Using Customer Integration to Improve Supply Chain Performance

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ABSTRACT

A successful supply chain (SC) management process must persistently evaluate its position based on customer preference on the qualitative and quantitative attributes pertaining to operational, technological, material management, information system and other relevant factors of the business. The goal of this evaluation is to enable a business to select both the customer, and the product where they can align best based on their capability and capacity, in addition to identifying which success factors to integrate when approaching their target customer about supplying the target product. This study defines the customer preference attribute metrics necessary for self-evaluation and determining customer integration requirements. A mixed integer programming (MIP) model is proposed to optimize profit by selecting customers and products for achieving SC goals based on the capacity and capability of the business. The model will also aid SC managers in their efforts to pinpoint the integration attributes that will improve the overall business performances. A numerical example illustrates the model's applicability.

Keywords: Customer integration attributes, Attribute metrics, MIP model, Customer integration factors, Self evaluation of business.

INTRODUCTION

Intense global competition and escalating customer expectations have compelled SCs to continuously reevaluate their business process in an effort to remain integrated with their customers. Customer integration (CI) has been established to be an enabler for the effective continuation of a business process and its growth. Several past and recent studies have been supporting the importance of CI for the overall improvement of SC performance (Bowersox and Monash, 1989; Lee and Billington 1992; Jammernegg and Kischka, 2005; Forme et al, 2007; Zhao et al, 2008, Payne and Frow, 2004). This study will use Ellram (1990) to define "partnering" as an ongoing relationship between two firms that involves a commitment over an extended period of time in addition to a mutual sharing of information regarding the risks and rewards of said relationship. The two firms included in this definition for the context of this paper are the supplying firm and the customer firm. Subsequent discussions will apply the same meanings to integration and partnering, with the understanding that most cases only use integration.

Customer integration is a central component of supply chain integration (SCI) process that contributes to a business's ability to compete—developed by coordinating the SC with their critical customers (Bowersox et al., 1999). Each business environment has its own way of defining and identifying integration factors. A make-to-stock (MTS) firm might narrow customer integration to incorporating the retailers, while make-to-order and assemble-to-order companies require a more diverse approach. Table 1 provides example of typical general factors and their attributes.

SCs explore customer requirements to compare customer expectations with the attributes for each integration factor. Retailers are the major customers for most MTS business firms, although some MTS firms may transform themselves into MTO based on the contractual arrangement with the retailers. In instances when retailers are the customers, it is possible to collect information from several customers regarding their expectations of the attributes under the factors (Table 1) that are relevant to each product. It is evident that the exploration of requirements for the relevant product ranges of a manufacturing firm may be considered a standard marketing step when prospecting for growth or an increased market share. Once the customer requirements for the product or product ranges have been collected, supplying firms must analyze their position using customer-product-attributes combination metrics to improve their on-going business performance, as well as support expansion that includes new businesses.

CI-related studies as they appear in literature are either directed at the performance evaluation of an already implemented integration process (Zhao et al., 2008; Chow et al, 2008; Forme et al., 2007), or advocacy of the integration process (Jacob, 2006; Vickery et al., 2003)—with both founded on an opinion-based survey of the SC mangers. Outside these two trends, Perona and Nicola (2004), and Jammernegg and Kischka (2005) examined the ongoing integration processes between two firms and finally recommended the inclusion of new attributes for the continuation and improvement of the integration process. There are also studies that identified customer services to be an important step in the CI process. White and Pearson (2001) mentioned how customer service becomes the link used to match and integrate the supplier and customer systems.

Although CI-related research has received a fair amount of attention in recent years—from both academia and practitioners—there is no comprehensive study that clearly identifies the critical sets of CI attributes and factors while defining a procedure for establishing comparative metrics for the relevant attributes. A study of this caliber would help SC managers evaluate their business position in reference to the metrics value of the customer requirements for the targeted products, allowing them to select customers and products based on how well their capacities and capabilities align. It also assists them in the selection of which integration attributes will be included to improve their business processes through satisfying customers. Chow et al. (2008) confirmed that customer satisfaction can be the result of SC competency achievements, in terms of quality, service, operations, distribution and design effectiveness—supporting the statement that the customer integration process leads to increased customer satisfaction.

This study focuses on the CI steps a SC must follow to achieve overall performance excellence. Our research objectives are: 1) defining CI attributes based on the factors and techniques identified in the literature, 2) developing the attribute metrics for CI factors at various levels or scales based on relative performance, 3) outlining guide lines for defining a firm’s position and customers for each product or service considering entire sets of attributes, 4) developing an MIP model that helps SC managers optimize profit by selecting customers and products that are well aligned with the capacity and capability of their business and, finally, 5) helping SC managers pin-point which CI attributes must be improved to achieve its targeted supply to a customer or market.

This paper is organized in the following way: next section defines the customer integration factors and attributes metrics. This section also proposes an MIP model for selecting customers and products that align best with the firm's priorities. Following mathematical model we solve a numerical example that illustrates applicability of the model, and in the last section we present discussions and a conclusion.

CUSTOMER INTEGRATION FACTORS

Customer integration (CI) factors may be divided into the following categories:

a) Operational
b) Material management
c) Technological
d) Strategic
e) Information
f) Customer services
g) Financial, power, link and others

***Operational Integration Factors* (*OIF*)** are the most frequently practiced CI factors. OIFs include several attributes (examples in Table 1) in different operational areas or practices (Perona and Saccani, 2004). OIFs affect the basic business transactions within the customer/supplier relationship and are the function of supplier attributes that are relevant to delivery, flexibility and market responsiveness. These are the supplier's core competencies within the customer/supplier interfaces that influence the customer most.

***Material Management Integration Factor* (*MMIF*):** MMIFs are the functions of a supplier's capability and capacity in terms of production, quality, reliability and other competencies vital to intra-firm operational performance. These create the foundations of customer influence.

***Technological Customer Integration Factor* (*TIF*):** TIFs include CI attributes for developing long-term relationships that may ultimately be transformed into partnerships. Often TIFs (Table 1) like joint investment in R & D and Virtual displaying, etc. come into play when the customer/supplier relationship has grown to operate on an impressive level, thanks to successful business transactions over some periods.

***Strategic Customer Integration Factor* (*SIF*):** SIFs (Table 1) include factors that reduce the complexity of transactions, develop joint venture businesses and initiate the inclusion of critical resources and systems through joint investments.

***Information Technology-based Customer Integration Factor* (*ITIF*):** ITIFs (Table 1) serve an independent, as well as supportive role in relation to the other integration factors. ITIF is the most vital factor for CI integration.

***Customer Services Integration Factor* (*CSIF*)**: CSIFs usually represent the cumulative impact of all the above factors, but some factors like presale after sales customer support and product support may be considered independent CSIFs. A customized product business has several customer service components that we may also consider CSIFs.

***Financial, Power, Links and Other CI Factors* (*FPIP*):** Customers, especially retailers or industrial customers for MTO products, always prefer a company with impressive financial strength. The terms "power" and "link" refer to the influence of the suppliers on industrial policy decisions or a business chamber decision that gets high value from the customer.

Factors and their attributes		Attribute metrics	Metrics range
1)	Operational		5 to 10
-	JIT replenishment	10	
-	Vendor managed Inventory (VMI)	8	
-	Scheduled Supply	5	
2)	Material Management		5 to10
-	Quality Certifications	7	
-	Six Sigma quality provider	9	
-	100 % defect free (Free pass supply)	10	
3)	Technological		
-	Virtual tool for product display to customers	9	
-	Joint investment in R&D	7	
-	ASRS for storage and supply	10	
4)	Strategic		5 to 10
-	Production selection offer	10	
-	Flexibility in volume and product mix	10	
-	Investment in Joint Venture	7	
5)	Information Technology		7 to 10
-	Online connection through SAP or ERP software	10	
-	E- business provision through retailer	9	
6)	Customer Service integration		7 to 10
-	Presale and post sale customer support	7	
-	Services relevant to customized product	10	
7)	Financial, Power, Link and others		8 to 10
-	Excellent Financial Health of the company	10	
-	Power and link to influence policy decisions	8	

Table 1: Examples of typical customer integration factors and attributes

Customer Integration Attribute Metrics

According to customer/supplier interface experience, a supplier firm should be able to define a set of integration attribute metrics that is relevant to each prospective product that the firm is planning to sell to a customer. A metric's relative importance or scale value can be partially verified using the SC performance measures published in the literature and SC council publications. Once the metrics are established for each attribute of a prospective product that the supplier is targeting to supply to a customer, the supplier firm can evaluate its capacity and capability (position) in relation to the CI attributes and their metrics scale value. As previously discussed, this evaluation will help SCs determine the products, quality levels, customers and customer locations that best align with its capability and capacity. It will also enable them to identify the additional critical attributes they need to include in their system for further performance improvement. This paper provides a problem statement, proposes an MIP model and illustrates the applicability of the model using a model example in the next section.

Problem Statement

It is assumed that CAM_{iq} is the manufacturing capacity of a business that produces products i: 1, 2,.., I. at quality level q: 1,2, .., Q compatible to the requirements of retailers/customers r : 1,2, .., R. For their success in the market, the business has been imparting much importance to the CI process and has been able to identify several CI attributes a : 1,2, .. , A, under the domain of integration factors m=1, 2,.. M. Their marketing effort reveals that the maximum and minimum quantity requirements for product i for retailer r at quality level q are y_{irq} max and y_{irq} min , respectively. Let x_{irq} be the quantity of product i at quality level q that the business manufactures and supplies to retailer r. Market information analysis reveals that the business needs CI integration metrics value SV_{irma} for CI attribute a under the integration domain factor m, relevant to product i to be supplied to customer r. In fact, SV_{irma} is the estimated CI metrics value or customer preference points, or CPPs for customer r for product i, relevant to m and a combination. From the customer's information the business could also estimate the minimum qualifying attributes metrics value MPM_{ir} that will be needed to get business from retailer r for product i. The business has also determined the maximum CPP value, PM_{irma} that they can offer for obtaining the business of product i from customer r. Based on the information from several other companies, the business determines cost involvement IC_{ima} for achieving CPP for each customer integration attribute a in the integration factor category m in order for product i to be supplied to a retailer. The objective of the model is to maximize profit through selecting customers; products; quantities, and quality level of the products that align best with the manufacturing capacity and capability of the business in terms of CPP attribute metrics values and satisfy customer requirements. The model also identifies which additional integration attributes and their scale values the business needs to include for further performance improvement.

Mathematical Model for Customer Integration

The MIP model for Customer Integration is presented in this Section.
In addition to the parameters defined in the problem statement, the following parameters are also needed to describe the mathematical model for Customer Integration

v_{irq}	price offered by the retailer ***r*** for their product ***i*** at quality level ***q***
u_{irq}	=1, if potential demand for product ***i*** at quality level ***q*** is there from retailer ***r***., 0 otherwise
PC_{irq}	production cost per unit quantity of product ***i*** to be supplied to retailer ***r*** at quality level ***q***
fac	a fraction to determine production cost based on sales price
Z_{irma}	=1, if product i with integration attribute ***a*** under the domain of CI integration factor ***m*** is supplied to retailer ***r***.
K	multiplication factor for converting CSI into currency value of profit

Objective function: ***Maximize*** *Z*

$$Z = \boldsymbol{ST + CSI - PIC} \qquad (1)$$

where Z : Proft, ST: Sales turnover, PIC : Production and Integration cost, and CSI : Customer satisfaction index converted to profit through a multiplication factor.

$$ST = \sum_{i} \sum_{r} \sum_{q} y_{irq} . facv_{irq} \tag{1.a}$$

$$CSI = K * \sum_{i} \sum_{r} \sum_{m} \sum_{a} Z_{irma} \tag{1.b}$$

$$PIC = \sum_{i} \sum_{r} \sum_{q} X_{irq.} PC_{irq} + \sum_{i} \sum_{m} \sum_{a} IC_{ima} \sum_{r} Z_{irma} \tag{1.c}$$

Subject to:

$$y_{irq} \le x_{irq} \qquad \forall i, r, q \tag{2}$$

$$\sum_{r} x_{irq} . \le CAM_{iq} \sum_{r} u_{irq} \qquad \forall i, q \tag{3}$$

$$y_{irq}^{\min} \le y_{irq} \le y_{irq}^{\max} \qquad \forall i, r, q \tag{4}$$

$$\sum_{m} \sum_{a} SV_{irma} * Z_{irma} \ge MPM_{ir} \qquad \forall i, r \tag{5}$$

$$SV_{irma} * Z_{irma} \le PM_{irma} \qquad \forall i, r, m, a \tag{6}$$

$$\sum_{q} u_{irq} \le \sum_{m} \sum_{a} Z_{irma} \qquad \forall i, r \tag{7}$$

$$Z_{irma} \in \{0,1\}, \ \forall i, r, m, a; \quad u_{irq} \in \{0,1\}, \ \forall i, r, q \tag{8}$$

The objective of the model is to maximize profit, and the details of this objective function are described in equation (1). The model maximizes profit by maximizing turnover and the customer satisfaction index and minimizing production and customer integration costs. Since the sales price for the product is fixed by the retailers based on the retail price, turnover described in equation (1.a) depends on two factors: the quantity of product that can be supplied for a quality level and the increasing quantity of a product at the highest quality level. The customer satisfaction index in equation (1.b) computes turnover that may be achieved by incorporating quality and service attributes of the products. A suitable factor is assumed to take into account contribution for each attribute and convert it into profit. The equation in (1.c) describes production and customer integration costs (***PIC***), which have two components: the production cost component that computes the cost of production, and the cost of including a CI attribute for any product for the improvement of SC performance. Equation (2) balances the planned production to the quantity supplied to the retailer at a quality level. Equation (3) plans production based on the capacity for supplying to a retailer at a quality level. Equation (4) keeps supply quantity within the range of a retailer's buying quantity for a product at a quality level.

Constraint (5) expresses the minimum metrics value as may be set by the retailers for any product to accept from a supplier firm. Equation (6) ensures that the scale value for the CI integration metric offered to the retailer is within the capability of the manufacturer. Constraint (7) sets the condition that manufacturing will plan for a potential retailer demand at a quality level after ensuring the required integration attributes to comply with the quality level of the retailer. Equation 8 imposes integrality.

NUMERICAL EXAMPLE

The model example involves 7 customer integration factors, 2 to 7 integration attributes under the domain of each factor and 15 products at 3 quality levels that are to be considered for 6 retailers. Table 1 as described in the previous section shows the typical assumed metrics value for each attribute under the domain of customer integration factors. The metrics values are assumed in 1 to 10 scales that depict the assumed preference (highest possible) that a customer may impart to the attributes. Metrics value for attribute JIT replenishment under operational CI integration factor is 10, as shown in Table 1. In practical business situations, customer preference value for the metrics may be set based on the market information from several similar customers. In the second step, the supplying firm should determine its position for each individual set of metrics. If this order of setting customer metrics first and supplier's next is followed, the metrics will contribute to effective decision-making. Our experience suggests that setting the metrics that way makes them quite robust. Even a considerable percentage of deviations in the scale value assumption would not change the decision. Table 2 provides the assumed typical requirements for 6 customers and supplier status for the retailers in terms of two attribute metrics for operational factors. Metrics for customer 1 to 6 for the attribute JIT replenishment are : 7, 9, 4, 6, 7 and 10; whereas the metrics for the supplier for this product (product 1) that the supplier firm can offer to the customers are 9,8, 9, 7, 8, and 7, as shown in Table 2. The ideal possible metric value for this attribute is 10 (Table 2).

CI factors and attributes	**Status for**	**Customers**						
		1	2	3	4	5	6	**Ideal Metrics** for the attributes
Operational								
- JIT replenishment	Customers	7	9	4	6	7	10	**10**
	Suppliers	9	8	9	7	8	7	
- Vendor Managed Inventory (VMI)	Customers	**6**	**5**	**6**	**4**	**7**	**5**	**8**
	Suppliers	7	7	8	6	6	6	

Table 2: Typical attributes metrics values (only two attributes shown as example) of operational CI integration factors

The typical supplying capacity of the firm to the customers for 3 products at different quality levels appears in Table 3, and based on this table, the capacity of the supply firm for product 1 at quality levels 1, 2 and 3 are 1345, 1826 and 1416 units, respectively.

Product	**Manufacturing Capacity at quality level**		
	1	**2**	**3**
1	1345	1826	1416
2	2047	1606	2248
3	2039	1527	1978

Table 3: Typical manufacturing capacity and quality level of 3 products of the supply firm

Product	Quality level	Product quantity ranges to be that may be supplied to retailers					
		1	**2**	**3**	**4**	**5**	**6**
1	1	1017- 1908	1279-2009	1065-2286	1299-1535	1476-1647	1243-1603

Table 4: Typical product quantity ranges for product 1 that may be supplied to retailers at specified quality level 1

Table 4 provides the typical product quantity ranges for product 1 at quality level 1 that may be supplied to 6 retailers. Retailer 1, for example, can be supplied between a maximum of 1908 units and a minimum of 1017 units of product 1 at quality level 1.
Typical product costs from the manufacturing firm and selling prices set by the retailers at quality level 1 for product 1 are presented in Table 5. The selling prices set by retailer 1 for product 1 at quality level 1 is $ 141.54, while the production cost for product 1 at quality level 1 is $102.00 (Table 5). The selling prices, costs and capacity data as presented in Tables 3, 4 and 5 are randomly generated following similar online business data from the internet for a typical product.

Product	Quality Level	Selling Prices for the products at quality levels set by the Retailers					
		1	2	3	4	5	6
1	**1**	**141.54**	145.92	145.77	140.08	142.66	152.13
Product	**Quality Level**	**Production cost of the products at quality levels supplied to retailers**					
		1	**2**	**3**	**4**	**5**	**6**
1	**1**	**102.04**	102.04	102.04	102.04	102.04	102.04

Table 5: Typical selling price and production costs for the product 1 quality level 1

Analysis of Typical Model Output

Table 6 presents the typical model output for deciding which customers, products and quantity and quality levels best align with the capacity and capability of the supplying organization, given the available market potential. For instance, the supplying organization in the model example has the acceptable capability to supply to retailer 1 product type 1 at quality 1, but they do not have the capacity to supply 1,908 units of product, which is the market potential for retailer 1, as can be seen in Table 6. Although it has capacity to supply up to 1,345 units, the model selected the minimum possible quantity 1,017 units of product based on cost and profit consideration.
Taking a similar example, the supplying organization does not have the capability to supply product 1 to retailer 1 at a quality level 3 (Table 6) although they have the capacity (see table 3). By capacity, we mean the capacity of the supplier's plant for fulfilling quantity requirement, and by capability we mean the capability of the customer preference metrics value for the attributes under customer integration factors similar to the metrics value shown in Tables 2, and discussed in detail above.

Product	Retailer	Quality level	Quantity decided by the model , X_{irq} (units)	Market potential (units)
1	***1***	***1***	***1017***	***1908***
1	1	2	1649	1649
1	***1***	***3***	***0***	***1521***

Table 6: Typical Model output: retailer and quality level for product 1 where the company can align best given the available market potential among the retailers (only 1 shown)

Table 7 describes the typical model output that pinpoints the integration factor and attribute the supplier should improve to exploit full market potential. For example, based on Table 7, the supplier needs to improve their attribute metrics value for integration attributes *frequent delivery, scheduled supply* under the operational CI factors for supplying product 1 to retailer 1 where they failed in Table 6. It may be mentioned here that the supplier has the capability to supply the product at quality levels 1 and 2 based on several attributes under the CI factors considered, but they do not have the capability in terms of attributes if the customer asks for quality level 3. It is clear that for the higher quality level product, the customer decides to pay for high metrics value attributes, but they would also like to have the desired metrics value for the lower quality level products based on the cost level and other criteria.

Product(*i*)	**Retailer(*r*)**	**Factor (*m*)**	**Attribute (*a*)**	**$^*Z_{irma}$**
1	1	Operations	- JIT replenishment	1
1	1		-Vendor Managed Inventory	1
1	1		- Frequent delivery	0
1	1		- Distribution networking	1
1	1		- Scheduled supply	0
$^*Z_{irma}$: 1 , if product *i* can be supplied to retailer *r* complying requirements of attribute metrics value *a* under integration factor *m*.), 0 otherwise				

Table 7: Typical identified integration factors and attributes where the organization needs to improve

The model provides options for what-if scenarios, and trade-off decision criteria. For example, the profit and objective function components as decided by the model output are Profit (Z): $6.36 million; sales turnover (ST):$50.65 million and production and integration costs:$44.29 million. When all the limitations and points are known, managers in the supplying firm will be able to simulate the what –if analysis and can make trade-off decisions by investing in the improvement efforts of integration attributes based on the targeted market potential for selling products in an effort to increase their profit.

CONCLUSIONS

Our research introduces a new procedure for developing logical CI metrics by defining CI factors and attributes suitable for a business. The example problem illustrates how the procedure allows the metrics to be simultaneously applied to understand the customer's preference level, as well as the supplying business's own capability. An MIP model has been developed for selecting customers, products, supply quantities and quality levels that best align with the capacity and capability of the supplier's business—leading to the improvement of their business performance in terms of profit and customer integration. The inputs for the proposed model are the multidimensional customer attribute metrics, other information from the market and manufacturing. The model also enables SC managers to identify their limitations in the customer supplier interface, as well as their internal operation, and pin-point the integration factors and attributes that need to be improved in order to exploit market potential and achieve their targeted performance level. The proposed procedure and the model may also be applied to make effective SC decisions using what –if scenario approach.

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