

PART 1

Strategic

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Chapter 1

Mass Customization as an Enabler of Network Resilience

1.1. Introduction

In 1954 Drucker stated that “[i]t is the customer who determines what a business is” [DRU 54, p. 37]. As this statement clearly shows, the competitiveness of many companies depends strongly on the firm’s ability to manage its supply chains in accordance with the customers’ preferences. In times of globalization, today’s industry often encounters an uninterrupted trend toward heterogeneity of customer demand. This trend has many causes a changing demographic structure, a growing number of single-households, an orientation toward design and a new awareness of quality and functionality that demands durable and reliable products corresponding exactly to the specific needs of the purchaser [ZUB 03, AND 07, FRA 09]. Owing to this heterogeneity in customer demand, manufacturers are forced to create product portfolios with an ever increasing number of product variants, but with rather low lot sizes at the same time.

Besides these changes in customer demands, the manufacturers themselves and their production processes have changed dramatically over time. Manufacturers today often serve customers all around the globe and thus have established global distribution networks to reach new customers. Furthermore, they tend to focus on their core competencies and outsource other production steps to their suppliers [PRA 90]. Particularly in today’s highly competitive business environment,

activities for serving customers within the production network have to be performed both efficiently and effectively – they have to be organized around a customer-centric supply and demand chain. Yet despite all the technological advances, this is by no means a straightforward task.

Since the early 1990s, mass customization has emerged as one leading idea for achieving precisely this objective. Mass customization is defined as “developing, producing, marketing, and delivering affordable goods and services with enough variety and customization that nearly everyone finds exactly what they want” [PIN 93a, p. 44]. In other words, the goal is to provide customers what they want and when they want it. Hence, companies offering mass customization are becoming customer-centric enterprises [TSE 03b], organizing all of their value creation activities during interaction with individual customers. In consequence, mass customization has to be regarded as a business paradigm that has the potential to add value by directly addressing customer needs and in the meantime utilizing resources efficiently without incurring excessive cost. This is particularly important at a time where competition is no longer just based on price and the conformance of dimensional quality.

However, the implementation of such a mass customization strategy is quite complex, as it requires customer centricity in all stages of the value chain. Companies need to gain specific, strategic capabilities in order to implement mass customization successfully. This chapter will describe how the concept of mass customization could be applied across global supply networks in order to enable network resilience.

1.2. The increasing importance of customer-centric manufacturing networks

The idea of a customer-centric enterprise and customer-centric supply chains is to focus all company and supply chain operations on serving customers and delivering unique value by treating customers as individuals [SHE 00, TSE 03b, PIL 06]. To offer a better understanding of the specifics of customer centricity, this section will briefly review the role of customer centricity in supply chains and manufacturing networks.

In the area of supplier relations and business-to-business-transactions, we can today discern that the dominating form of organization for carrying out value creation processes is represented by networks. The supplier networks in today's automobile industry are a suitable example for this trend. In order to differentiate themselves more efficiently from their competitors, many companies today concentrate on their core competencies – or, the areas in which they have a high

level of competence in fulfilling customer needs [PRA 90]. However, this also means that all activities not belonging to a company's core competencies are outsourced to external suppliers, who can deliver using the advantages of specialization (production based upon economies of scale and scope). Vertical partnerships along the supply chain (integration of suppliers in manufacturing processes), as well as horizontal partnerships in distribution (e.g. sales cooperation) result. These topics have been comprehensively discussed in literature [FRO 01, GHO 95, HAY 84, PIC 94, PIC 03, ZAH 02].

Customer centricity combines the organizational perspective of customer orientation with the individual perspective of relationship management [TSE 03b, PIL 06]. It also extends the responsibility of dealing with customers from solely the marketing function to the entire organization. Customer centricity means that the organization as a whole is committed to meeting the needs of all relevant customers. At the strategic level, this translates to the orientation and mindset of a firm toward sharing interdependencies and values with customers over the long term. At the operational level, companies have to align their processes with the customers' convenience, instead of focusing on the convenience of operations. Of course, sufficient infrastructural systems and leadership structures have to be implemented to achieve this state. These changes include a customer-centric organizational structure. Traditionally, separated functions such as sales, marketing (communications) and customer service will be integrated into one customer-centered activity [SHE 00]. Further, customer centricity is switching the marketing perspective from the demand side to the supply side [PIL 05]. Marketing management has traditionally been viewed as demand management. The focus has been on the product or the market, and marketing has had to stimulate demand for an offering through promotional activities such as incentives or pricing policies. The customer-centric enterprise is switching its focus to the individual customer as the starting point for all activities. Instead of creating and stabilizing demand, that is trying to influence people in terms of what to buy, when to buy and how much to buy, firms should try to adjust their capabilities including product design, production, sales and supply chain design to respond to customer demand.

Mass customization can be seen as a way of thinking for companies to achieve these goals of customer centricity, both with regard to marketing and sales as well as to operations and supply chain management. Therefore, the following chapter will briefly introduce the concept of mass customization and describe a set of organizational capabilities that are necessary for a successful implementation of mass customization within a manufacturing network.

1.3. Mass customization: providing an organizational structure for resilient manufacturing networks

From a strategic management perspective, mass customization is a differentiation strategy. Referring to Chamberlin's [CHA 62] theory of monopolistic competition, customers gain the increment of utility of a customized good that better fits their needs than the best standardized product attainable would. The larger the heterogeneity of all customers' preferences, the larger is the gain in utility [KAP 07].

Davis, who initially coined the term in 1987, refers to mass customization when "the same large number of customers can be reached as in mass markets of the industrial economy, and simultaneously [...] be treated individually as in the customized markets of pre-industrial economies" [DAV 87, p. 169]. Pine defined mass customization as "developing, producing, marketing and delivering affordable goods and services with enough variety and customization that nearly everyone finds exactly what they want" [PIN 93a, p. 44]. This definition clearly highlights the idea of customization. Every individual customer should be able to find products and services that exactly fit his needs. This concept is based on the idea that every customer envisions an "ideal product", which will be used as a benchmark for all products that are available on the market. In consequence, customers will most likely choose the one product that is closest to their "ideal product". Research has shown that this "distance" between an available product and the respective ideal product can be regarded as an indicator for the value that a customer perceives in a product; the better a product fits the customer's needs, the higher will be the willingness of this customer to pay [FRA 04, PIL 04]. Subsequently, customizing a product to the needs of individual customers might lead to increased revenues.

However, companies can only benefit from this increase in revenues, if the cost of providing the customized goods does not increase even more than the revenues. This notion is captured better in the definition by Tseng *et al.* [TSE 96]. They define mass customization as a business strategy that "[...] aims at best satisfying customers' individual needs with near mass production efficiency" [ZHA 07]. The definition clarifies that companies can only benefit from mass customization, if they provide their customized products in an efficient manner. This aspect is crucial for the idea of mass customization, as the process of delivering products that fit individual customers' needs can be described with the word "customization" only.

However, to reap the benefits of mass customization, managers must not think of it as a stand-alone business strategy for replacing production and distribution processes, but as a set of organizational capabilities that can enrich the portfolio of capabilities of their organizations. Mass customization means to profit from the fact that all people are different, that is, turning heterogeneities in the customer domain

into an opportunity to create value, rather than a problem to be minimized, challenging the “one-size-fits-all” assumption of traditional mass production.

Companies that master the proposition of mass customization successfully have built competences around a set of core capabilities. The key to profiting from mass customization is to regard it as a set of organizational capabilities that can supplement and enrich an existing system. While specific answers on the nature and characteristics of these capabilities are clearly dependent on industry context or product characteristics, research has shown that three fundamental groups of capabilities determine the ability of a firm to mass customize: solution space development, robust process design and choice navigation [SAL 08, SAL 09]. These capabilities are briefly introduced in the following:

- Solution space development: First, a company seeking to adopt mass customization has to be able to understand the idiosyncratic needs of its customers. This is in contrast to the approach of a mass producer, where the company focuses on identifying “central tendencies” among its customers’ needs, and targets them with a limited number of standard products. Conversely, a mass customizer has to identify the product attributes along which customer needs diverge the most. Once this is understood, the firm knows what is required to properly cover the needs of its customers. Consequently, it can draw up the so-called solution space, clearly defining what it is going to offer and what it is not.

- Robust process design: A second critical requirement for mass customization is related to the relative performance of the supply chain. Specifically, it is crucial that the increased variability in customers’ requirements does not lead to significant deterioration in the firm’s operations and supply chain [PIN 93b]. This demands a robust supply chain design – defined as the capability to reuse or recombine existing organizational and supply chain resources to fulfill differentiated customers’ needs. With robust process design, customized solutions can be delivered with near mass production efficiency and reliability.

- Choice navigation: Finally, the firm must be able to support customers in identifying their own problems and solutions, while minimizing complexity and burden of choice. When a customer is exposed to too many choices, the cognitive cost of evaluation can easily outweigh the increased utility from having more choices [HUF 98, PIL 05]. As such, offering more product choices can easily prompt customers to postpone or suspend their buying decisions. Therefore, the third requirement is the organizational capability to simplify the navigation of the company’s product assortment from the customers’ perspective.

In the following, the three fundamental capabilities of mass customization will be presented in greater detail.

1.3.1. *Solution space development*

A mass customizer must first identify the idiosyncratic needs of its customers, specifically, the product attributes along which customer needs diverge the most. This is in stark contrast to a mass producer, which must focus on serving universal needs, ideally shared by all the target customers. Once that information is known and understood, a business can define its “solution space”, clearly delineating what it will offer and what it will not. This space determines what universe of benefits an offer is intended to provide to customers and then within that universe what specific permutations of functionality can be provided [PIN 95].

1.3.1.1. *Options for customization*

From the perspective of product development, customization can create value via three design features of a product (or service), any of which can become the starting point for customization: the fit (measurements), the functionality and the form (style and esthetic design) of an offering [PIL 05]. These are generic dimensions that match the demand of a customer toward an offering. Along those dimensions, heterogeneities of demand from a customer perspective can be derived. The solution space should represent choice options for those dimensions where customer heterogeneities matter in a particular case.

– *Fit and comfort (measurements)*: The traditional starting point for customization in consumer good markets is to fit a product according to the measurements provided by the client, for example body measurements or the dimensions of a room or other physical objects. Market research identifies a better fit as one of the strongest arguments in favor of mass customization [BOE 07]. Often, however, it is also one of the most difficult dimensions to achieve, demanding complex systems to gather the customers’ proportions exactly and to transfer them into a product that has to be based on a parametric design (for fulfilling the requirements of a stable solution space). This often calls for a total redesign of the product and the costly development of flexible product architectures with enough slack to accommodate all possible fitting demands of the customer base. In sales, expensive 3D scanners or other devices are needed, which in turn demands highly qualified sales staff for their operation [BER 05].

– *Functionality*: Functionality addresses issues such as speed selection, precision, power, cushioning, output devices, interfaces, connectivity, upgradeability or similar technical attributes of an offering according to the requirements of the client. This is the traditional starting point for customization in industrial markets, where machines, for example, are adjusted to fit in with an existing manufacturing system, or components are produced according to the exact specifications of their buyers. Functionality demands similar efforts to elicit customer information about the desired individual functionality as the fit dimension. In manufacturing, however, the growing

software content of many products today enables the customizability of functional components more easily.

– *Form (style and esthetic design)*: This dimension relates to modifications aiming at the sensual or the visual senses, that is selecting colors, styles, applications, cuts or ideas. Many mass customization offerings in business-to-consumer e-commerce are based on the possibility of codesigning the outer appearance of a product. This kind of customization is often rather easy to implement in manufacturing, particularly if digital printing technology can be applied. The desire for a particular outer appearance is often inspired by fashions, peers, role models, etc., and the individual's desire is to copy and adopt these trends. Along this line, the construct of consumers' need for uniqueness has been discussed in the psychological marketing literature [TEP 01]. Consumers acquire and display material possessions for the purpose of feeling differently from other people or they perform explicit actions in order to be recognized by others (counter-conformity motivation). Some consumers express their desire for uniqueness by selecting material objects (fashion) that are ahead of the average trend, by purchasing hand-crafted items, or vintage goods from non-traditional outlets. Mass customization can be a further means to express their uniqueness, where consumers can design products according to their own personal specifications in order to look different from others.

1.3.1.2. *Methods for solution space definition*

To define the solution space, the company has to identify those needs where customers are different – and where they care about these differences. Matching the options represented by the solution space with the needs of the targeted market segment is a major success factor of mass customization [HVM 08]. The core requirement at this stage is to access “customer need information”, that is information about preferences, needs, desires, satisfaction, motives, etc. of the customers and users of the product or service offering. Need information builds on an in-depth understanding and appreciation of the customers' requirements, operations and systems. Spotting untapped differences across customers is not an easy task, because information about customers' unfulfilled needs is “sticky”, that is difficult to access and codify for the solutions provider [VON 98]. While this problem is shared by both mass producers and mass customizers, it is more demanding for the latter, because of the extreme fragmentation of customers' preferences. Understanding heterogeneous customer needs in terms of identifying differentiating attributes, validating product concepts and collecting customer feedback can be a costly and complex endeavor, but several approaches can help.

– *Conventional market research*: The first approach is to engage in conventional market research techniques, that is, to meticulously gather data from representative customers in a chosen market sector. To reduce the risk of failure, need-related

information from customers is integrated iteratively at many points in the new product development process (for example, [GRI 93, DEL 09]). The manufacturer selects and surveys a group of customers to obtain information on needs for new products, data analyses, develops a responsive product idea and screens this idea against customer preferences (needs) and purchasing decisions. This model is dominating, especially in the world of consumer goods, where market research methodology such as focus groups, conjoint analysis, customer surveys and analyses of customer complaints is used regularly to identify and evaluate customer needs and desires. In particular, conjoint analysis, also called multi-attribute compositional models, can be regarded as a tool suited to define a company's solution space in a mass customization environment. The term denotes a set of methods to measure and analyze consumers' preferences by assessing their perception of the value of various attributes of a product [GRE 81, GRE 90, LOU 94]. The method is based on an experimental design that allows for systematically manipulating product or service descriptions shown to a respondent. This method is efficient in the sense that the survey does not need to be conducted using every possible combination of attributes. The utilities can be determined using a subset of possible attribute combinations. From these results, one can predict the desirability of the combinations that were not tested [GRE 81].

– Toolkits for user cocreation: A second approach companies can use to define their solution space is to provide customers with toolkits for user cocreation [VON 02, FRA 04]. These are software design tools such as a computer-aided design (CAD) system, but with an easy-to-use interface and a library of basic modules and functionalities. With these toolkits, customers can, by themselves, translate their preferences directly into a product design, highlighting unsatisfied needs during the process. The resulting information can then be evaluated and potentially incorporated by the company into its solution space. When Fiat was developing its retro, award-winning Fiat 500, for example the automaker created Concept Lab, an innovation toolkit that enabled customers to freely express their preferences regarding the interior of the car long before the first vehicle had been built. The company received more than 160,000 designs from customers – a product-development effort that no automaker could replicate internally. And Fiat allowed people to comment on others' submissions, providing a first evaluation of those ideas. Of course, mass producers can also benefit from innovation toolkits, but the technology is particularly useful for mass customization, because it can be used at a low cost for large pools of heterogeneous customers.

– Customer experience intelligence: Third, in developing their solution space, companies can employ some form of “customer experience intelligence”, that is, to apply methods for continuously collecting data on customer transactions, behaviors or experiences, and analyzing that information to determine customer preferences. This also includes incorporating data not just from customers, but also from people

who might have taken their business elsewhere. Consider, for example, information about products that someone has evaluated, but did not order. Such data can be obtained from log files generated by the browsing behavior of people using online configurators [RAN 03, SQU 04, PIL 04]. By systematically analyzing that information, managers can learn much about customer preferences, ultimately leading to a refined solution space. A company could, for instance, eliminate options that are rarely explored or selected, and it could add more choices for the popular components. In addition, customer feedback can even be used to improve the very algorithms that a particular application uses. When someone skips a song that Pandora Radio has suggested, for example, that information is not just used to provide better personalization of the music stream for that particular individual. It is also aggregated with similar feedback from millions of other customers to prevent the system from making that kind of incorrect recommendation in the future.

1.3.2. Robust process design

A core idea of mass customization is to ensure that an increased variability in customers' requirements will not significantly impair the firm's operations and supply chain [PIN 93b]. This can be achieved through robust process design – the capability to reuse or recombine existing organizational and supply chain resources to deliver customized solutions with high efficiency and reliability. Hence, a successful mass customization system is characterized by stable, but still flexible, responsive processes that provide a dynamic flow of products [PIN 95, TU 01, SAL 04, BAD 07]. Value creation within robust processes is the major differentiation of mass customization versus conventional (craft) customization. Traditional (craft) customizers reinvent not only their products, but also their processes for each individual customer. Mass customizers use stable processes to deliver high-variety goods [PIN 93b], which allows them to achieve “near mass production efficiency”, but it also implies that the customization options are somehow limited. Customers are being served within a list of predefined options or components, the company's solution space.

1.3.2.1. Cost drivers of variety

The core objective of robust process design is to prevent or counterbalance the additional cost resulting from the flexibility a company needs to achieve in order to serve its customers individually. We can differentiate two sources of the additional cost of flexibility [SU 05]: 1) increased complexity and 2) increased uncertainty in business operations, which by implication results in higher operational cost. A higher level of product customization requires greater product variety, which in turn entails a greater number of parts, processes, suppliers, retailers and distribution channels. A direct consequence of such proliferations is an increased complexity in

managing all aspects of business from raw material procurement to production and eventually to distribution. Furthermore, an increase in product variety has the effect of introducing greater uncertainty in demand, increases in manufacturing cycle times and increases in shipment lead times [KUM 06, YAO 07]. Increased system complexity and uncertainties (in demand and lead time) drive the operational cost upward due to more complex planning, greater hedging, increased resource usage, more complex production setups, diseconomies of scope and a higher distribution cost spread throughout the supply chain. Finally, a sizeable increase in costs to offer choice navigation for customers is integral to a mass customization strategy. This includes, for example, implementing a configuration system on a Website or in a physical store.

1.3.2.2. *Methods to establish robust processes*

The most important aspect of robust process design is the outcome of an manufacturing process that allows for an efficiency that is comparable to that of mass customization, despite an increasing product variety. For this purpose, literature suggests a number of different methods that can be employed to reduce or even avoid the additional costs of variety. In the following, several options will be discussed:

- Postponement: A primary mechanism to create robust processes in mass customization is the application of delayed product differentiation (postponement). Delayed product differentiation refers to partitioning the supply chain into two stages [YAN 03, YAN 04]. A standardized portion of the product is produced during the first stage, while the differentiated portion of the product is produced in the second stage, based on customer preferences that have been expressed in an order. The success of delayed product differentiation is a direct manifestation of the fact that most companies offer a portfolio of products that consists of families of closely related products, which differ from each other in a limited number of differentiated features. An example of delayed product differentiation in the automotive industry would be to send a standard version of the car (a stripped or partially equipped version) to dealers and then allow the dealer to install, on the basis of customer-specific requests, options such as a CD/DVD player, the interior leather or fabric and the cruise control system, etc. Prior to the point of differentiation, product parts are reengineered so that as many parts or components of the products as possible are common to each configuration. Cost savings result from the risk-pooling effect and reduction in inventory stocking costs [YAN 04]. In addition, as common performance levels of functionalities are selected by a number of customers, economies of scale can be achieved at the modular level for each version of the module, generating cost savings not available in pure customization-oriented production systems.

– Flexible automation: While postponement starts at the design of the offerings, another possibility to achieve robust processes is through flexible automation [TU 01, ZHA 03, KOS 04]. Although the words “flexible” and “automation” might have been contradictory in the past, this is no longer the case. In the automotive industry, robots and automation are compatible with high levels of versatility and customization. Even processing industries (pharmaceuticals and food, for example), once synonymous with rigid automation and large batches, nowadays enjoy levels of flexibility once considered unattainable. Similarly, many intangible goods and services also lend themselves to flexible automated solutions, often based on the Internet. In the case of the entertainment industry, increasing digitalization is turning the entire product system over from the real to the virtual world.

– Process modularity: A complementary approach to flexible automation is process modularity, which can be achieved by thinking of operational and supply chain processes as segments, each one linked to a specific source of variability in the customers’ needs [PIN 93b]. As such, the company can serve different customer requirements by appropriately recombining the process segments, without the need to create costly *ad hoc* modules [ZHA 03]. BMW’s Mini factory, for instance, relies on individual mobile production cells with standardized robotic units. BMW can integrate the cells into an existing system in the plant within a few days, thus enabling the company to quickly adapt to unexpected swings in customer preferences without extensive modifications of its production areas. Process modularity can also be applied to service industries. IBM, for example, has been redesigning its consulting unit around configurable processes (called “engagement models”). The objective is to fix the overall architecture of even complex projects while retaining enough adaptability to respond to the specific needs of a client.

– Adaptive human capital: To ensure the success of robust process designs, companies also need to invest in adaptive human capital [BHA 05]. Specifically, employees and managers have to be capable of dealing with novel and ambiguous tasks in order to offset any potential rigidity that is embedded in process structures and technologies. After all, machines are not capable of determining what a future solution space will look like. That task clearly requires managerial decision-making, not software algorithms. Our research revealed that, for example, individuals need a broad knowledge base that stretches beyond their immediate functional specialization, in order to be able to proficiently interact with other functions in the process of identifying and delivering tailored solutions to the customer [SAL 09]. Such a broad knowledge base has to be complemented with relational attitudes that allow the individual to easily connect with other employees on an *ad hoc* basis.

1.3.3. *Choice navigation*

Lastly, a mass customizer must support customers in identifying their own needs and creating solutions while minimizing complexity and the burden of choice. When a customer is exposed to myriad choices, the cost of evaluating those options can easily outweigh the additional benefit from having so many alternatives. The resulting syndrome has been called the “paradox of choice”, [SCH 04] in which too many options can actually reduce customer value instead of increasing it [HUF 98, DES 02]. In such situations, customers might postpone their buying decisions and, worse, classify the vendor as difficult and undesirable. Recent research in marketing has addressed this issue in more detail and has found that the perceived cognitive cost is one of the highest hurdles toward a larger adoption of mass customization from the consumer perspective [DEL 05]. To avoid this, companies have to provide the means of choice navigation to simplify the ways in which people explore their offerings.

The traditional measure for navigating the customer’s choice in a mass customization system has been product configuration systems, also referred to as “co-design toolkits” [FRA 03, FRA 04]. Codesign activities are performed as an act of company-to-customer interaction and cooperation [KHA 03, TSE 03a]. In mass customization, codesign activities are in general performed with the help of dedicated systems. These systems are known as configurators, choice boards, design systems, toolkits, or codesign platforms [SAL 07, HVM 08]. They are responsible for guiding the user through the elicitation process. Whenever the term configurator or configuration system is quoted in the literature, for the most part, it is used in a technical sense, usually addressing a software tool. The success of such an interaction system, however, is by no means defined solely by its technological capabilities but also by its integration into the sales environment, its ability to allow for learning, its ability to provide experience and process satisfaction and its integration into the brand concept. Tools for user integration in a mass customization system contain much more than arithmetic algorithms for combining modular components. In a toolkit, different variants are represented, visualized, assessed and priced with an accompanying learning-by-doing process for the user. The core idea is to engage customers into fast-cycle, trial-and-error learning processes [VON 98]. In the following, several important aspects of choice navigation will be discussed:

- Enjoyment and process satisfaction: Offering choice to customers in a meaningful way can become a way for new profit opportunities [FRA 10]. Recent research has shown that up to 50% of the additional willingness to pay for customized products can be explained by the positive perception of the codesign process itself [FRA 04, SCH 06, FRA 10, MER 10]. Product codesigns by customers may also provide symbolic (intrinsic and social) benefits, resulting from

the actual process of codesign rather than its outcome. Schreier [SCH 06] quotes, for example, a pride-of-authorship effect. Customers may cocreate something by themselves, which may add value due to the sheer enthusiasm about the result. Participating in a codesign process may be considered a highly creative problem-solving process by the individuals engaged in this task, thus becoming a motivator to purchase a mass customization product. An important precondition for customer satisfaction derived from codesign is that the process itself should be felicitous and successful. The customer has to be capable of performing the task. This competency issue involves flow, a construct often used by researchers to explain how customer participation in a process increases satisfaction [CSI 90]. Flow is the process of optimal experience achieved when motivated users perceive a balance between their skills and the challenge at hand during an interaction process [NOV 00]. Recent research has recommended several design parameters of a configurator that should facilitate this effect of process satisfaction [RAN 05, DEL 09, FRA 09].

- Customer loyalty: The interaction between the manufacturer and the customer that is underlying a codesign process further offers possibilities for building loyalty and lasting customer relationships. Once a customer has successfully purchased an individual item, the knowledge acquired by the manufacturer represents a considerable barrier against any potential switching to other suppliers. Reordering becomes much easier for the customers. The more customers tell the vendor about their likes and dislikes during the integration process, the better is the chance of a product being created that meets the customers' exact needs at the first try. Additionally, manufacturers can draw on detailed information about the customer for the next sale, ensuring that the service provided becomes quicker, simpler and more focused. A new supplier would need to repeat the initial process of gathering data from the customer. Moreover, the customer has now learned how self-integration into the process can successfully result in the creation of a product. Furthermore, manufacturers also gain valuable market research knowledge by aggregating information from a segment of individual customers. As a result, new products can be planned more efficiently, and market research is more effective, because of unfiltered access to data on market trends and customers' needs. This is of special benefit to those companies that unite large-scale make-to-stock production with tailored services. Mass customization can thus become an enabling strategy for higher efficiency of a mass production system.

- Recommendations: One effective approach to help customers to navigate choice in a mass customization system is the so-called "assortment matching" [SAL 09], in which software automatically builds configurations for customers by matching models of their needs with characteristics of existing solution spaces (i.e. sets of options). Using some basic information about the customer the system can recommend items out of the vast assortment of an online merchant. Nevertheless, customers may not always be ready to make a decision after they have received recommendations. They might not be sure about their real preferences, or the recommendations may not appear

to fit their needs. In such cases, combining a recommendation system with a codesign toolkit is a potential solution. Through the iterative process of the toolkit, the customers learn about their own preferences – important information that is then represented in subsequent configurations.

1.4. Conclusion

This chapter argues that the concept of mass customization could be applied across global supply networks in order to enable network resilience, which means the flexibility of supply networks to deal with a small-lot, high-variety production that the heterogeneity of customer needs demands in many industries today. If applied successfully, mass customization offers the potential of improvements in all dimensions of operation strategy: responsiveness, price, quality and service [ISM 07]. As described in this chapter, such an implementation of mass customization requires certain changes to the organizational structure of a company or manufacturing network. Three fundamental capabilities that are necessary in this context have been introduced in this chapter.

Admittedly, the development of these strategic capabilities might demand drastic organizational changes that are often difficult to bring about, because of powerful inertial forces that might exist within a company. We have seen a repeating pattern of companies that failed in implementing mass customization. These companies unsuccessfully managed the change process from a product-focused, mass producing firm to a customer-centric organization [MOS 07]. However, shifting the locus of value creation toward true customer centricity requires no less than a radical change in the management mind-set [FOR 07]. Therefore, companies must be willing to break with existing routines and business paradigms and develop an attitude of customer centricity. The business process has to be changed and aligned with customer demand. Subsequently, the implementation of a mass customization business paradigm requires a thorough and well-planned change management process across the whole manufacturing network.

Indeed, one of the most important lessons from mass customization research is that there is no one best way to mass customize. Various industry cases have shown that mere copying of successful mass customization approaches can lead to serious failures [SAL 09]. It seems that it is not sufficient to just understand the three categories of strategic capabilities, but the difficulty of implementing mass customization lies within finding a suitable transformation from theory to the specific setting of an individual company. Companies need to “customize [their] mass customization strategy” [LAM 96], based on the requirements of their specific customer base, the competitive situation in their respective industries and the technology available.

At the same time, mass customization should be considered a journey rather than a destination. It is not about achieving a “perfect” state of mass customization [SAL 09], but about thinking in ways that make the most sense for a specific business or supply chain. Companies that have found individual means to implement methods and approaches to match the three fundamental capabilities are succeeding in their mass customization endeavor. Literature calls this understanding “mass customization thinking” [PIL 10]. It provides a way to profit from heterogeneities of a firm’s customers. Mass customization thinking means to build the three capabilities outlined above and to apply them for designing a resilient manufacturing network that creates value from serving customers individually.

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