EXAMINING THE RELATIONSHIPS BETWEEN
DEMAND CHAIN INTEGRATION, FLEXIBILITY, AND CUSTOMER
OUTCOMES IN A B2B CONTEXT

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ABSTRACT

Although externally-driven flexibilities, i.e., volume, variety, and physical distribution flexibility, are considered to be key competitive tools, little research exists on how each of these flexibilities may be improved in the demand chain. Similarly, only few studies have examined the outcomes of externally-driven flexibilities in the demand chain. Accordingly, the purposes of this paper are to study the antecedents and outcomes of externally-driven flexibilities. Specifically, this study explores the relationships between (i) web-based DCM integration, volume, variety, and physical distribution flexibilities, and (ii) volume, variety, physical distribution flexibilities, and perceived customer value. These research objectives are examined in a Business-to-Business (B2B) context. Survey responses from 330 senior-level managers representing various manufacturing industries in India, are analyzed with Structural Equation Modeling (SEM) statistical technique. The findings indicate that web-based DCM integration is positively related to volume, variety, and physical distribution flexibilities. Results also show strong, positive relationships between volume, variety, and physical distribution flexibilities, and perceived customer value. These findings have key implications for manufacturing research and practice.

INTRODUCTION

Manufacturing flexibility refers to the ability to cope with environmental uncertainties with few penalties in time, effort, cost, or performance (e.g., Gupta and Gupta, 1991; Upton, 1994).
Specifically, flexibility strategies are used to deal with uncertainties in customer demand, length of product life cycles, supplier deliveries, or machine downtime (Vokurka & O’Leary-Kelly, 2000). Researchers have explicated several dimensions and levels of flexibility (Correa & Slack, 1996; D’Souza & Williams, 2000). These dimensions are usually viewed as externally-driven or internally-driven flexibilities. Externally-driven flexibilities are visible to the customer unlike their internally-driven counterparts. Hence these capabilities facilitate the market needs of the plant (D’Souza & Williams, 2000; Zhang, et al. 2002). Volume, variety, and delivery flexibilities are externally-driven dimensions (D’Souza & Williams, 2000; Zhang et al, 2002). However, research regarding externally-driven dimensions and their impact on customer perceptions is scarce (Zhang et al, 2003). Hence, the present research will seek to fill this void by examining issues affecting externally-driven dimensions of flexibility.

The demand chain emphasizes integration of activities and information across all enterprises in order to meet customer requirements more efficiently and effectively (Costello, 2001). The focus is on critical customer information flow upstream from the customer to the supplier (Heikkila, 2002). Web-based DCM Integration denotes the use of the Internet for high levels of simultaneous integration among suppliers, manufacturers, and customers.

Since web-based DCM integration provides real-time information, often directly from the customer, it seems intuitive that such prompt and accurate information may help improve externally-driven flexibilities. However, there are no studies examining the influence of web-based DCM integration on these dimensions of flexibility. Hence, our first objective is to examine the relationship between web-based DCM integration and externally-driven flexibilities.

By definition externally-driven flexibilities are those that are visible to the customer, hence, an examination of their impact on some aspect of consumer perceptions seems necessary. In addition the demand chain exists to improve customer value perceptions (e.g., Walters, 2002). Besides, anecdotal evidence suggests that flexibility maybe a key driver of customer value in the demand chain (Christopher & Towill, 2002; Walters, 2002). However, the impact of externally-driven flexibilities on perceived customer value is still an ignored issue in the literature. Hence, our second research objective is to examine how externally-driven flexibilities affect perceived customer value.

In summary our hypothesized model tests the relationship between web-based DCM integration and customer value mediated by externally-driven flexibilities. These variables are assessed among suppliers, manufacturers, and wholesalers/retailers. We limited the scope of the study to B2B customers in order to focus on one customer segment. Besides, the number of B2B customers is increasing rapidly (Reid & Plank, 1995). Hence, it is important to investigate issues affecting this customer sector.

**RESEARCH MODEL AND HYPOTHESES**
The Effect of Web-based DCM Integration on Externally-Driven Flexibilities

The major externally-driven flexibilities include volume, variety, and delivery flexibilities (D’Souza & Williams, 2000; Zhang et al., 2002). Volume flexibility has been defined as the ability of the organization to operate at various batch sizes and/or different production output levels economically and effectively (Suarez, Cusumano, & Fine, 1996). Variety flexibility will enable an organization to customize product features effectively and at short notice (Boyer, Ward, & Leong, 1996; Gupta, 1993). Delivery flexibility implies the ability to modify inventory, packaging, warehousing, and transportation to meet customer requirements quickly (Day, 1994; Lambert & Stock, 1993).

Gunasekaran (1999) proposed that demand chains adopt a virtual enterprise model, including the use of Internet technology, to facilitate flexibility and improve demand chain performance. The central premise of Gunasekaran’s suggestion is that real-time information flow across demand chain enterprises helps reduce uncertainties because of the ability to detect changes in customer demand instantly (Reekers & Smithson, 1994; Khouja & Kumar, 2002). Speedy information regarding customer order changes will help improve demand forecasts (Zellen, 2001; Lilley, 2003). Thus, conditions of excess inventories or stock outs can be avoided. A firm is considered to be flexible if it can avoid such extreme states of inventories during periods of low and high demand (Jordan & Graves, 1995).

Secondly, exchange of real-time information on customer orders and availability of resources may enable demand chain members to make production arrangements even before the arrival of materials or components (e.g., Greis & Kasarda, 1997). Specifically, real-time demand information concerning customer order changes, customer profiles, and delivery requirements and changes will enable a manufacturing firm to adjust its capacity, production schedules, labor, inventory, mix, or delivery options in a timely and cost-effective manner. Similarly, real-time supply information including inventory planning, demand forecasts, order schedules/ tracking, and product designs will enable the manufacturing firm to modify its volume, create new products or alter existing designs, customize features and inventory, and alter delivery schedules for downstream customers in a timely and cost-effective manner. Thus, the ramifications of real-time information flow for externally-driven flexibilities are quite evident. The above discussion leads to the following hypotheses:

H1a: Web-based DCM integration will be positively related to volume flexibility.
H1b: Web-based DCM integration will be positively related to variety flexibility.
H1c: Web-based DCM integration will be positively related to physical distribution flexibility.

The Effect of Volume Flexibility on Perceived Customer Value

Volume flexibility is posited to have a significant relationship with customer satisfaction (Zhang et al., 2003). However, a number of studies have found that perceived customer value is an antecedent of customer satisfaction (Patterson & Spreng, 1997; McDougall & Levesque, 2000; Lam et al., 2004). Specifically, perceived customer value is shown to be a cognitive-based construct that captures the trade-off between perceived benefits and sacrifices (Oliver 1993). On
the other hand, customer satisfaction, considered to be an affective response, is affected by these
cognitive evaluations (Weiner, 1986; Patterson & Spreng, 1997; Lam et al., 2004).

From the above line of reasoning, it follows that customers will perceive value from the firm’s
ability to rapidly adjust volumes, before they are even satisfied with the firm’s benefits.

Moreover, researchers have suggested that volume flexibility directly influences customer
perceptions of the company (Vickery, Calantone, & Droge, 1999). This is because volume
flexibility is associated with inventory levels. Accordingly, manufacturers should be able to
increase or decrease production instantly in a highly uncertain environment (Hayes &
Wheelwright, 1984). Thus, volume flexibility helps reduce the customers’ inventories, lead
time, and associated costs (e.g., Zhang et al., 2003).

Customers may perceive high levels of value if the firm is able to make such modifications to
inventory levels rapidly. In particular, retailers will perceive that the price, effort, risk, and time
spent on buying the product are worth the benefits accrued from demanding rapid
increases/decreases to inventory levels. Thus, it is hypothesized that:

H2: Volume flexibility will be positively related to perceived customer value.

The Effect of Variety Flexibility on Perceived Customer Value

Variety flexibility will enable the manufacturer to alter production processes in order to create
new or modified products very quickly (Sethi & Sethi, 1990; Gupta & Somers, 1992; Gupta,
1993; Boyer & Leong, 1996). A firm will have high levels of variety flexibility if it is able to
rapidly produce several varieties of new and existing products, while maintaining
keeping the costs down of these products.

The perceived value literature has asserted that customers will perceive higher value if the price
they pay is worth the benefits they receive (e.g., Haas, 1995; Berry & Yadav, 1996; Ravald &
Gronroos, 1996; Slater, 1997; Lapierre, 2000). Since customers are willing to pay a premium
price for rapid innovation and customization (e.g., Walters, 2002), it follows that:

H3: Variety flexibility will be positively related to perceived customer value.

The Effect of Physical Distribution Flexibility on Perceived Customer Value

Several authors have proposed the notion of customizing delivery options to meet different
customer needs or add customer value. While some authors denote such customizations as
“tailored logistics” systems (e.g., Fuller, O’Connor, & Rawlinson, 1993), others use the term
“discrete logistics” (Greis & Kasarda, 1997) or “logistics as a value-creation” (Langley &
Holcomb, 1992). However, the rationale is the same: customer needs can be segmented on the
basis of the logistics function. These authors have suggested that companies can customize the
logistics package by using different channels, packages, delivery timing, order response times,
delivery frequencies, shipment modes, and product handling characteristics. Hence, a company
following a differentiation strategy can add customer value if it differentiates its delivery options
to suit diverse customer needs.
Furthermore, some researchers have advocated that firms can add customer value by building the necessary capabilities to respond to diverse needs in delivery (e.g., Langley & Holcomb, 1992; Walters, 2002). Physical distribution flexibility is conceptualized as a key customer-facing capability (Vickery et al., 1999; Zhang et al., 2002), wherein customers are able to obtain the right product at the right time and place. Specifically, flexibility in packaging, warehousing, and transportation operations are important strategic responses to changes in demand (Zhang et al., 2002). Since the literature indicates that physical distribution flexibility is a key driver of customer value, it is hypothesized that:

H4: Physical distribution flexibility will be positively related to perceived customer value.

METHODOLOGY

A market-research firm identified a target sample of 1040 executives from various manufacturing companies in six cities in India. Of the 1040 executives contacted, 330 filled out our questionnaire, i.e., a response rate of 32%. Most of the survey items were measured on a 7-point Likert scale ranging from “strongly disagree” to “strongly agree.” The hypotheses were tested using Structural Equation Modeling (SEM).

RESULTS

Results indicated that the model fit the data well (Table 1). In addition, the model explained 43%, 37%, and 23% of the variance in volume flexibility, variety flexibility, and physical distribution flexibility respectively. Furthermore, the model explained 46% of the variance in perceived customer value.

Table 1. Structural Model Fit

<table>
<thead>
<tr>
<th>Goodness of Fit Criteria</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square</td>
<td>1548.69 (d.f. = 517); n = 330; p = 0.000</td>
</tr>
<tr>
<td>CFI</td>
<td>0.90</td>
</tr>
<tr>
<td>GFI</td>
<td>0.77</td>
</tr>
<tr>
<td>NNFI</td>
<td>0.90</td>
</tr>
<tr>
<td>SRMR</td>
<td>0.076</td>
</tr>
<tr>
<td>RMSEA</td>
<td>0.083</td>
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</tbody>
</table>

Note: CFI = Comparative Fit Index, GFI = Goodness-of-fit Index, NNFI = Non-normed Fit Index, SRMR = Standardized Root-mean-square Residual, RMSEA = Root-mean-square Error of Approximation

Direct and Indirect Effects

The standardized path estimates ($\beta$) are all significant at $p < 0.001$. Hypotheses 1a, 1b, and 1c state that web-based DCM integration will be positively related to volume flexibility, variety flexibility, and physical distribution flexibility respectively. The significant $\beta$ coefficients for
H1a, H1b, and H1c are 0.65, 0.61, and 0.48 respectively, providing support for the hypotheses. This finding shows that web-based DCM integration has a direct and positive effect on volume, variety, and physical distribution flexibility. In addition, web-based DCM integration has a stronger effect on volume flexibility compared to variety and physical distribution flexibility.

The second hypothesis states that volume flexibility will be positively related to perceived customer value. The significant $\beta$ coefficient of 0.27 provides support for H2. The third hypothesis states that variety flexibility will be positively related to perceived customer value. The significant $\beta$ coefficient of 0.35 supports H3. The fourth hypothesis states that physical distribution flexibility will be positively related to perceived customer value. $\beta$ coefficient of 0.28 was significant, thereby supporting H4. These findings indicate that volume, variety, and physical distribution flexibility have direct and positive impacts on perceived customer value. Moreover, variety flexibility has a stronger effect on perceived customer value than volume or physical distribution flexibility.

In addition, web-based DCM integration has a positive and indirect effect on perceived customer value ($\beta$ coefficient = 0.52, $p < 0.001$). Specifically, the indirect effects of web-based DCM integration on perceived customer value through volume, variety, and physical distribution flexibility are 0.18, 0.21, and 0.13 respectively. It is also interesting to note that although web-based DCM integration has a stronger direct effect on volume flexibility, the strongest indirect path is through variety flexibility.

**DISCUSSION**

The findings of the research indicated that web-based DCM integration was significantly, positively, and directly related to volume, variety, and physical distribution flexibility. Therefore, web-based DCM integration may be a key competitive weapon for manufacturers to improve volume, variety, and physical distribution flexibilities.

Specifically the simultaneous online integration that facilitates information sharing upstream and downstream in the demand chain, is crucial towards improving externally-driven flexibilities. In particular, real-time demand and supply information such as customer order changes, customer profiles, inventory plans, demand forecasts, order schedules/tracking, and product designs will enable the manufacturer to swiftly alter capacity, labor/production schedules, products, and delivery options.

The second objective of the study was to examine the relationship between externally-driven flexibilities and perceived customer value. The results showed that volume, variety, and physical distribution flexibilities had strong, direct, and positive impacts on perceived customer value. Thus, it is clear that industrial customers value each type of externally-driven flexibility.

For the industrial customer, a high level of volume flexibility (from the manufacturer) may imply lower inventories and associated costs and increased sales and profits. Similarly, high levels of variety and physical distribution flexibility (from the manufacturer) indicate lower inventories and transportation lead times for the industrial customer. Therefore, industrial customers
perceive that the price paid for the product/service is worth the benefits accrued from volume, variety, and physical distribution flexibility.

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