply chain practices of product modularity design, process modularity design, and supplier segmentation should be guided by an interaction mechanism that involves both buyers and suppliers in proactive participation since buyer and suppliers are separate parties in the same alliance. Our model develops and identifies this mechanism based on resource dependency theory. Resource dependency theory focuses on the long-term views of members in an alliance to emphasize the importance of cooperation in an alliance. In a supply chain context, when manufacturers and suppliers communicate with one another and make joint or related decisions, both can remove part of their environmental uncertainties and receive higher benefits (Powell, 1990). Therefore, the members in a successful supply chain should maintain a long-term view to prioritize cooperation over competition.

Previous researchers have developed different ways to enable alliance members to choose long-term and cooperative views over short-term and competitive views. Zeng and Chen (2003) proposed a model that enhanced partner cooperation through structural solutions including changing allocation rules (Zeng and Chen, 2003; Chen, 1999; Rapoport and Amaldoss, 1999) and minimizing greed or fear of competition of other parties (Holm et al., 1999; Doz, 1996).

By adapting general alliance structural solutions into a supply chain management context, this study attempts to facilitate cooperation within the supply chain. Operations management researchers have previously studied buyer-supplier relationship characteristics extensively through empirical studies (Cao and Zhang, 2010; Hurmelinna et al., 2002; Lettice et al., 2010; McCutcheon and Stuart, 2000; Yang et al., 2009). Based on Zeng and Chen's research on structural solutions and McCutcheon and Stuart's field research, a conceptual research model denoting a practice generating mechanism in MC is developed. The model includes five parts: (1) each of the supplier's postponement orientation and the supplier's operational alignment with the buyer has a positive relationship with the supplier's information sharing practices with the buyer (H1 and H2); (2) the supplier's operational alignment has a positive impact on its own process modality design (H3); (3) the supplier's information sharing with the buyer has a positive impact on its own supplier segmentation and product modularity design, respectively (H4 and H5); (4) the supplier's product modularity design has a positive impact on its own process modularity design (H6); (5) the supplier's process modularity design and supplier segmentation respectively increases its mass customization capabilities (H7 and H8). The entire model of this research is shown in Figure 1. Constructs in this model and major hypotheses are described in the following sections, as well as the definitions and relevant literature of those constructs.

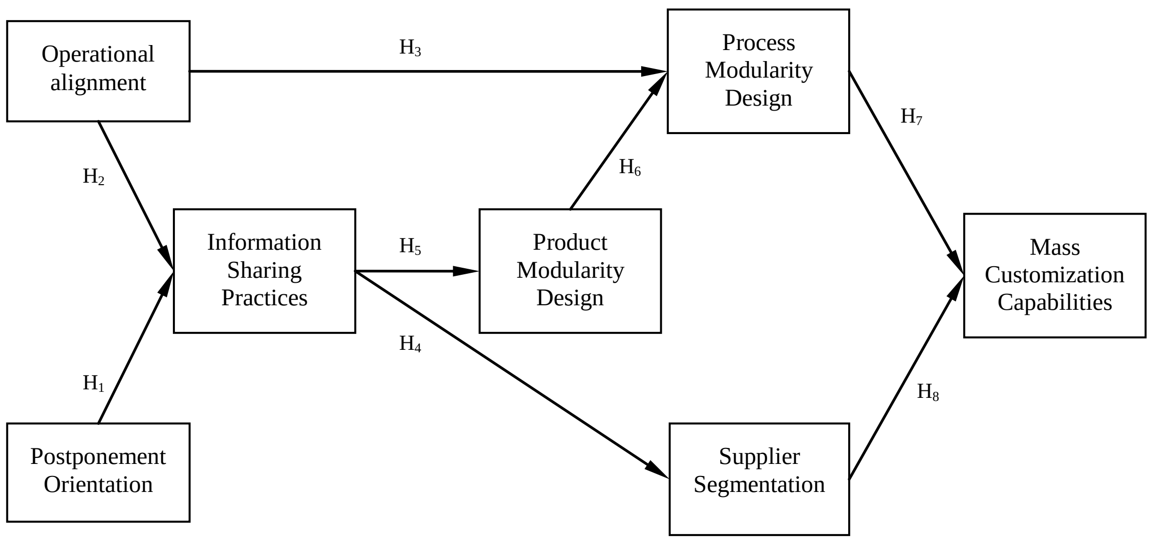

Figure 1: The Research Model

Supplier postponement is to delay the time to assemble final products to the latest possible moment, even until the order is placed in some cases, to have as few inventories of final products and as few obsolete inventories as possible. Information sharing is critical to allow the demand information and the inventory information available to the manufacturer and the supplier. From a strategic perspective, a supplier with postponement orientation demands free and frequent information sharing practices. So, this study proposes the following hypothesis:

Hypothesis H1: The more a supplier has postponement orientation, the more the supplier shares its information with the customers.

Fairly allocating responsibilities among the buyer and its suppliers measured in operational alignment can induce both the buyer and the supplier to work in a close friendship to make the profit pie bigger and then share it fairly. In summary, a buyer and a supplier will have more activities of information sharing when the buyer and the supplier align well in their operations (Liker and Choi, 2004). Therefore, this study proposes the following hypothesis;

Hypothesis H2: The more a supplier aligns its operations activities with its customers, the more the supplier shares its information with the customers.

Operational alignment integrates buyers and suppliers in activities. The buyer-supplier integration increases supplier modularity practices in process design. In the manufacturing process, with alignment between buyers and suppliers, suppliers are willing to adapt to market changes for the final products and thus adopt more modular manufacturing processes that respond to the fast changed products, which in turn demand flexible manufacturing requirements for suppliers. Therefore, this study proposes the following hypotheses:

Hypothesis H3: The more a supplier aligns its operations activities with its customers, the more the supplier modularizes its processes.

Buyer's changing demands also require suppliers to respond quickly through their modular manufacturing processes, affecting their supply base. Throughout the process, information sharing is required since free and frequent information sharing plays a critical role for supply base optimization and segmentation (Dyer et al., 1998; Lee, 2004). Therefore, this study proposes the following hypotheses:

Hypothesis H4: The more a supplier shares its information with its customers, the more the supplier effectively segments its suppliers.

In product design, aligned suppliers proactively cooperate with the buyer in design, using their expertise to design modules for the final products. In this way, the total design time becomes shorter and the introduced new products have a higher quality. However, without frequent information sharing between the buyer and the supplier, knowledge intensive design work cannot be done effectively. Therefore, the following hypothesis is proposed:

Hypothesis H5: The more a supplier shares information with its customers, the more likely the supplier modularizes its product design.

In addition, modularity product design largely affects modularity process design since the purpose of process is to make the design realistic and grouped according to the modules of products at different locations. Therefore, the following hypothesis is proposed:

Hypothesis H6: The more a supplier modularizes its product design, the more the supplier modularizes its processes.

Modularity supply chain practices apply modularity architecture to the dimensions of process and supply base. Modularity processes allow managers to more easily manage a process, to schedule or reschedule manufacturing processes to meet changed demands, and maintain a low inventory of final products. Supplier segmentation allows the manufacturer to save time in managing the supply base by focusing on critical suppliers, and to save on the cost of managing suppliers and to respond to changing demands quickly. Therefore, this study proposes the following hypotheses:

Hypothesis H7: The more a supplier modularizes its processes, the higher the supplier's mass customization capabilities.

Hypothesis H8: The more a supplier segments its suppliers, the higher the supplier's mass customization capabilities.

3. RESEARCH METHODOLOGY

The proposed research model was tested with data collected from automotive suppliers in China and the United States. Of the 456 distributed questionnaires, the usable responses were 208, representing a 45.6% response rate. Non-response bias was examined with the responses. The p-values were all greater than 0.05.

4. RESULTS AND DISCUSSION

A two step approach suggested by Anderson and Gerbing (1988) was followed to assess the measurement models and the hypothesized research model. Adequate reliability, unidimensionality, and discriminant validity for measurement models will help build the confidence in the subsequent interpretations of path coefficients from the theoretical model through structural equation modeling (Segars, 1997).

Descriptive statistics, reliability, average variance extracted of each variable, correlations between variables, and Chi-square differences for discriminant validity assessment of the measurement instruments suggested that that the scales were normally distributed (Ghiselli et al., 1981). The values of Cronbach alpha (α) for the seven variables in the model were greater than 0.70, ranging from 0.75 for information sharing practices to 0.89 for process modularity design. All measurement instruments were, thus, viewed as reliable. Convergent validity measures the extent to which the measurement items of a construct form a common dimension (Kerlinger, 1978). All standardized item-factor loadings in the measurement models were above 0.70 except for items ISP8 and ISP10 with marginal values at 0.68 and 0.69, respectively. The scores of AVE were all equal to or higher than 0.50. Based on all these evidences, we concluded that the measurement model had adequate convergent validity. The square root values of AVE scores were all greater than the correlations between the focal construct and other constructs, thus providing evidence of discriminant validity.

Given the adequate reliability, unidimensionality, and discriminant validity of the measurement model, a structural model (see Figure 2) was constructed to test the research hypotheses suggested in Figure 1. The structural model had a good model-data fit with a chi-square of 299.21 for 180 degrees of freedom, chi-square per degree of freedom = 1.66, p-value = 0.00000, RMSEA = 0.057, NNFI = 0.95, and CFI = 0.96. Figure 2 illustrated the structural path coefficients (γ) between the exogenous variables and the endogenous variables. Figure 2 also illustrated the structural path coefficients (β) among the endogenous variables and included the reported error terms (ζ) of the endogenous variables.

The supported model above provides theoretical as well as practical implications. There are three major parts in the model. The first part is on two major antecedents for mass customization, postponement orientation and operational alignment; suppliers are willing to increase their mass customization capabilities should has a postponement orientation and proactively establish alignments with the customer in terms of production processes, logistics, and quality improvement. The second part is on the heavy duty of information sharing; the two antecedents affect product modularity design and supplier segmentation through free information sharing practices. With free information sharing, the postponement orientation can be implemented through designing the supplier's products and its supplier base as well. The third part is on the modularity architecture used in product design, process design, and supply base rationalization, increasing the supplier's mass customization capabilities.

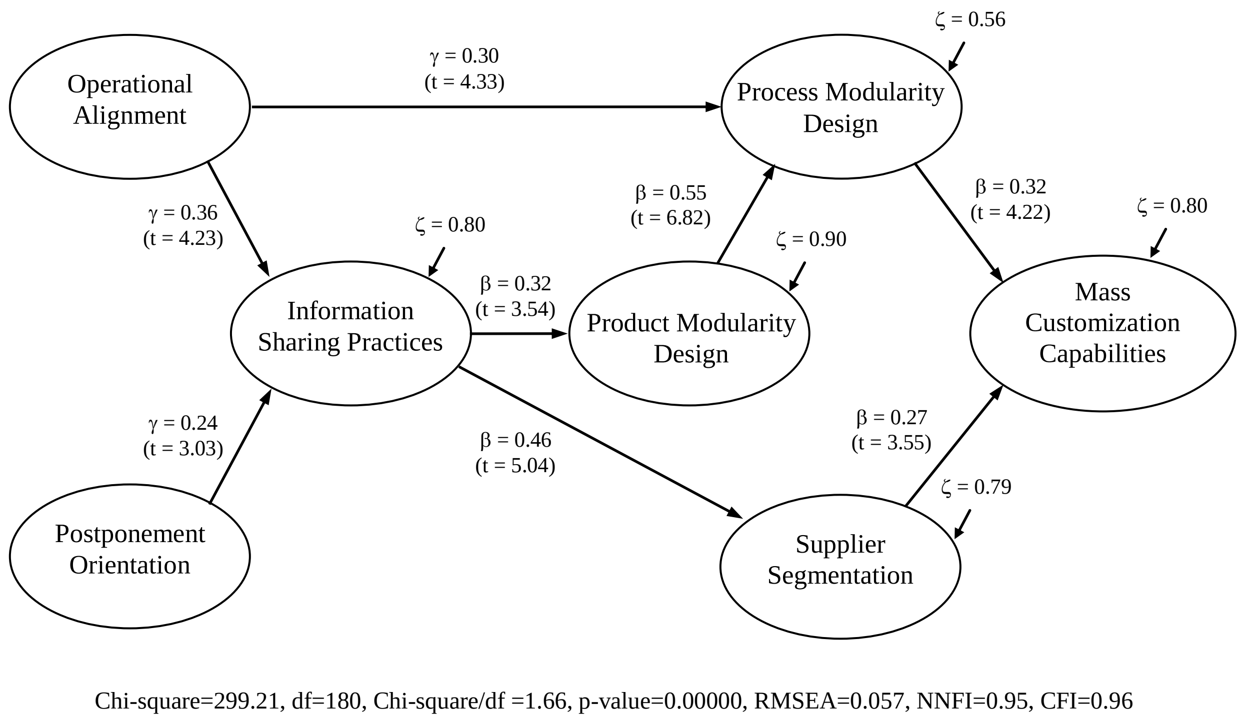

Figure 2: The Structural Model for Hypotheses Testing

5. CONCLUSIONS

This study builds a comprehensive model, based on resource dependency and 3D concurrent engineering theories, that captures the drivers and supply chain practices that achieve mass customization capabilities for suppliers. Operational alignment and postponement orientation are shown to coordinate product design, process design, and the supply base as a system to achieve mass customization by using modularity.

REFERENCES

References available upon request from Kun Liao at liaok@cwu.edu