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Mass Customization in SMEs – Literature Review and Research Directions

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Abstract. . As mass customization is spreading to more and more different niches, this business strategy is no longer only applied by large companies offering products to end costumers. More SMEs are beginning to adopt this business strategy. This research is a literature review study to identify Mass Customization literature, which specifically addresses the challenges, which are relevant to SMEs. The literature study first indicates that very little literature has been published on Mass Customization in SMEs. Second, the literature study classifies the identified literature into 1) general or strategy focused SME Mass Customization literature, 2) SME Mass Customization case studies, 3) choice navigation and information systems in SMEs, 4) colution space development in SMEs, 5) robust process design in SMEs and 6) research focused on mass customization in specific industries. The paper concludes by identifying major gaps in literature and pointing out future research directions.

Keywords: Mass Customization, SME, literature review

1 Introduction

Mass customization was introduced more than two decades ago and was popularized by Pine in his book from 1993 [32]. In the research and literature published since there, it seems there is a focus primarily on large enterprises. The examples that are most often highlighted as successful implementations of mass customization are usually from high volume consumer electronics or automobiles.

However, as the approaches to implement mass customization have matured, including IT tools, methods and flexible manufacturing equipment, mass customization has become more accessible to companies. Whereas mass customization was initially applied mostly by companies, which were former mass producers, more companies producing one of a kind products, or engineer to order products, have recently recognized the potential in utilizing mass customization tools. Since many small and medium enterprises (SMEs) produce high variety in lower volumes, mass customization is intuitively an attractive business strategy.

One example of where the tools of mass customization have become more accessible is product configuration software. Product configuration software is the software,

which is used for clarifying customer requirements and translating these into a product specification from which a product can be manufactured. In the early days of mass customization, companies would have to develop product configurators from scratch, using ordinary programming languages, which implied that only large companies with sufficient IT competences and resources would be able to develop product configurators. Today however, affordable commercial off the shelf product configurator software is available which allows companies to easily develop a configurator. There is even open source product configurator available free. This means that product configuration is no longer only for large companies, but can now be implemented by SMEs as well. As pointed out by Salvador et al.[34], mass customizers need three fundamental capabilities to be successful: 1) Solution Space Development – Identifying the attributes along which customer needs diverge, 2) Robust Process Design – Reusing or recombining existing organizational and value chain resources to fulfill a stream of differentiated customer needs and 3) Choice Navigation – Supporting customers in identifying their own solutions while minimizing complexity and the burden of choice [23], [34]. These are general capabilities which must be present in large companies as well as SME's. However we suspect that the approach to obtain and maintain these capabilities will differ from large companies and SME's. Looking into previous literature reviews within mass customization reveals that hardly any literature identified in those reviews focuses directly on mass customization and SME's [12], [35]. It is hence relevant to investigate to what extent any other previous literature has had this focus. The research question of this paper is thus:

What literature has focused on SME related issues of mass customization, and within which specific areas has this research had its focus?

2 Methodology

To address the research question above it was chosen to perform a systematic literature review [4], where an explicit procedure is followed. No restrictions were imposed on the publication year, however only peer reviewed articles from journals and conference proceedings were included in the review. The literature review was performed by the steps outlined below:

1. The databases Thomson Reuters Web of Science and Elsevier Scopus were queried using the search string: (“mass customization” OR “mass customization”) AND (SME OR SMEs OR “small and medium enterprises”). This initial search returned 32 records from Scopus and 25 records from Web of Science.
2. Lists of references from previous literature studies regarding mass customization were analyzed for SME relevant literature.
3. Forward and backward search was applied on the identified literature.
4. The results from the steps above were combined into one data set, and a number of records were excluded based on the following criteria: 1)

- duplicates, 2) hits in sub-strings, e.g. querying for SME returns results on SMED, 3) Duplicates, 4) retracted articles and 5) editorials and conference descriptions. In this step, abstracts were also reviewed to assess relevance.
5. The full text of the papers was read to further ensure relevance and to be able to perform a categorization.
 6. Classification in categories:
 - a. Solution space development
 - b. Choice navigation and information systems (these two categories are joined since it is difficult to distinguish between these in a mass customization context and there are strong relations between choice navigation systems and other information systems in mass customization companies).
 - c. Robust process design
 - d. General mass customization and strategy research
 - e. Mass Customization in specific industries
 - f. Case studies

The categories were defined through an iterative process, where categories a through c were the initial categories taken from Salvador et al. [34]. Categories d through f were established during the categorization process, when literature appeared which did not fit into any other pre-defined category. Papers were allowed to be present in more than one category as some papers address multiple issues.

3 Results

A total of 39 papers were included in the review after the exclusions performed in step 4. These papers were categorized, and the results of the categorization can be seen in figure 1. Furthermore, table 1 shows which papers are included in which categories. In the subsections below, the characteristics of the individual papers are briefly reviewed.

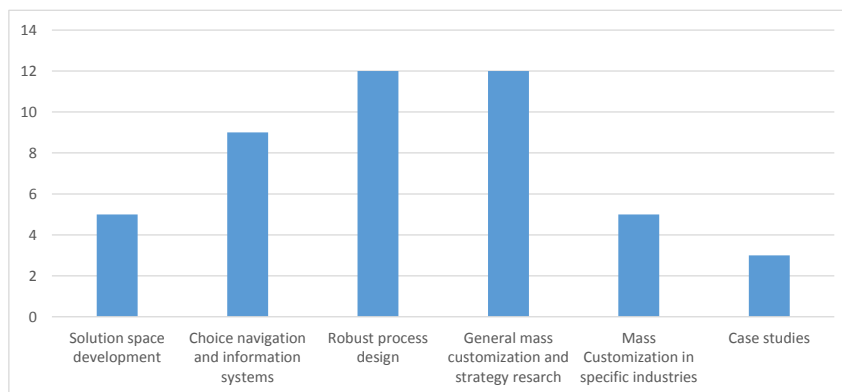


Fig. 1. Distribution of contributions on categories

Table 1. Overview of categories

Category	References to papers in category	Number of papers
Solution Space development	[22],[36], [18],[17],[2]	5
Choice Navigation and information systems	[8],[22],[11],[9],[37],[27],[10],[21],[25]	9
Robust Process Design	[9],[6],[19],[5],[26],[43],[28], [1],[7],[3],[16],[14]	12
General Mass Customization and Strategy Research	[36],[18],[31],[44],[42],[40],[41],[20],[33],[13],[39],[36]	12
Mass Customization in Specific Industries	[25],[24],[15],[38],[29]	5
Case Studies	[19],[17],[30]	3

3.1 Solution Space development

Within solution space development, which is the concept of identifying how customer requirements diverge and developing products which meet these diver requirements, five contributions were identified. The technologies of rapid prototyping and its implications for mass customizers are explored by Ayyaz et al. [2].

The reserach presented by Stojanova et al. [36] present a way to measure customer preferences, defining configurable attributes and finally a way to measure results of implementing mass customization implemented in an information system. A decision support system is proposed by Liu et al. [22], which can support companies in defining how a product should be customized. A feature component matrix is introduced by Is mail et al. [18] as a means to balance diverse customer requirements with manufacturing efficiency. Finally, by Ismail et al. [17], it is described how component commonality can be measured and assessed in order to reduce the internal variety to enhance efficiency.

3.2 Choice Navigation and information systems

Choice navigation, which is the capability to guide customers to purchase a product which matches their unique requirements, was in this literature review combined with general information systems for mass customization as these two areas are often closely integrated. Within this category, ten contributions were identified.

Some of these contributions are quite technology focused. An ASP-based product configuration system is described by Su et al. [37] and Mourtzis et al. [27] looks into how mobile telephone apps can be utilised for product configuration.

Issues related to how configuration system and customization can be utilized in the food industry is investigated in Mertins et al. [25].

General information systems for mass customization in SMEs are discussed by Dean et al. [8], Little et al. [21], and Liu et al. [22]. Similarly, general information system is discussed by [11] where it is also addressed how electronic data interchange can be utilized. Furthermore, development of information systems supporting automation of engineering tasks in mass customization SME settings is addressed [9].

Finally, by Durá et al. [10] it is described how product configurators can be applied in relation to customization of clothing for people with special needs and how this can aid eco-efficient production.

3.3 Robust Process Design

The term robust process design covers how to enable production and business processes to handle the increased variety which is introduced with mass customization. Within this category, 12 contributions were identified.

Two papers focus on the automation aspect of robust process design, where Kokla [19] investigates effectiveness and profitability of automating welding and Bi et al. [3] focus on reusing industrial robots in mass customization SMEs.

Two papers focus on supply chain and network issues. Chiu & Okudan [6] address the issue of optimizing supply chain decisions in relation to product variety, by e.g. altering suppliers and Antonelli et al. [1] investigate how SMEs may benefit in a mass customization context from collaboration in a production network.

Five papers address various planning issues. Gillies et al. [14] evaluate how SMEs may benefit from implementing agile manufacturing, whereas Villa [43] discusses how configuration of products and processes can be coordinated. Closely related to this, the papers by Mourtzis et al. [28], Hvolby et al. [16] and Mleczko [26] discuss more in detail how scheduling and simulation can be carried out in mass customization SME contexts.

On a production system level Cedeno-Campos [5] discuss how self-configurable systems can be developed to create systems which can rapidly form a layout for manufacturing customized products.

The contribution from Dai et al. [7] is also quite technology focused and investigates how RFID can be utilized in a mass customization manufacturing execution system. Finally, it is addressed how engineering automation can be applied in SMEs to make the process of preparing manufacturing more efficient [9].

3.4 General Mass Customization and Strategy Research

Being one of the categories in which the highest number of papers are identified, the literature within general mass customization and strategic aspects counts 12 papers.

Two papers discuss intercompany collaborations, where Li & Liu [20] discuss industrial mass customization clusters and Wiendahl et al. [44] investigates industrial networks. Implementation issues of mass customization in SMEs are discussed by Stojanova et al. [36], where the process from identifying customer preferences to implementing product configuration is described. Similarly Ismail et al. [18] address how to choose the right product strategy in terms of introducing just the right level of product variety.

An approach to address performance measurement systems in SME mass customizers is presented by Gamme et al. [13]. Knowledge management in relation to mass customization and SMEs is discussed by Tsakalerou & Lee [42].

The differences in success factors when implementing mass customization in SMEs compared to large enterprises is discussed by Suzić et al. [39]. Similarly, Svensson & Barfod [40] discusses how build to order oriented SMEs may benefit or experience challenges in applying elements of mass customization.

By Pizmoht et al. [33] it is discussed how the concept of mass customization may fit with SMEs in relation to their core competences and limitations. Similarly, in Taps et al. [41] it is discussed how SME subcontractors may benefit from mass customization.

Finally, an entirely new manufacturing paradigm, dubbed fit manufacturing, is presented by Pham & Thomas [31], which combines the efficiency of lean manufacturing with the ability to break into new markets, enabling mass customizing SMEs to become more economically sustainable.

3.5 Mass Customization in Specific Industries

In the literature review, five papers were identified, which investigate how mass customization can be applied in SMEs in specific industries. Two papers focus on the furniture industry, where Suzić et al. [38] focus on a single case, and Ollonqvist et al. [29] focus on networks and on how to stimulate innovation. Other industry specific papers include one paper on the food industry and how it can benefit from customization and enhance interoperability [25], one paper on clothing and fashion customization [15], and finally one paper on customization within the tourism industry [24].

3.6 Case Studies

Only three case studies focusing specifically on mass customization in SMEs were identified during the literature review. One case study focused narrowly on how automation of welding processes could be utilized in a metal furniture manufacturer [19]. By Ismail et al. [17] two cases are presented, involving companies manufacturing children's playground equipment, and luxury domestic showers illustrating how tools from mass customization can benefit SMEs. Finally by Orsila & Aho [30] a case study was presented of how an e-commerce system could improve business processes in a manufacturer of custom semiconductor products.

4 Research activity over time

Figure 2 shows the historical development in research activity related to mass customization in SMEs, measured by the number of published contributions per year. It is obvious that the research activity has been much higher during the last decade, compared to the early years of mass customization (introduced in 1993), however this can be attributed to a general adoption of mass customization in industry. The number of papers published in 2015 is low, since the literature study was done early 2015, and this number is thus somewhat misleading. Although there is a clear long-term trend in the publication activity, it is not deemed possible to interpret the data to indicate a short-term trend, as the relatively low number of publications per year is somewhat fluctuating.

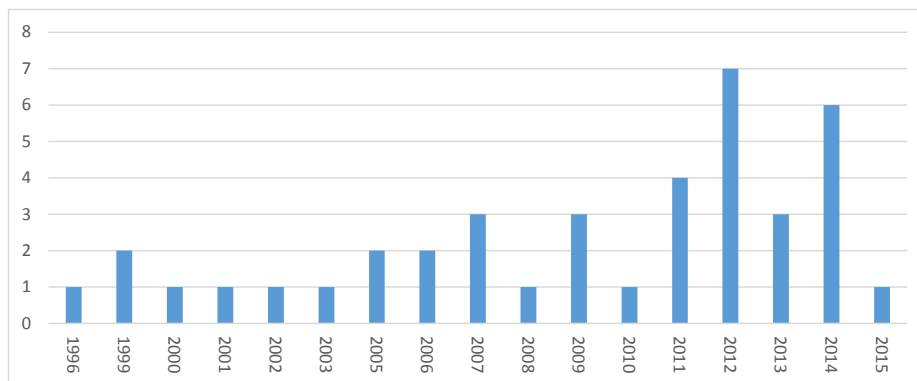


Fig. 2. Papers published on mass customization in SMEs per year.

5 Conclusion

In this paper, a literature study was done, searching for contributions related to mass customization in SMEs. A total of 39 papers were identified which had this

particular focus. If a search is made, using only the keywords “mass customization”, 2077 results are found on Web of Science and 2821 results are found on Scopus, which covers all literature published on any subfield of mass customization indexed in the same databases. It is hence only a very small fraction of the available mass customization literature, which is focused on SMEs. Looking into the time aspect of publications, it was observed that in a long-term perspective, there was an increase in the publication rate of research in SME mass customization, however, on short term, the frequency is too low to conclude anything.

Looking into which categories had received the most attention from scholars, there was a rather large range between the categories with the most and the categories with the least literature. The categories “robust process design”, “general mass customization and strategy”, and “choice navigation and information systems”, were the categories with the most papers, with 12, 12 and 9 papers respectively. The categories with the least papers were “solution space development”, “mass customization in specific industries” and “case studies”, where the categories contained five, five, and three papers.

Given that it is generally acknowledged that SMEs are of vital importance for growth in the national societies, and given that mass customization in many cases can be a catalyst for growth, the authors believe that mass customization in SMEs is a very important topic to stimulate in society and to do research on. Given the very small amount of research on mass customization in SMEs identified in this study, there is hence a major potential in doing more research within this area. The author recommend that more research is done within each of the identified categories, on short term especially case studies, which can help understand what benefits and challenges SMEs can expect when implementing mass customization.

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