SUCCESS FACTORS AND FUTURE TRENDS IN MASS CUSTOMIZATION

Czynniki sukcesu i przyszłe trendy w masowej indywidualizacji

Vladimir MODRAK, Zuzana SOLTYSOVA, Dorota STADNICKA

A b s t r a c t: At first, this paper focuses on the market-oriented challenges associated with the necessity to continuously update product offers in order to serve today's markets and remain competitive. Subsequently, some success factors for mass customization (MC) are identified in this study. Then, a generic model of a mass customization system for manufacturing companies is proposed. Additionally, chosen problems concerning the mass customization implementation are highlighted. Finally, the work provides a summary of the features and trends of MC and offers new views on the subject.

K e y w o r d s: mass customization, modular products, success factors, mass customization system

S t r e s z c z e n i e: Na początku niniejsza praca koncentruje się na wyzwaniach rynkowych związanych z koniecznością ciągłego aktualizowania ofert produktów w celu obsługi dzisiejszych rynków i utrzymania konkurencyjności. Zidentyfikowano również wybrane czynniki sukcesu dotyczące masowej indywidualizacji (MC). Następnie zaproponowano ogólny model systemu dotyczącego masowej indywidualizacji dla firm produkcyjnych. Dodatkowo wskazano na wybrane problemy dotyczące wdrażania masowej indywidualizacji. Na końcu, praca zawiera podsumowanie cech i trendów MC i przedstawia nowe spojrzenie na poruszony temat.

S ł o w a k l u c z o w e: masowa indywidualizacja, wyroby modułowe, czynniki sukcesu, system masowej indywidualizacji

Introduction

In a global business environment, manufacturing companies face several important challenges. Among them, mass customization (MC) plays an important role, since it offers new potential for acquiring new markets and generating benefits for itself and participating companies. MC is likely to be a future trend of the business strategy development. In this context, questions arise regarding what characterizes the current trends of MC, how it differs from previous manufacturing strategies, and what will be the future of manufacturing when it takes a global approach. Providing accurate answers is not easy and requires considering at least two aspects of the term. If we comprehend MC as a marketing and manufacturing technique that combines personalized customization and mass production, then we can see manufacturing and marketing perspectives in determining optimal overall strategies for companies.

The first view regards the world of manufacturing that is changing as it follows the world of technology. Technological changes are driven by many factors such as safety and environmental standards, social demands, the diffusion of innovation, etc. Technology is changing very rapidly and the newest technological developments are reshaping the manufacturing sector in its original form. For example, additive manufacturing (AM), cloud computing, radio frequency identification, fifth generation (5G) wireless systems, and the Internet of Things (IoT) are only a few of the new technologies that are driving a paradigm shift in manufacturing. The umbrella term for this new wave of the so-called smart manufacturing is European Industry 4.0. This promising concept includes, among others, important attributes such as machine connectivity, data gathering and the analysis for productivity improvement and software tools for digitizing the manufacturing world leading to smart factories. Although till now still not many companies declare that they have implemented elements of the Industry 4.0 concept [27, 28], in the future the successive implementation of smart manufacturing capabilities will allow for the faster and better response to the customer requirements than ever before. Wide adoption of the IoT into smart manufacturing systems will allow for the improved flexibility and productivity of a production process, and it will enable a higher level of MC than it is possible today. This way, the manufacturing sector is undergoing a serious transformation process that promises other disruptive innovations, including the adoption of new business models and the production of mass customized products with the improved quality and reduced direct costs. Mass customization can be implemented in different business areas. This paper deals with material goods manufactured in a customized way for clients.

Incentives for mass customization development

Further development of mass customization from the point of view of a consumer will depend on the willingness of customers to spend time on specifying their preferences and to accept an increased price and delivery time of a customized product. Experience shows that modern consumers desire more and more customized products. At least one of the reasons that consumers prefer custom-made products relates to the so-called counter-conformity motivation [31]. This kind

of motivation is based on the fact that consumers want to be recognized from others as having a particular status in their communities. According to Piller [20], the key element of MC from the consumer's perspective is that customers are integrated into value creation as product code signers by defining, configuring, matching or modifying an individual solution. However, it is also worth underlining that still many customers prefer to choose one of the existing solutions instead of spending time on a product configuration.

A good starting point in the identification of differences between the current situation of MC and the future scenarios is to outline distinct approaches to MC and its evolutionary development, what will be presented in this paper.

The concept of product customization

An elementary condition for the application of MC is the consideration and analysis of alternative strategies aiming at increasing competitiveness through an innovative product design and customer satisfaction management. A well-known fact is that overall customer satisfaction is higher when the product matches the customer's ideal preference better. Long-standing strategies, by which this objective can be achieved, are product proliferation and product customization.

A company pursuing product proliferation offers many different product types with different features and functions, etc. When applying this strategy, production and logistic costs can be negatively affected by the number of different products. If an increasing number of products is provided by a company on a replenishment basis, then its suppliers have to expand their product lines. Such a situation makes it more difficult to forecast the demand and calls out for a transition from a *make-and-sell* model to the so-called *sense-and-respond* organization. The first model is focused on the production efficiency and the other one is customer satisfaction oriented. Moreover, the sense-and-respond organization business model allows all members of a supply chain to adapt to the changing market conditions and to work together seamlessly [12].

Product customization can be defined as producing physical goods that are tailored to a particular customer requirements [5]. This strategy makes it possible to meet each customer´s specific needs more precisely than through product proliferation, although the level of tailorization is limited. According to Zipkin [37], increasing the complexity of MC processes can potentially limit the degree to which customization is beneficial to its customers. A reasonable degree of customization depends on several factors, such as the kind of industry a company is part of, the level of manufacturing flexibility, the clients' wishes, etc. It is rather difficult for companies to find optimal rates of customization for an existing or new product due to a wide range of opinions represented by the number of the offered product configurations. For this purpose, a generic concept of identifying an optimal degree of product customization can be used (fig. 1). This balancing concept adopts Tainter's curve of complexity [30] and ensures that products are neither under-customized nor over-customized.

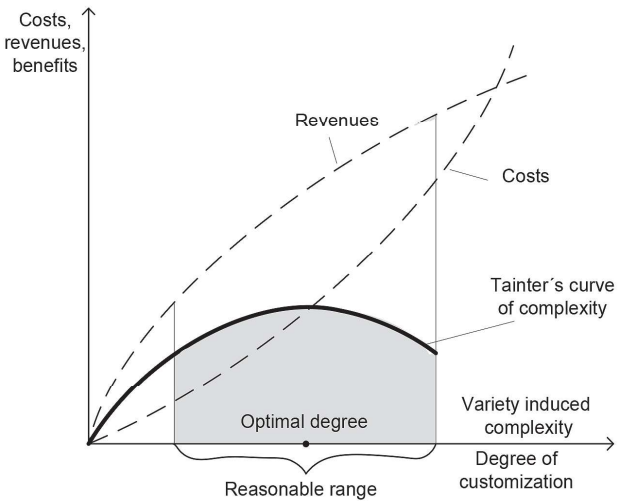

Fig. 1. Generic concept of identifying an optimal degree of product customization
Rys. 1. Ogólna koncepcja określania optymalnego stopnia indywidualizacji produktu

As outlined previously, there are at least two ways to deliver a higher level of a product variety, and MC may not always be the best. Therefore, an early and reliable decision whether MC is the right prescription for a company or not is a critical step towards achieving sustainable development objectives.

Success factors of mass customization

Four fundamental factors

In order to implement MC, a company has to assess:

- Whether, and if so, to what extent its products can be built from modules?
- Whether its customers are ready to configure the products or maybe they prefer to choose from standard products?
- Whether MC implementation will give the company a competitive advantage on the market on which it operates?
- Whether the company has organizational, managerial and technological capabilities to implement MC at reasonable costs?

The factors which can have fundamental influence on mass customization can be indicated and they are effectively analyzed in this paper (fig. 2).

These factors are: customers' readiness, type of products, market characteristics and company's readiness. They will be analyzed in the next chapters of this work.

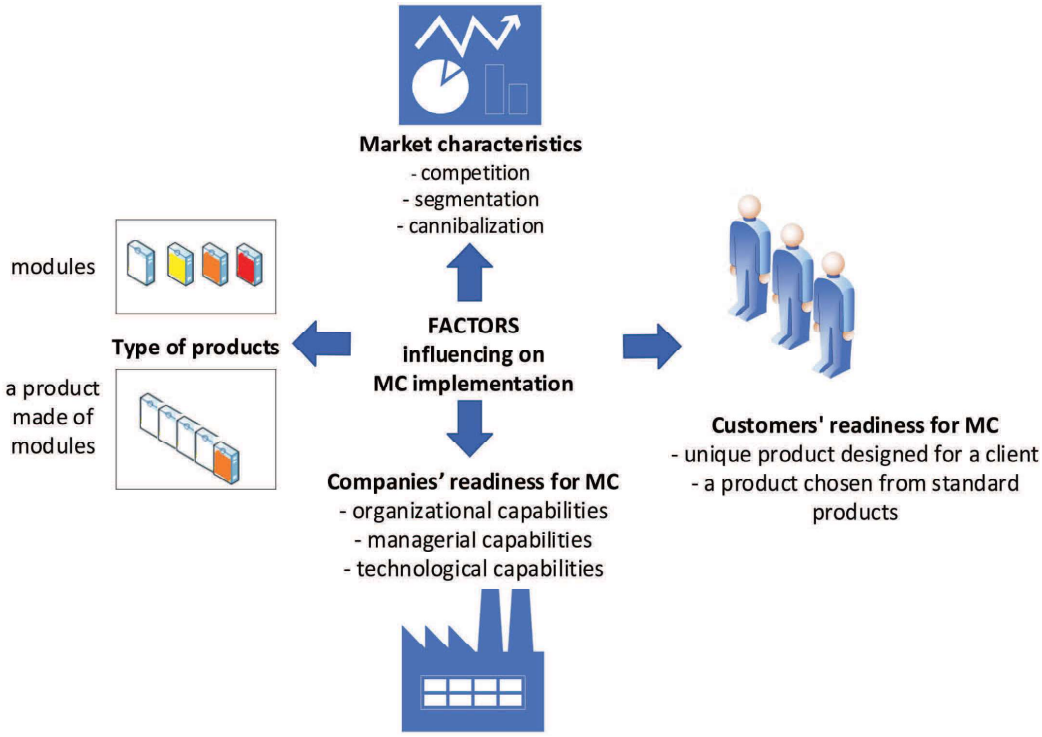

Fig. 2. Factors influencing MC implementation in a company
Rys. 2. Czynniki wpływające na wdrożenie MC w firmie

Customers' readiness

According to Da Silveira et al. [7] "mass customization encompasses the ability of original equipment manufacturers (OEMs) and their suppliers to provide individually designed products and services to customers in the mass-market economy". Notable attention is paid to the role of OEMs, who sell their products to personal consumers. Guilabert and Naveen [11] argue that knowing how significant customization is for potential consumers as well as how it varies by the type of products will help producers to implement one of the customization strategies.

Basically, customers' readiness can occur in an explicit or implicit form. Based on this categorization, the following construct of customers' customization readiness (CCR) can be outlined. The so-called explicit customers' readiness for buying customized products can be seen in daily life. For example, most people prefer customizing their furniture by choosing their style, size, and finish to suit their individual needs, rather than purchasing standard products. In such situations, MC is directed by the customer's specific needs and whims (fig. 2a).

The so-called implicit customers' readiness for buying customized products has to be revealed through the interaction between a marketer and a customer by offering a full range of customization options. When applying such an approach, one can then say that MC is pushed by the marketer's options (see Figure 2b). Both types of CCR are highly pivotal in paving a way towards implementing an MC strategy. The proposed CCR construct differs from the customer customization sensitivity (CCS) construct developed by Hart [13]. The CCS construct is based on two factors: uniqueness of customer's needs and customer's sacrifices. According to Hart, the level of CCS is directly proportional to the uniqueness of customer's needs and/or customer's sacrifices.

Type of products

According to Da Silveira et al. [7], MC will never be possible for all types of products. In this sense, Duray [9] argues that "the production of standardized modules is the key to high volume mass customization". In addition, Tseng and Hu [33] point out that convenient products for MC are those with short life cycles, and Blecker [3] emphasizes that "companies have to offer tailored products while ensuring short delivery times simultaneously". All things considered, the following factors predispose products to MC:

- products can be grouped together into a product family;
- products are designed as modules so that they can be easily assembled into different ones;
- products can be delivered in short time.

Market characteristics

Some markets offer fully customized product varieties, whereas on other markets they are mostly available as discrete product varieties. Obviously, under specific

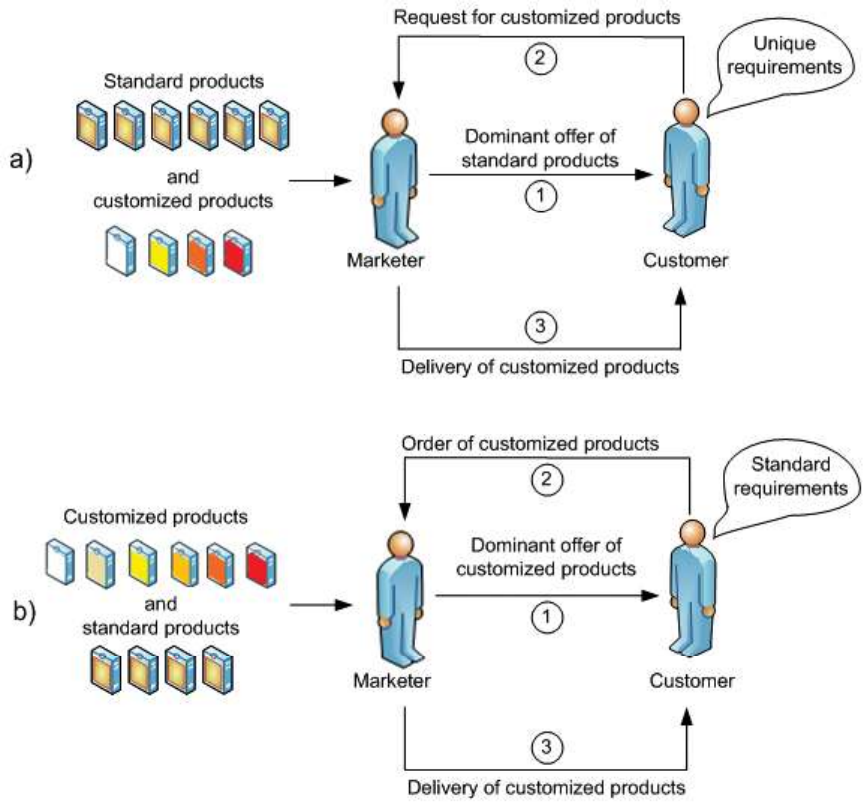

Fig. 3. Customers' customization readiness construct; a) explicit form; b) implicit form
Rys. 3. Gotowość do dostosowywania się do wymagań klienta; a) forma jawna; b) forma niejawna

conditions, both types of markets can bring opportunities or indicate threats when a company intends to implement one of the MC strategies. Cavusoglu et al. [6] identified the following market categories as critical in choosing an optimal customization strategy: competition, segmentation and cannibalization.

The intensity of *competition significantly* influences customization possibilities and predetermines a choice of the strategic patterns of the players on the market. Pine [22] recommends three ways to shift to MC: incrementally over time, more quickly through business transformation, or by creating a new business. The incremental path towards a MC strategy, apart from other factors, assumes that competing companies that operate on the same reference market do not deliver customized products.

However, this can be a slow process if competitors are already effectively issuing MC. For the companies facing such competition, rapid transition to an MC business strategy helps them remain competitive on the marketplace. The increased need for new products on a highly dynamic market environment can be reflected by transforming businesses into a higher level of customer satisfaction. Pine [22] claims that transforming business in such a way can be achieved by creating a group of related businesses focused on individual customers' needs.

Segmentation is often the key to develop a competitive edge. The research conducted by Jiang [16] shows that MC is not totally the same as segmenting to one of the many segments. In this context, it has been highlighted that companies that aim at customization in the specific consumer segments may not be optimal [6].

The cannibalization effect is understood as the extent to which a product variety reduces company's profits from the standardized varieties it produces. Yayla-Küllü et al. [36] argue that the cannibalization effect dominates on a highly competitive market. A useful insight into this rate is provided by Selladurai [29].

Company's readiness

Company's readiness for MC can be understood as having the right conditions and resources in place in order to support the transformation process. Knowing that MC means a huge variety of products by combining a large number of product modules, companies that want to follow this path, at first, have to analyse their technological, organizational and managerial capabilities in order to determine whether they are potentially transformative to this strategy. El Kadiri et al. [10] predict that in the MC environment, intelligent device technologies using sensors and actuators will dominate. It is expected that the extension of 5G technologies to the information and communication technology (ICT) sector will facilitate automation. This brings a new impetus for manufacturing to foster MC. Rapid technological progress continues in

AM technologies. This paradigmatic change in manufacturing poses significant challenges for enterprises to utilize the technology for MC. For example, laser-sintering machines present an attractive mode of production that has a great potential to customize widely the products such as bone implants, prostheses, medical devices, etc. Equally, direct metal laser-sintering is widely and effectively used e.g. to manufacture metal prototypes. When looking at the economic evaluation, cost comparisons between AM technologies show that traditional processes are more economically effective than AM technologies in high output quantities (see e.g. [8], [26]).

Thomas and Gilbert [32], in this context, state that these viewpoints come from analyses of the well-structured AM costs, and they add that significant benefits and cost savings in AM may be hidden in the ill-structured costs. An important advantage of AM technologies is the freedom of design. Reeves et al. [25] point out that due to this design freedom, assembly operations that were previously required to build a complex component can be reduced. Moreover, AM technologies remove the risk of a long time for the delivery of tooling [15]. When assuming the need for the combination of these trends and technologies, in particular, MC calls for the development of entirely new business organizations.

Then, a company needs to choose the way MC will be implemented: in small steps, by business transformation or by creating a new business.

New approaches to the organization of manufacturing systems

A generic system of the mass customization system, proposed in figure 4, comprises of four subsystems, namely the product configuration system (1), product arrangement system (2), manufacturing system (3) and final product assembly system (4).

The wide implementation of the product configuration systems in mass customization provides customers with the possibility to configure their products according to their requirements and to send their orders with mouse-click to a manufacturer who can begin the production. A product configurator allows customers to meet their needs effectively, by connecting them with appropriate products and features, while handling modifications and specifications. Firstly, customers can use a configurator and select a product with its components and/or functions on their own preferences. In the configuration system, the selected product features are divided into stable and compulsory optional components. Stable components are available immediately in stock, while compulsory components need to be produced. Subsequently, in the product arrangement system, some of the selected components are manufactured by the company itself and some of them are produced by a supplier. Finally, if all the needed components are produced, delivered and consolidated in the manufacturing system, then, it is possible to start the

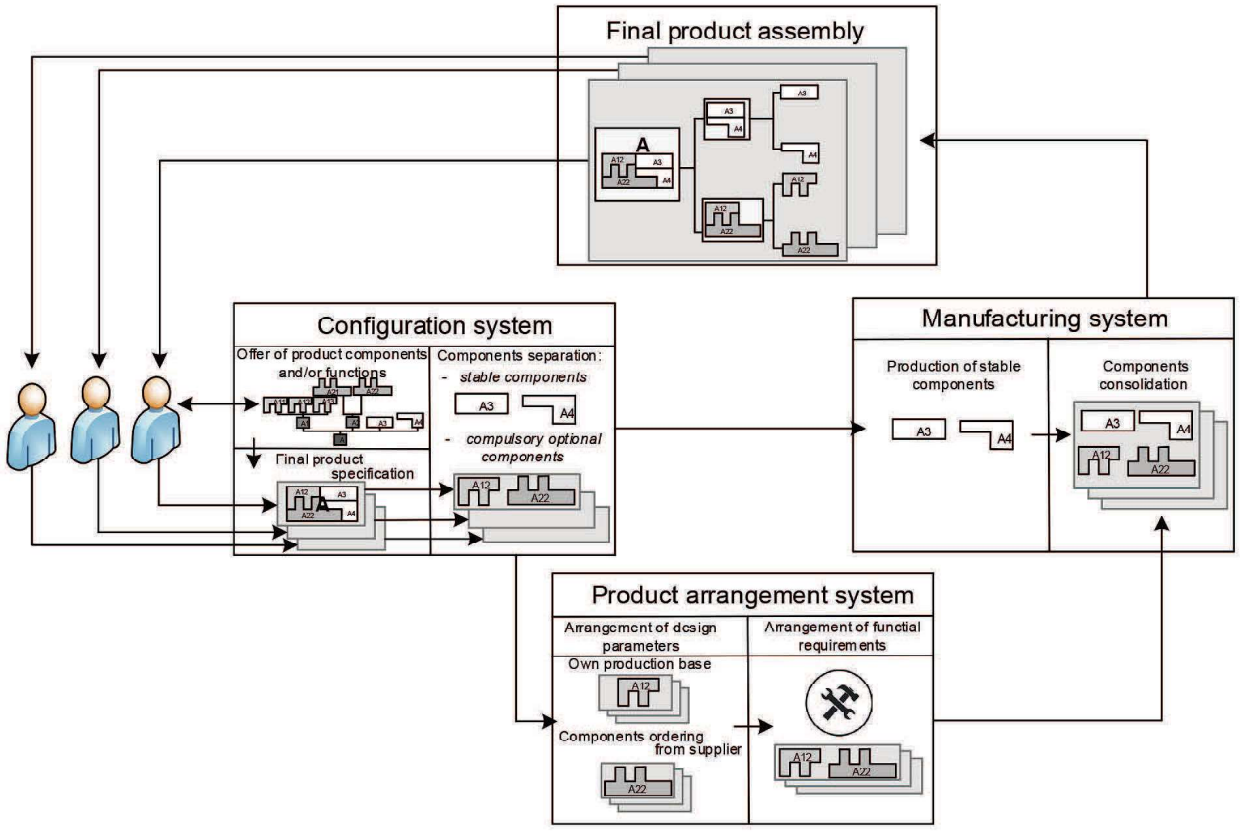

Fig. 4. Generic model of mass customization system (adopted from [4])
Rys. 4. Ogólny model systemu masowej indywidualizacji (opracowany na podstawie [4])

assembly process where all components are assembled into a final product which will be transferred to a customer.

New approaches to employee's skills management and network-based cooperation

MC implementation also requires the implementation of new approaches concerning employees' skills management. MC requires a dynamic network composed of autonomous operating units which perform the tasks related to modular manufacturing [23, 35]. The diversity of employees' skills is basic for increasing the capabilities of a company to react to customer's requirements. A greater range of skills focused on the understanding and exploitation of IT for business goals is connected with grooving customization requirements. MC is a continuous adaptation to new and unexpected clients' requirements. That is why, employees look for the possibilities to meet new requirements of the customers all the time. In order to meet clients' requirements, an employee can propose a product which will be manufactured in the company, which can be manufactured in cooperation with other companies. He/she can also convince a customer to change his or her requirements. Therefore, adequate skills of an employee are needed. Employees will work with knowledge, and their skills and needed knowledge have to be identified and improved. New demands of a client should be treated as an opportunity for the company.

Other issue concerns the company's cooperation with other companies in order to ensure a large range of possibilities to meet customers' requirements. Therefore, networked manufacturing concepts (see, e.g., [24]) can be the answer for the supply chain management in MC environment.

Common problems in mass customization

Some examples of the problems which can be identified in mass customization are:

- Too many options from which a customer has to choose. A real customer wants to spend minimum time and effort to specify a product [2].
- A company tries to have an inventory of each component, which can be built in a ready product in order to ensure a fast response to the client's demand instead of increasing flexibility of the manufacturing lines. Mass customization is not just assembling modules. It depends on manufacturing custom products quickly and efficiently in order to achieve customer's satisfaction [1]
- Offering different options of products without determining what the customers really want, and without assessing if a customer will ever buy a certain variation of the product. Mercedes offers far more variations of the chosen models than the company will ever be able to sell in its entire life [14].
- Offering options of the products which are impossible to meet without adequate cooperation with other companies on the market.

A company which implements MC has to be aware of different problems which can appear in order to avoid cost. Sometimes a strategy which should improve a company's efficiency and increase benefits can have an opposite effect when implemented in a wrong way.

Concluding remarks

Initially, MC was seen as a contradictory approach that could not lead to an entrepreneurial success. Despite its conflicting ideas, the existence of MC is a reality especially thanks to the advances realized in the fields of flexible manufacturing and IT. As it was predicted as well as more in some recent literature [17, 19, 21], MC has become an imperative rather than a choice leading to success and sustainability across business sectors.

One of the most presumptive trends in product and service customization is mass personalization as the highest degree of mass customization. It is expected that a transformation from MC to mass personalization will be triggered by a diffusion of digital manufacturing technologies. Kumar [18] argues that IT capabilities will drive MC programs towards the mass personalization strategy. Mass personalization differs from MC in many aspects. While MC assumes stable product architecture and product modules, for mass personalization possible changes of the basic design architecture and product features are typical [34]. However, wider acceptance of this strategy in individual industries will strongly depend on the availability of attainable digital manufacturing devices belonging to the smart manufacturing concept. Better identification of the key skills of employees and the implementation of a management system to ensure adequate skills should be proposed. Moreover, the development of a net of co-operators can be suggested.

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