ANNALS OF FACULTY ENGINEERING HUNEDOARA
– International Journal of Engineering
Tome XI (Year 2013) – FASCICULE 2 (ISSN 1584 – 2665)

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ANALYSIS OF FACTORS FOR SUCCESSFUL IMPLEMENTATION OF MASS CUSTOMIZATION: KEY RESOURCES AND KEY ACTIVITIES

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ABSTRACT: Nowadays mass customization (MC) is a strategy pursued by many firms in order to achieve a sustainable competitive advantage through providing customers with customized products while at the same time keeping desired level of efficiency. This paper analyzes the key resources and activities that could be considered as enablers of MC. This paper aims at investigating in deep different enablers of MC focusing on key resources and key activities while trying to create a better understanding about potential impact of these enablers on four pillars of MC called as customer co-design, stable solution space, meeting needs of each individual customer and adequate cost and price level.
KEYWORDS: Mass customization, Key activities, Key resources, Enablers

INTRODUCTION

Increasing customers interest on individualized offers and their fascination in co-creation processes make MC a winning solution in different sectors. As any other strategy MC requires proper resources and activities to support its implementation in a successful manner. This paper analyzes the key resources and activities that could be considered as enablers of MC. Key activities are the most important actions that a company needs to operate successfully while key resources are referred to any physical, financial, intellectual, or human resources that let an enterprise to offer value proposition, reach customer, maintain relationships with customer segment and earn revenues [2].

By this study a list of possible key resources and key activities is provided to make it easier for newcomers to select their appropriate alternatives on the way to perform MC. It is evident that once the reference list becomes available, it is necessary to understand which elements have to be considered to select some alternatives over the others. The answer depends on contingent elements like product type, customization level, available technology, internal and external context analysis of single enterprise and etc. Regarding to this point, this paper bases its analysis on main drivers of MC and tries to create better understanding about impact of each alternative on these drivers. Drivers are known as pillars of MC and are pointed out for the first time in most agreed MC definition given by Piller where he defines MC 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. As a result the costs associated with customization allow for a price level that does not imply a switch in an upper market segment"[12]. Accordingly selection of alternatives is investigated by their impact on the four pillars, namely: customer co-design, stable solution space, meeting needs of each individual customer and adequate cost and price level.

To structure list of alternatives primarily it is necessary to introduce objectives that through implementation of MC an enterprise should have in mind to configure its key activities and key resources. Definition of objectives and supporting alternatives in this paper is based on literature review. Regarding selection of alternatives one should take into account that:

1. One objective can be reached by implementation of one or more than one supporting alternatives
2. One alternative can act as a pre-requisite of another alternative.

Consequently in sections 2 and 3 objectives and alternatives of key activities and key resources are going to be described (Table1 and 2 show allocation of alternatives on objectives). Section 4 will indicate the impact analysis of alternatives on the MC pillars (Table3) and section 5 will draw some concluding remarks.

KEY ACTIVITIES. Objectives

Any strategy requires set of key activities to actually assure execution of its goals. MC as a customer oriented strategy needs a set of key activities to efficiently provide customized products to mass market. Different studies tried to distinguish key activities of MC. Fogliatto et al.[9] divided them into four stages as order elicitation, design, manufacturing and supply chain coordination. In this study we define five main objectives through which MC goals can be achieved.

- *Elicit customer requirements: MC with its intention to translate individual needs into products and services requires undertaking a set of activities to generate information about customer preferences. This process is known as "elicitation process" and supports enterprise in different ways [34]. Obtained information during elicitation can help enterprise to find the best solution for customer and can create better understanding about actual customer expectation from customized product.*
- *Develop product variants and solution space based on MC dimensions (axes): to develop proper product variants and solution space it is necessary to initially decide about one main issue which is value of customization. Value of customization refers to the added value that through MC a customer can gain. This value is categorized in three general dimensions (fit (measurements), form (style and aesthetic design) and functionality) and can match the demand of a customer toward any offering [12]. Once customization dimensions have been decided (it could be only one dimension or three of them), it is possible to develop product variants and associated solution space. Development of mass customized offer is based on translation of individual needs into a generic product and service architecture. This general architecture supports adaptation of different customer requirements into final product and service variants at low cost [39]. Consequently process of product development in MC should drive into development of a stable/limited space which represents "the pre-existing capability and degrees of freedom built into a given manufacturer's production system" [8]. This space which is known as stable solution space actually includes set of stable but still flexible and responsive processes through which customized offers are possible to be produced [12].*
- *Increase agility of supply chain: In fast changing environment enterprises are faced with many challenges in supply chain to meet up with demand variability, service improvements, inbound costs, on-time delivery and shorter customer lead times and etc. In order to find a way out Marcus [18] believes that enterprises need to redesign their supply chain in a more agile way. Based on Christopher [28], agile supply chain is characterized as a system which is flexible/adaptable, quick and responsive to changing markets. Hedefines flexibility/adaptability as "the ability to implement different processes and apply different facilities to achieve the same goals", quickness as "the ability to complete an activity as quickly as possible" and responsiveness as "the ability to identify changes and respond to them quickly, reactively or proactively, and also to recover from them" [28]. Essentially agile supply chain is explained as "the alliances of legally separated, but associated by their activity companies (suppliers, designers, producers, logistics), that are interrelated by forward material supply and backward information flows" [25].Some authors believe that agility in supply chain can be achieved by collaborative relationship, process integration, information integration and customer sensitivity [18], [28].*
- *Share and manage customer knowledge: MC with its intention to deliver customized product to each single customer includes large set of knowledge along its whole supply chain which needs to be shared and managed within whole supply chain smoothly [39]. Daaboul et al. [19] define knowledge management as a "business process that identifies, collects, creates, organizes, stores and distributes valuable knowledge in order to apply it to problems and use it to attain certain goals" and they believe that it can result into better customer relationship management, supply chain management and product development.*
- *Arrange efficient production: Based on Tseng and Jiao [30], through MC goods and services have to be customized while keeping the level of efficiency near mass production. Consequently arranging a production which is able to have an efficient performance is essential.*

Alternatives

- *Supporting alternatives for "Elicit customer requirements" objective:*
  - *Recognizing customer individuality:Based on type of customization, different ways are possible to extract customer preferences and individualize offers. For instance, thanks to new in-store technologies some supermarkets are able to customize their services by identifying customers based on their previous purchases and propose them coupons or discounts [23]. Another way is to mine this information during customer selection from list of alternatives. This procedure could be followed by internet or through sales and distribution points. In some related offers extraction of customer requirements are done through physical measurements [34].*
  - *Collecting customer feedback from prototypes: Prototypes are used in order to elicit information. In some industries like building, architecture and even furniture prototypes are used to better*

understand customer needs. For instance, furniture maker, simply provides online 3-D views of sofas and chairs or Streif as a construction company invites customers in its website to "build your house with the mouse" in order to elicit customer information [34].

- *Translating customer requirements through co-creation: In MC, creation of the final product is carried out together with customer who is involved since design, production or delivery phase. Therefore, one way to understand customer preferences is during co-creation process when he/she interacts directly to define final product [34].*

□ *Supporting alternatives for "Develop product variants and solution space based on MC dimensions (axes)" objective:*

- *Developing product platform and modules by considering commonality in modules and components: Product platform is a mean to develop product family with minimum cost [15]. A product from a family is produced by using the platform and adding or removing some components or modules which are assembled in a platform. Fogliattoet al.[9] state that platform is a combination of commonality and modularity. PreviouslyBlecker and Friedrich [39]defined product platform as a "common module that can be implemented into a wide range of end variants of the product family". Many companies develop their product variants through platform architecture like Volkswagen since it reduces development and production cost. Based on Blecker and Friedrich [39]"Modularity ideally involves a one to one mapping from the elements of the function structure to product building blocks". MC with its finite solution space, requires set of stable, responsive and flexible processes which result into yield output limited to certain specifications. Theses specifications represent modular product design. Each module represents one or some functions of the product and would be available by several options which results into different performance of the product. Actually varied performance, points out product variants which are output of different combination and mixture of modules [10]. Modularity could result into advantages in economy of scale and scope and further reduction in lead time if well be defined hence, it may result into elimination by competitors although their development are costly [39]. Likewise, commonality is used to take advantage of economy of scale, lower inventory level and less difficulties in forecasting needs [35]. Multiple use of components, modules and subassemblies within and across product variants significantly effects on level of internal complexity [40]. Commonality could be applied internally (internal components or parts like hidden wires inside the car which is not distinguishable for customer) or externally (same dashboards for all car variants) and although internal commonality brings stated advantages to manufacturer but risk of customer difficulties in recognizing difference between variants creates threat of cannibalization [34].*
- *Undertaking variety management: MC with its scope to translate customer requirements into offers can result into a very high amount of variants. Blecker et al.[40]differentiate product platform in two types of customer-inherent and customer-coherent configurations. By customer-coherent configuration level of configurational freedom is limited and customer has to choose between predefined numbers of variants while by customer-inherent configuration additional freedom is given to customer for constructional changes within a certain defined scopes. Evidently inherent product configuration leads to high level of complexity and requires being efficiently managed [40].*

□ *Supporting alternatives for "Increase agility of supply chain" objective:*

- *Integrating with supply chain partners in processes and in sharing information: Integration of supply chain in fast changing environment that customer asks for individualized offers especially in complex products enhances operational capability of system to deliver requested product or service. Integration of supplier means the extent in which a supplier could collaborate and manage some inter-organizational activities with manufacturer. Because of standardization of operations in MC, the role of integrated suppliers are more tangible and even it becomes more essential to create a long-term collaboration between manufacturer and supplier. Based on what has been described, supplier integration make manufacturer to align its offer with suppliers competences and limitations. Although mentioned alignments are multidimensional but at last supplier integration provides critical knowledge to manufacturer and improves its level of competitiveness [31]. Moreover Piller believes that by co-creation customer also has been integrated to create value with manufacturer and by this way customer competence is transferred [11]. An effective integrated information technology system for MC supply chain could help to translate customer requirements and convert them to parts and manufacturing specifications manage inventory and production processes; and plan for logistics and distribution [39].*
- *Reaching customers through efficient logistics services: MC with low volume and high variety of customized products that delivery in some cases needs to take place in customer door makes it challenging for companies to guarantee on-time delivery and control level of cost. Consequently companies choose to take advantage of third-party services. Nowadays, close relationship with logistics partners enables companies to provide customized products such as vitamins, coffee and*

etc. into hands of customers. Depending on type of product, customized offers could be delivered online without any physical distribution. Products such as CDs, books, software products and movies can be delivered electronically thanks to the internet [23].

☐ *Supporting alternatives for "Share and manage customer knowledge" objective:*

- *Managing customer knowledge: Knowledge management has been recently gaining wide attention. Wind andRangaswamy [23] stress the need to transfer knowledge to and from customers to facilitate implementation of MC. Huang et al. [43]studied customer knowledge in MC and they divide it in four types as knowledge about customers (which includes customer requirements, customer information and consumer satisfaction and loyalty that mainly refers to customer information about what they need in functional, quality and even emotional point of view and what are their conditions like their level of income and etc.), knowledge from customer (which consists of the options of mass customized products and market assessment that on one hand it points out customer evaluation of the received mass customized product and services and on the other hand it evaluates competitive positioning of company in comparison with competitors in market), knowledge for customer (it includes product introduction and module functions and options) and knowledge co-creation with customers (it contains knowledge that customer created in design and marketing stage which brings advantage to a company in creating sustainable competitiveness).*

☐ *Supporting alternatives for "Arrange efficient production" objective:*

- *Applying efficient and flexible manufacturing system: MC as a solution for fast changing environment requires having a flexible and efficient system in order to adapt itself to changes but before introducing flexible manufacturing system, it is better to define flexibility in first stage. Flexibility is referred as "capability of a system to adapt to changes that occur in its environment" and in manufacturing has been recognized in eight types as machine, process, routing, volume, expansion, operation and production [42]. Mass customized products with standard and customized parts are required to be manufactured in almost the same cost that standard mass produced products are manufactured in order to keep level of efficiency high. Consequently they should use proper flexible manufacturing system.*
- *Implementing postponement strategy: MC system requires a strategy to ensure flexibility and efficiency in supply chain and postponement is common solution. Graman defines postponement as "the capability of a supply chain to delay product differentiation, or customization, until closer to the time that demand for the product is known" [14]. Decoupling point represents the stage that differentiation happens. Activities before decoupling point are standard and are based on forecast while following activities are production for customization and are based on customer order [17]. Decoupling point can be located at five positions in the supply chain and provides different levels of customization: customer (mass production), retailer (minor customization), assembler (partial MC), manufacturer (MC), and supplier (real-time MC) [22].*

Table 1. List of MC Key Activities

Objective	Alternative
Elicit customer requirements	Recognizing customer individuality
	Collecting customer feedback from prototypes
	Translating customer requirements through co-creation
Develop product variants and solution space based on MCdimensions (axes)	Developing product platform and modules by considering commonality in modules and components
	Undertaking variety management
Increase agility of supply chain	Integrating with supply chain partners in processes and in sharing information
	Reaching customers through efficient logistics services
Share and manage customer knowledge	Managing customer knowledge
Arrange efficient production	Applying efficient and flexible manufacturing system
	Implementing postponement strategy

KEY RESOURCES. Objectives

Implementation of MC is not feasible without application of some key resources. These resources might be physical, intellectual, human or financial resources. There are different studies focusing on required key resources to pursue MC. Pollard et al. [7] mention flexible manufacturing processes and integrated information system as two main resources for MC, while some others focus also on other physical resources such as scanners and measurements systems. Xing et al. [3] consider reconfigurable manufacturing system as one of the main resources for a MC company. Considering above mentioned facts we defined five main objectives which can be achieved applying key resources of MC:

- *Increase flexibility of manufacturing system: Due to the fact that flexibility is one of the key enablers of MC, increase of flexibility level of manufacturing system should be considered as a critical objective in order to implement MC successfully. One of the critical enablers of MC is flexible manufacturing system. It is a customer-centric manufacturing system which tries to balance two important principles of MC which are product standardization and manufacturing flexibility. Based on many studies MC can be implemented successfully by having reconfigurable processes and operations to satisfy quickly changing customers demands. Hence one of the important goals in design a manufacturing system for MC is to reach the above mentioned goal. In this regard a competitive manufacturing system needs to be flexible enough to respond to small batches of customer demand [36].*
- *Increase reconfigurability of manufacturing system: In some cases it is not enough to have a flexible manufacturing but we need a manufacturing system which can adapt itself to sudden changes and reconfigure based on different requirements. Pursuing MC in a business means a shift from high volume and low variety production to low volume and high variety production. In this regard manufacturing system needs to be not only flexible enough but also responsive enough in product delivery. In order to provide manufacturing system with required flexibility and responsiveness and therefore gain a competitive advantage in a MC environment, reconfigurable manufacturing systems (RMS) are one of the main solutions proposed by many studies and researches. Reconfigurable manufacturing systems are capable of quick change in software and hardware modules as well as their structure and this is the main feature enabling them to adjust quickly to required production capacity and functionality.*
- *Increase customization level using points of sales system: Applying some resources in point of sale of company can have a considerable impact on level of customization of the product which is proposed to customer. New technologies applied in measurement and scanning devices enable companies to determine exact information related to customers in order to provide them with customized products.*
- *Increase level of information integration: Knowledge management is a key success factor for MC. Consequently having an integrated information system which can facilitate information flow in organization is a main objective while talking about key resources. Information system in MC has critical functions. It enables company to access its resources in different parts of the globe, collect information and data about customers and create knowledge out of these data. Based on Kissimoto and Laurdino [24] there are four main functions of IT for MC: (i) customer interaction and monitoring, (ii) collection and analysis of customer's data, (iii) flexibility in the supply chain, and (iv) integration of the links in the chain. The acquisition of customized products, in most of the cases, is positively correlated to the level of customer satisfaction. However, it is not feasible to reach such a level of satisfaction without acquiring enough information about customer needs. Therefore the integration and alignment between IT strategy and business strategy is essential for a successful implementation of a MC strategy. In general, a MC system depends a lot on an efficient information system that integrates customers and partners within company and customization process [20].*
- *Support customers in co-design via human resource: A MC Company should provide support for customers during co-creation process. This is an objective which can be fulfilled by some human resources of the company.*

Alternatives

Supporting alternatives for "Increase flexibility of manufacturing system" objective:

- *Automated manufacturing and assembly: Automated manufacturing and assembly system is one of the key components of flexible manufacturing systems. It mainly refers to implementation of automation in different manufacturing and assembly procedures in factory. This can be reached thanks to different components and technologies such as Computer integrated machines (CIM), Computer Numerical Controlled machines (CNC), different types of robots and Direct Numerical Controlled machines (DNC). Having an automated manufacturing and assembly is a key enabler to implement MC since it increases system ability to respond to changes. Hence it leads to higher consistency and quality, reduced lead times and simplification production.*
- *Automated material handling system: In order to keep level of flexibility in a required level and facilitate handling of materials in FMS, application of automated handling system is a key approach. Automated material handling systems consist of Automated Guided Vehicle (AVG), Automated Storage and Retrieval Systems (ASRS) and conveyors.*
- *Automated inspection system: Nowadays different types of sophisticated sensors have been developed for different functions. This leads also to application of automated inspection and quality control system to maintain an optimum level of consistency and quality of products. According to Hedenborn and Bolmsjo [32] product quality and inspections is an important factor in flexible manufacturing system to ensure product quality. In traditional systems inspection is done*

manually buy using fixtures or coordinates measuring. However, in automated manufacturing systems, this is not feasible due to the absence of human inspectors [29]. In order to design a flexible robotized inspection system different factors and aspects need to be considered.

- *Supporting alternatives for "Increase reconfigurability of manufacturing system" objective:*

- *Reconfigurable machine tools: One of the key sub-systems of a reconfigurable manufacturing system is reconfigurable machine tools. By having a modular design of machine tools it is possible to create a high degree of reconfigurability by changing, adding or removing modules/ tools. According to Koren et al. [45] the primary aim of a reconfigurable machine tool (RMT) is to cope with various changes in the products or parts to be manufactured. RMT can be used for different objectives such as Reconfigurability for work piece size, Reconfigurability for part geometry, Reconfigurability for production volume and rate, Reconfigurability for changes in machining process and Reconfigurability for machining accuracy. Reconfigurable machine tools has are designed to meet the requirements of modularity, integrability, customization, convertibility, and diagnosiability, so that the machines can reconfigure frequently in the fast-changing environment [45].*
- *Reconfigurable assembly systems: Reconfigurable assembly systems are usually robotized. Degree of reconfigurability can be even increased by using modular robots. In order to meet the product requirements different types and numbers of assembly equipment can be used [46].*
- *Reconfigurable inspection system: Reconfigurable Inspection System (RIS) is a new type of inspection equipment which allows in-line measurements of machined parts. RIM allows manufacturing a rapid and real-time inspection and correction of manufacturing processes. This type of inspection system is made of a precision conveyor which moves the processing part along an accurate axis of motion. There are digital or line scanning camera as well as laser-based sensors to inspect the processing part. Using RIP not only increase quality level in manufacturing line but also reduces required time to reach production level targets during ramp-up [44].*
- *Reconfigurable material handling system: The main types of reconfigurable handling systems are AVGs and conveyors. Development of such system, however, is one of the main research areas nowadays. Fukuda and Takagawa [41] have designed a flexible transfer system for a large number of product variants. The main system components are autonomous robots. Ho et al.[21] have developed a reconfigurable conveyor system; which allows to change the product volume in real-time. Automation Tooling System (ATS) in Canada has developed a programmable conveyor, which allows the conveyors to turn pallets from one section to another [6].*
- *Process monitoring system: In a reconfigurable manufacturing system there is an essential need to monitor the manufacturing processes in real time. This lets the firm to increase degree of flexibility in processes and respond in real time. The main devices in this regard are different types of sensors. For instance as Minhas et al. [37] declare in their study laser triangulation sensors can be used in a broad range of applications; particularly in assembly and joining operations. They have become more and more important in process measurement due to the fact that they are capable of real time measurement with high accuracy. Using these sensors in different activities leads to decrease in the required time to do the activity. A clear example in this regard is assembly activity.*

- *Supporting alternatives for "Increase customization level using points of sales system" objective:*

- *Measurement devices: Measurement device is usually used in customization of apparel and shoes in order to capture the exact measurement of customers' foot and body. According to Boer and Dulio [5] there are two classes of these kind of devices in shoe sector that can be used by MC companies 1) Manually/automatically operated measuring machines: This type of scanners which are usually manually register the 3d location of some selected points of customer's foot, preparing a digital model out of it and then based on this data some features such as width, breadth and length are calculated. Due to the fact that these types of devices are operated manually there is a need of trained personnel who can operate them. 2) Fully fledged foot scanners: This type of scanners use emerging technologies such as optical, photogrammetric and laser technologies which can create a 3D digital model of customer's foot. Based on the complete data provided by these technologies different measures of customer's foot can be calculated in order to provide customers with exactly fit customized shoes. According to Lee and Chen [38] in the apparel industry, there are different enabling technologies for MC. Each individual customer can be measured using laser body scanning and special software can generate a digital image of customers based on measurements. The most highly developed measurement device measures the entire body three-dimension trend for apparel industry production and retail [26].*

- *Supporting alternatives for "Increase level of information integration" objective:*

- *Configurators: A Configurator is an essential resource to implement MC and it is widely applied by MC companies to enable their customers to design a product based on their needs and desire. According to Ardito et al. [4] configuration of a mass customized product takes place in several* *steps and considering different aspects of customization defined by the company such as colour, material, fit etc. The role of configurator is to handle all the steps of configuration. It is a highly visual interactive environment where customers have the possibility to configure their product and see it at the same time every time that they modify their design. They can confirm purchase of final product designed by them only after they are satisfied with virtual product presented by configurator.*

- *Order processing system: Order processing system is a critical module of integrated information system which facilitates easy information flow among different parts of the company. Order processing systems vary based on their functionalities. Some of them simply transfer collected data from points of sale to manufacturing unit while others integrate points of sale with production management and planning system.*

□ *Supporting alternatives for "Support customers in co-design via human resource" objective:*

- *Trained personnel: In order to implement MC in a successful manner, one of the key resources is trained human resource. Trained personnel in MC usually refer to personnel working in physical stores giving help and advice to customers to personalize their product.*

Table 2.List of MC Key Resources

Objective	Alternative
Increase flexibility of manufacturing system	Automated manufacturing and assembly
	Automated material handling system
	Automated inspection system
Increase reconfigurability of manufacturing system	Reconfigurable machine tools
	Reconfigurable assembly systems
	Reconfigurable inspection system
	Reconfigurable material handling system
	Process monitoring system
Increase customization level using points of sales system	Measurement devices
Increase level of information integration	Configurators
	Order processing system
Support customers in co-design via human resource	Trained personnel

WHAT ARE THE IMPACTS ON MASS CUSTOMIZATION PILLARS?

Different alternatives of key resources and key activities can be applied to affect different pillars of MC defined by Piller [12].Therefore it is crucial to identify which pillar is covered by which alternative. In this way companies can select desired enablers more effectively based on their predefined goals and targets. We would like to mention that the four illustrated pillars of MC in table 2 are exactly based on definition suggest by Piller. Below is a brief description of each aspect:

□ *Customer co-design: The process of integration of customer in defining, configuring, matching or modifying the customized product that takes place during a direct interaction and cooperation between company and customer.*

□ *Meeting the needs of each individual customer: The core competitive advantage of MC is providing customized products that match customers' needs much better than standard products. Therefore is not simply produced to satisfy a general need but to satisfy different needs of different customers from very divers perspectives such as function, aesthetic and fit.*

□ *Stable solution space: Solution space is defined as "the pre-existing capability and degrees of freedom built into a givenmanufacturer's production system" [8]. In MC, however, it is not adequate to have a solution space but it is essential to have a stable solution space. The term "stable" here refers to stable but still responsive and flexible processes to existing dynamic demand change in MC. Without having a stable solution space it is not possible to keep the desired efficiency. It is a pre-requisite for another aspect of MC which is described below.*

□ *Adequate price and cost level: MC should not let companies to target a higher level of the market therefore the price should be substantial but still affordable. This requires a tight control on cost level of the product which can be reached through economies of integration [12].*

In table 3 wherever an alternative corresponds to a specific pillar of MC, this correspondence is illustrated by "X". For instance the alternative "develop product platform and modules considering commonality in modules and components" impacts on three pillars of MC. It supports company to meet the needs of each individual customer due to the fact that diverse customized products can be configured by different customers through combinations of common modules. Moreover applying modularity helps company to define a stable solution space and it is an enabler to control cost level (and consequently price level) since standard modules do not require high cost. Hence two MC pillars "stable solution space" and " adequate cost and price level" are covered by this alternatives in addition to " meeting the needs of each individual customer". Therefore the higher number of "X" in a row represents the fact that the specific alternative covers higher number of MC pillars.

Table 3.List of MC Key Activities and Key Resources on MC pillars

		MC Pillars / Alternatives	Customer co-design	Meeting the needs of each individual customer	Stable solution space	Adequate price and cost level
Key Activities	Elicit customer requirements	Recognizing customer individuality	X	X		
		Collecting customer feedback from prototypes	X	X		
		Translating customer requirements through co-creation	X	X		
	Develop product variants and solution space based on MC dimensions (axes)	Developing product platform and modules by considering commonality in modules and components		X	X	X
		Undertaking variety management	X	X	X	X
	Increase agility of supply chain	Integrating with supply chain partners in processes and in sharing information	X	X	X	X
		Reaching customers through efficient logistics services		X		X
	Share and manage customer knowledge	Managing customer knowledge		X		X
	Arrange efficient production	Applying efficient and flexible manufacturing system			X	X
		Implementing postponement strategy		X	X	X
Key Resources	Increase flexibility of manufacturing system	Automated manufacturing and assembly		X	X	X
		Automated material handling system			X	X
		Automated inspection system				X
	Increase reconfigurability of manufacturing system	Reconfigurable machine tools			X	X
		Reconfigurable assembly systems		X	X	X
		Reconfigurable inspection system				X
		Reconfigurable material handling system				X
		Process monitoring system				X
	Increase customization level using points of sales system	Measurement devices	X	X		X
	Increase level of information integration	Configurators	X	X		X
		Order processing system	X	X		X
	Support customers in co-design via human resource	Trained personnel	X	X	X	X

CONCLUSIONS

Any kind of strategy can fail to deliver value and gain benefits, if they don't get implemented well. This implementation derives by set of key activities and key resources. This research supports implementation of MC by highlighting the impact of alternatives on pillars of the concept and enables enterprise to understand which alternatives are more critical as they impact on more pillars. For instance if company decides to "Developing product platform and modules by considering commonality in modules and components", it can be considered as critical enabler since it can impact on 3/4 pillars. Although this study investigates on correspondent pillars for each alternative but further investigation on evaluation of impact is recommended.

ACKNOWLEDGEMENT

This work has been partly funded by the European Commission through S-MC-S (Sustainable Mass Customization – Mass Customization for Sustainability) Project (Grant Agreement No: FoF.NMP.2010-2 260090 - S-MC-S).

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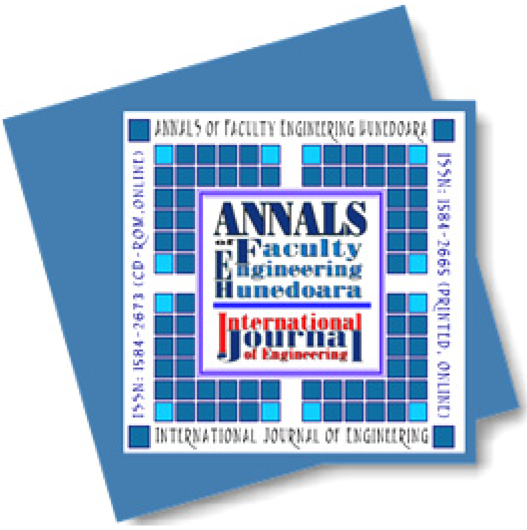

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