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# Mass Customization in Supply Chain Level: Development of a Conceptual Framework to Manage and Assess Performance

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**Abstract.** Recent market interest on customized offers and intensive competition on attracting market globally, lead companies to implement supply chain management to improve performance and gain competitive advantage. To this aim, Supply chain management in customer-oriented environment is pursuing the transition from traditional supply chain into concurrent flexible and efficient one. This paper aims to understand specifically how supply chain within this environment needs to be configured and managed in order to enable efficient customization for mass market. To reach this goal, a conceptual framework and list of indicators to support the framework have been developed and tested.

**Keywords:** Mass customization, Supply chain management, Performance measurement.

## 1 Introduction and Research Objectives

There is a growing recognition among scholars and practitioners that individual businesses no longer compete as stand-alone entities, but rather as supply chains [3]. Recently, we are now entering the area of “network competition,” where the awards will go to those organizations who can better structure, coordinate, and manage the relationships with partners in a network which is committed for a better, closer, and more agile relationships with final customers [3]. It can be argued that in today’s challenging global markets, the route to sustainable advantage lies in being able to leverage the respective strengths and competencies of network partners to achieve greater responsiveness to market needs [3]. Evidently market interest on more customized offers better aligned to individual’s needs, brings further challenges in terms of complexity and uncertainty. Being competitive in this environment requires concurrent efficiency and flexibility [8]; accordingly enables the ability to provide higher variety at lower cost, enabling strategies of mass customization to be pursued [3]. Mass customization is defined differently by many scholars

time after time [5], [27], [29], [41] but the most well-known definition used by this study, is given by Piller as “Customer co-design process of products and services, which meet the needs of each individual customer with regard to certain product features. All operations are performed within a fixed solution space, characterized by stable but still flexible and responsive processes”[28].

Inspired by extensive literature review, we recognized that the literature on mass customization in supply chain level has been growing recently and there are still some areas that need further research. In particular we believe that more understanding is needed on how to configure and manage a supply chain in such environment. Therefore, the purpose of this paper is to analyze the configuration and management of supply chain while implementing mass customization. More specifically, the research objectives of this paper are (1) understanding factors necessary to be considered in order to configure and manage the supply chain while implementing mass customization; and (2) recognizing how these factors can be measured. To reach these goals, we first did the literature review and tried to cluster it into research areas to construct our understandings. Four research areas relevant to our objectives were identified. Afterwards relevant factors and indicators related to each research areas were identified and structured in a consistent and understandable framework. In this framework, factors were structured from literature while indicators were developed by this study. As last step we tried to validate the framework by three case studies that employed mass customization at the time of data collection in diverse industries. We shaped this paper as follows: first, we delivered a literature review, next we explained the methodology employed. Then, we presented the framework and finally, we explained validation phase and made the conclusion.

## 2 Literature review

With the aim of mass customization, customer needs to be involved into value creation processes. This involvement can happen in different stages, in relation to different actors within supply chain. The degree of customer involvement in literature is known as *customization level* and has been discussed extremely by scholars [6], [18], [30], [36, 37]. Moreover, the capability of supply chain in implementing it is known as *postponement*. Graman defines postponement as the capability of supply chain in delaying the activities associated to differentiation of product\_ customization processes\_ closer to the time that demand is known [8]. Literature positions postponement differently. Some recognize it only in manufacturing operations [2], [11], [32, 33] while some others take a broad view and distinguish it in supply chain level specially emphasize on differentiation in distribution point [39]. Within those who consider postponement in supply chain level, many discuss about

issues such as the conflict between product variety and quick response time [16], or product growth and cost control at certain point [32, 33]. Generally literature discusses about postponement by either focusing on types of postponement (time, form and place), their evaluation and comparison [11], [17], [39, 40]; or targeting management of inventory to set optimal level of inventory [2], [8], [24], [32, 33]. In both of these groups modularization has been recognized as an enabling method for efficient customization. Based on our literature review, this study analyses modularization to the aim of a better understanding about this method by focusing on its characteristics and advantages [4], [19], [35], [44]. It specifically discusses about the need for a more intimate relationship among supply chain partners to produce, supply and manage the inventory of modules for customization [13], [20], [22, 23]. Literature has put more attention on relationships among partners in customer oriented environments where a more flexible and efficient supply chain is requested. The relationship is interpreted as integration and cooperation between supplier-manufacturer, manufacturer-customer; and among internal divisions of manufacturer [15], [22], [25], [34], [45, 46]. Literature rarely differentiates cooperation and integration and draws the line between them. Some studies, like Pan and Holland [4], defines cooperation as a beneficial relationship between actors namely customer, manufacturer and other partners such as supplier and distributors. It is believed that this relationship aims to improve outcomes like customer satisfaction, time to market or resource usage by setting common objectives and reducing duplicated activities for increasing value added activities [46]. Integration is a more rigorous concept which aims to integrate the actors in both ends (downstream and upstream) to achieve an optimal output. It includes integration of processes, activities, locations and etc. to optimize the performance of all actors as a whole [15], [20, 21]. Moreover, it decreases uncertainties and increases flexibility and responsiveness [20, 21].

### **3 Methodology**

In the first step of this research “supply chain” and “mass customization” were searched in keywords and abstract sections without any restriction or preference over journals. In total 71 articles from 39 different journals were selected to be reviewed. Papers were analyzed in a more detailed level and their main focuses in supply chain were recognized and subsequently clustered (e.g. postponement, modularity and etc.). The output of this step was twelve clusters covering different strategies and methods, called research areas. These research areas have been the starting point for the construction of our framework. Since the conceptual framework was based on literature, this study validated it empirically by three case studies in different industries. Unit

of analysis was manufacturer supply chain (only including first layer suppliers), research domain was manufacturing industry/sector implementing mass customization at the time of data collection, regardless of the size or the level of customization; and expected respondents were operation manager and owner. Validation phase was done by online questionnaire. In particular, the questionnaire consisted of four parts representing framework subjects and aimed to test associated factors and indicators. Questions were multiple choice (without restriction on number of choices) and open-end. Multiple choice questions were used for validation of factors and indicators while open-end questions aimed to initiate respondents to add missing impacting factors and/or indicators.

### 4 Conceptual Framework

A conceptual framework was developed to support configuration and management of supply chain. It identifies four main decision areas that are about relationship management, postponement, level of customization, and modularity level. To reach our objectives, by conceptual framework, we tried to understand relevant elements to be considered for each decision area. For instance in order to manage relationship along a supply chain, this study expects that an industry needs to consider elements such as customer integration level and supplier selection criteria. By following, we structure the work in four sections associated to the framework decision areas. In each section, first we briefly define the decision area and associated elements. Afterwards, we specify relevant impacting factors and indicators for each element (see Table 1).

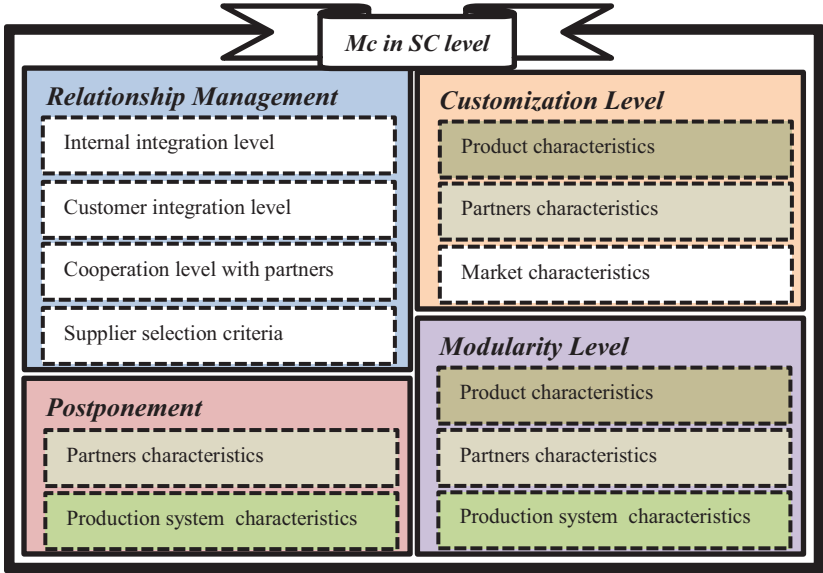


Figure 1\_ Conceptual Framework

#### 4.1 Relationship management

The first decision area is related to different relations that a company (manufacturer) should have with players in supply chain. The aim is to primarily understand who is considered as key partner and is necessary to build close relationship; and how to manage these different kinds of relationships while practicing mass customization. To reach this goal, four types of elements are necessary to be considered. These elements are briefly defined by following:

**Internal integration level:** This element refers to relations inside the manufacturer and points out the importance of internal capabilities in satisfying customer needs responsively. In particular, this element brings out level of interaction between internal departments and employees.

**Customer integration level:** This element highlights the importance of customer and their value-adding contribution inside the supply chain processes. Specifically this element deals with the extension of customer contribution and management of the transferred knowledge.

**Cooperation level with partners:** This element focuses on how to define the extent of relation and then how to manage it with different actors such as suppliers and distributors.

**Partners' selection criteria:** This element emphasizes on the basics which needs to be considered in order to select some partners over the others.

#### 4.2 Customization level

The second area relates to the marginal value that customization brings to the end customer. Definition of this value impacts on the way supply chain operates and creates the customization marginal value. Mass customization levels can be driven from tailored customization (customization in fabrication), customized standardization (customization in assembly); and segmented standardization (customization in package and distribution) [18]. In order to identify the customization level, a company needs to consider three elements. These elements are briefly defined by following:

**Product characteristics:** This element refers to product features that support decisions related to customization.

**Partners' characteristics:** This element refers to capabilities, characteristics and relationships of actors inside the supply chain.

**Market characteristics:** This element refers to extent of customization in relation to market need.

#### 4.3 Modularity level:

Third decision area is related to a method known as modularization that enables a company to efficiently customize products. This study considers only the set of elements, related to the production process and supply chain characteristics, that impacts on product modularization, hence excluding elements related to other types of modularization (such as organizational modularity). The impacting elements are briefly defined by following:

**Product characteristics:** This element refers to product features that support decisions related to customization.

**Partners' characteristics:** This element refers to capabilities of actors inside the supply chain which operationally support modularization.

**Production system characteristics:** This element refers to production capabilities inside of the manufacturing which operationally support modularization.

#### 4.4 Postponement:

Last subject is related to the postponement strategy known as capability of a supply chain to perform customization in a way to delay differentiation or customization closer to the time that demand for the product is known [8]. The aim of this group is to understand appropriate position of customer integration point. To reach this goal, we identify two elements necessary to be considered. These elements are briefly defined by following:

**Partners' characteristics:** This element refers to partners' capability in either carrying out the customization in their location (e.g. distributors' ability in customizing products) or being collaborative and responsive to support core company postponement strategy.

**Production system characteristics:** This element refers to production capabilities inside of the manufacturing which operationally support customer intervention.

## 5 Validation and conclusion

As a final step this study conducted three case studies to validate its findings. In particular by case studies, we tried to understand if impacting factors are practically considered in configuration and management of supply chain. Moreover we tried to test indicators relevance by asking if they are already applied in practice or can be considered beneficial. Based on our case

studies, all impacting factors were validated but certain indicators were not. Customer willingness in participation was never measured and its measurement was believed challenging. Moreover, although all three cases had modular product, but believed that proposed indicator for product architecture was not representative; instead they assert that ration of customizable modules cost on production cost was suggested to be substitute. As a result of this study we create a better understanding of how different factors impact on configuration and management of supply chain in customer-oriented environment. Moreover, we suggest a list of indicators that can support decisions with a better indication on circumstances.

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Table 1 \_List of Indicators dedicated to conceptual framework

<b>Decision area</b>	<b>Elements</b>	<b>Impacting factors</b>	<b>Factor Description</b>	<b>Indicator</b>
<b>Relationship Management</b>	Internal integration level	Capability in exchanging information [20], [21], [25], [45]	This factor impacts on ability of a company to exchange information internally and be responsive to final customers	Number of times that information has been exchanged between departments on a time base (e.g. weekly/ monthly)
		Organizational readiness [25]	This factor refers to employees' skill in understanding the end customer needs and their ability in translating it into know-hows	Order response time
	Customer integration level	Customer willingness in participation [15]	This factor refers to customer willingness in sharing actual demand and in providing feedbacks to issues such as product development	Percentage of customers participating in data collection phase via employed methods/mechanisms/tools
		Information exchange level [15], [25], [26], [45]	This factor focuses on the actual level of information exchanged which has a direct impact on effective implementation of mass customization	Number of methods/mechanisms/tools employed to gather data from customers
	Cooperation level with partners	Joint profits [46]	This factor refers to decisions made jointly to bring out better results in set of aspects such as profit	Percentage of partners with joint profit agreement
Supplier selection criteria	Type of shared information [34]	This factor refers to set of information that its sharing can bring advantages to partners. Sharing information such as delivery due date, cost of delay, total time of manufacturing, and distribution with partners, are some examples which beside profit, brings improvements in service level, quality and etc.	Percentage of partners with shared information with core manufacturer	
	Agility of supplier [45]	This factor refers to dynamic characteristics of a customer-oriented environment. Consequently, concurrent flexible and responsive suppliers are required	Percentage of orders committed to be fulfilled on time	
	Capacity of supplier [19]	This factor refers to power of manufacturer on supplier. In particular it focuses on portion of capacity allocated to the manufacturer	Percentage of capacity allocated to manufacturer	
	Information exchange level [20], [21], [22], [25], [26], [45]	This factor refers to internal capability of supplier in sharing information	Expected time interval in sharing information between supplier and manufacturer (e.g. weekly/ monthly)	
<b>Customization level</b>	Product characteristics	Product architecture [16], [38]	This factor refers to architecture of the product which can impact on its customizability in different levels	Percentage of customizable modules/parts
		Supply chain information exchange level [38]	This factor refers to level of information integration among partners	Expected time interval in sharing information between partners(e.g. weekly/ monthly)
	Partners characteristics	Cost of customization [16]	This factor refers to the trade-off between cost and value of customization. In particular it highlights the advantage of customization, by comparing the cost of customization with the advantages coming from customization	Ratio of cost of customization and customization marginal price
		Market demand [31], [38], [42]	This factor refers to market interest on customized product. It points out the market enthusiasm on type of customization	Percentage of customer interested to aesthetic/function/fitting features
	<b>Modularity level</b>	Product characteristics	Product architecture [19]	This factor refers to the product architecture and points out the feasibility of translating customer requirements into modules
Partners characteristics		Cooperation with supplier [13], [19], [20], [21], [44]	This factor refers to partners' capability in collaborating in customization by considering level of information integration	Percentage of partners with shared information with core manufacturer
Production System characteristics		Production capability [23]	This factor refers to production capability in manufacturing and assembling modules efficiently. In particular it targets efficiency by considering cost of production	Ratio of customization cost on unitary production cost
<b>Postponement</b>	Partners characteristics	Cost of postponement [8], [10], [17], [32], [33], [39]	This factor refers to the cost associated to customization and is faced by supplier	Utilization rate of customization processes/resources (e.g. machine) in supplier plant
		Supply chain information exchange level [38]	This factor refers to level of information integration among partners	Expected time interval in sharing information between partners(e.g. weekly/ monthly)
	Production System characteristics	Inventory levels [11], [2], [9], [12]	This factor refers to the inventory level of partners. It is assumed that the inventory is used for uncertainties and it highlights the impact of penetration point on partners	Inventory level of customized parts/modules on total inventory
		Production capability [10], [40]	This factor refers to manufacturing capability in manufacturing and assembling final products efficiently. In particular it targets to highlight the efficient integration of customers by considering its impact on time	Ratio of point of customization time to delivery and production time

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