Preface

Nowadays, the competitive situation of companies is characterized by a very strong orientation towards product individualization. The change from a seller to a buyer market has led to a saturation situation within the industrial goods' markets where the offer by far exceeds the demand. Companies have to struggle to gain new customers. This major change has increased the customer's power, which has driven companies to differentiate their products from those of competitors by offering individualized problem solutions (Nilles, 2002). The customer's expectations with respect to services and physical products have also dramatically risen. Therefore, companies tend to increasingly fragment the markets, sometimes to an extreme level, to where each market is occupied by only one customer ("markets of one").

The individualization trend is mainly ascribed to social changes. The high growth of population was a key factor for the emergence of the mass production system, one century ago. But nowadays, especially in the industrial nations, the demographic development shows the population to be steadily decreasing. Simultaneously, wealth and the demand for luxury continuously increase. Psychologists know that in the postmodern era, the need for change and novelty is becoming as important as survival for human beings. The human behavior is essentially determined by the individual principles and is rarely oriented on the behavior of the others (self-determination). It is also well known that if more and more people possess the same object, then the possession of this object is no longer interesting and loses its attractiveness (Piller, 1998). All of these reasons have contributed to a need for individualization and the demand for products that exactly meet the individual expectations of customers.

Another important trend in the business world is the continuous decreasing of the product life cycles. Consequently, the timeframes for product amortization are considerably reduced. At the same time, the costs of research and development steadily increase because of higher technological complexity of products (Nilles, 2002). In addition, the ability of fulfilling individual customer needs necessitates the capability of producing a large number of product variants, which induces high costs at both operations- and manufacturing-related tasks. In effect, in contrast to the mass production system, in which the economies of scale can be fully utilized, the individualization of customer requirements usually involves a loss of efficiency. On the other hand, globalization and deregulation of markets as well as the rapid diffusion of e-commerce and e-business over the Internet has led to more intensive and aggressive competition. This has also forced companies to develop strategies in order to resist strong price pressures, especially from those companies that are producing in low-wage countries.

The challenge that manufacturing companies have to face is to provide individualized products and services while maintaining a high cost efficiency. To be successful, companies have to address both of these perspectives, which are necessary for gaining a competitive advantage. The manufacturing of products according to individual customer needs is referred to as product customization. Whereas customization does not necessarily imply a focus on the cost perspective, in this book we will concentrate on both product customization and cost efficiency, namely mass customization, which is a new business paradigm that is very challenging for manufacturing companies.

Mass customization is a business strategy that aims at fulfilling individual customer needs with near mass production efficiency (Pine, 1993). Whereas the literature includes many contributions that discuss the strategic benefits of mass customization, there are large deficits concerning its implementation in practice. Companies that

want to pursue this strategy need a set of practical tools in order to make mass customization work efficiently. The main problem is about how to be able to produce a large number of customer-oriented product variants by simultaneously providing prices that do not considerably differ from those of mass products.

Providing customers with individualized products at affordable prices is the main goal of mass customization. However, customers generally accept paying premium prices compared to standard products because they honor the additional benefits of customized products. Therefore, if mass customization fails in providing customers with an optimal or a better solution than any mass products, then the product resulting from the customization process will have, from the customer's perspective, no more additional value than any other standard product. As a result, an optimal understanding of customer needs is a necessary requirement for the success of the strategy. In fact, the focus on customers is not new and not only specific to mass customization. Concepts such as "customer orientation", "close to the customer", "customer segmentation", "niche marketing" and "customer relationship management" reveal the importance of the customer. However, during the pursuit of mass customization, customers have to be seen as partners in the value creation, which implies a deeper customer-supplier relationship. The customer provides a valuable input in the production process and is considered to be a "prosumer" as coined by Toffler (1980).

Unfortunately, although the focus on the customer's perspective is a well-known issue, the customer in the specific context of mass customization is still misunderstood. Customers are provided with a high number of product variants and are generally supposed to have the capability of making a rational decision. But this is not true because customers are not able to make optimal choices in extensive choice environments. Thus, models for a better conception of customer needs and preferences are required because the customer is a key factor that considerably determines the success or failure of the strategy. Furthermore, a customer orientation through customization tends to trigger increasing costs because of variety and complexity requirements (Blecker, Friedrich, Kaluza, Abdelkafi, & Kreutler, 2005).

Due to the fact that it is necessary to satisfy the customer, the only chance to meet this challenge is to reduce the customizing costs during the product modeling process. The universal remedy for this is to design, implement, and use a supporting computer system. A computer system is, once implemented, the best way to cope with the problem, because it automates main parts of product designing and producing. This reduces complexity and human efforts, which in the end lead to lower costs. Even if the additional investment for creating such systems is taken into account, the cost-cutting effect of mass-customization supporting systems will exceed this by far.

Furthermore, the advances realized in information technology are critical enablers, which make this strategy function efficiently. Information systems can be implemented to support diverse activities in the mass-customization value chain. They assist customers during the product specification phase in order to lead them in a fast-paced manner to the product variants corresponding to their individual requirements. Modern information systems, which support open innovation, even enable customers to participate actively in the product design. In addition, mass customization information systems contribute to helping companies mitigate excessive product variety and increase cost efficiency on the shop floor and logistics through optimal product modeling, production planning, and scheduling.

Another upcoming logistical challenge is caused by the companies' ambitions of focusing on core competences and therefore reducing the level of vertical integration. Increasing efforts for coordinating the product's supply chain are an inevitable consequence. Logistical issues like planning deliveries of raw materials as well as semi-finished goods become more important. Information systems can support companies in their supply chain management and furthermore promote the automation in the company (Blecker & Friedrich, 2006).

Although the need for supporting information systems becomes obvious, suitable tools for addressing this relevant issue in the specific case of mass customization are missing. Therefore, the intention of this book is to bridge the gap between demand and supply in order to provide information and managerial tools that aim at coping with all of the depicted problems.

This book is divided into three sections. The first section (Chapter I-IV) deals with the ways of product configuration and modeling for mass customization as well as the existing benefits and challenges for mass customization, especially in engineer-to-order companies. Furthermore, the functionality and features of the

Supply Chain Operations Reference Model in terms of scope and modularity to support an "open variant process model" are investigated.

The second section (Chapter V-IX) starts with a presentation of frameworks in the course of mass customization. Afterwards, mass customization information systems are organized across the supply chain.

Finally, this book's last part (Chapter X-XIII) examines several new approaches for mass customization like Scenario-based, Knowledge-based and Fuzzy Cognitive Maps and gives an outlook on future developments in the field of information technology for mass customization.

More detailed, this book includes the following:

Section I - Theory of Information Technology for Mass Customization

Chapter I (*Mass Customization with Configurable Products and Configurators: A Review of Benefits and Challenges*) provides a systematic review of literature on how mass customization with configurable products and the use of configurators affect companies. Configurable products are an important way to achieve mass customization. A configurable product is designed once, and this design is used repetitively in the sales-delivery process to produce specifications of product individuals meeting customer requirements. Configurators are information systems that support the specification of product individuals and the creation and management of configuration knowledge, therefore being prime examples of information systems supporting mass customization. However, to the best of our knowledge, there is no systematic review of literature on how mass customization with configurable products and the use of configurators affects companies. This chapter focuses on benefits that can be gained and challenges that companies may face. A supplier can move to mass customization and configuration from mass production or from full customization. The chapter also reviews benefits and challenges from the customer perspective. Finally, the future research directions, open challenges, and problems are identified.

Chapter II (*Product Modeling and Configuration Experiences*) attempts to present an alternative for product modeling based on applied research activities. The model proposed is based on a concept supported by different views: functional, technological, and physical. With the aim of making the model learner-friendly, the chapter also presents an industrial case applied in the lift industry. The specific problems, the model used, the implementation carried out, and the results obtained are described in detail. The objective is to make a contribution based on the industrial practice to one of the basic enablers for product configuration. The final aim is to speed up the supply-chain process in mass customization scenarios.

Chapter III (*Product Configuration in ETO Companies*) reviews how mass customization and product configuration can benefit engineer-to-order companies. The relevant main literature in the area is reviewed to identify the benefits. Furthermore, the challenges of implementing product configuration in an engineer-to-order company are described. Finally, a number of suggestions for meeting these challenges are presented. In addition, a case description is introduced which supports that product configuration can benefit engineer-to-order companies even though there are a number of challenges to be met. The chapter concludes that engineer-to-order companies can certainly benefit from product configuration by improving business process efficiency as well as information quality and ultimately improving the company's competitive advantage.

Chapter IV (*Open Variant Process Models in Supply Chains*) will elaborate on complexity in supply chains and the implications on supply chain design. It investigates the specific requirements of supply chain processes in terms of flexibility versus standardization, evaluating the feasibility of designing, customizing, assessing, and improving logistics processes within a framework provided by process reference models. Mass customization and, in particular, a configuration approach for financial services will be discussed for their applicability for reducing complexity in a process environment. Process reference frameworks will be used as elements of an "open variant process model". The Supply Chain Operations Reference model defined by the Supply Chain Council as the major cross-industry standard for supply chain management will be discussed for its usefulness and shortcomings in "process mass customization", with a focus on systems implementation.

Section II - Frameworks for Mass Customization

Chapter V (*An Associative Classification-Based Recommendation System for Personalization in B2C E-Commerce Applications*) presents an associative classification-based recommendation system to support online customer decision-making when facing a huge amount of choices. Recommendation systems have been recently introduced to e-commerce sites in order to solve the information overload and mass confusion problem. This chapter applies knowledge discovery techniques to overcome the drawback of conventional recommendation systems approaches. The framework of the associative classification-based recommendation system has been addressed in this chapter. The system analysis, design, and implementation issues in an Internet programming environment are also presented. Taking the advantage of accumulative knowledge from historical data, the efficiency and effectiveness of B2C e-commerce applications are improved.

Chapter VI (*Knowledge-Based Recommender Technologies Supporting the Interactive Selling of Financial Services*) presents the knowledge-based recommender environment Koba4MS (Knowledge-based Advisors for Marketing and Sales) which allows a flexible mapping of product, marketing, and sales knowledge to the representation of a recommender knowledge-base. In Koba4MS diagnosis, personalization and knowledge acquisition techniques are integrated to provide an infrastructure for the interactive selling of financial services. Those require deep knowledge about the product domain as well as about potential wishes and needs of customers. In this context, sales representatives can differ significantly in their expertise and level of sales knowledge. Therefore, financial service providers ask for tools supporting sales representatives in the dialog with the customer.

Chapter VII (*Developing Interoperability in Mass Customisation Information Systems*) proposes a standard-based framework to assist industrial organizations to develop interoperability in mass customization information systems. After identifying the major challenges for business and information systems in mass customization, the authors propose an innovative standard-based conceptual architecture for a combined model-driven and services-oriented platform. The chapter concludes by describing a global methodology for integration of models and applications, to enhance an enterprise's interoperability in the support of mass customization practices, keeping the same organization's technical and operational environment, improving its methods of work and the usability of the installed technology through harmonization, and integration of the enterprise models in use by customers, manufacturers, and suppliers.

Chapter VIII (*An Agent-Based Information Technology Architecture for Mass Customized Markets*) presents a Web-enabled, agent-based information system model to support mass-customized markets. Furthermore, a distributed, real-time, Java-based, mobile intelligent information system is presented. This interfaces with firms' existing IT infrastructures, follows a build-to-order production strategy, and integrates order-entry with supply chain, manufacturing, and product delivery systems. The model provides end-to-end visibility across the entire supply chain, allows for a collaborative and synchronized production system, and supports an event-based manufacturing environment. The system introduces four general purpose intelligent agents to support the entire mass-customization process. The adoption of this approach by a semiconductor manufacturing firm resulted in reductions in product lead time (by half), buffer inventory (from five to two weeks), and manual transactions (by 80%). Similarly, the adoption by a leading automotive manufacturer resulted in a 51% total inventory reduction while increasing plant utilization by 30%. These results verify that the successful adoption of this system can reduce inventory and logistic costs, improve delivery performance, increase manufacturing facilities utilization, and provide a higher overall profitability.

Chapter IX (*Critical Role of Supply Chain Decoupling Point in Mass Customisation from its Upstream and Downstream Information Systems Point of View*) concentrates on the role of supply chain decoupling point. Therefore, this chapter introduces different levels of customization and mass operations as well as three types of mass customization. It argues that in each mass customization type, information systems in upstream and downstream of the decoupling point can be varied. Consequently, information flows in different types of mass customization have been examined. This analysis is an endeavor to organize mass customization information systems across the supply chain; it can also be a useful structure for future researches in this area as well.

Section III – Innovative Information Technology Approaches for Mass Customization

Chapter X (*From Strategy Definition to Product Derivation Using a Scenario-Based Architecting Approach*) presents a set of scenario-based methods and techniques to support the development of system architectures that are more future-proof, and are also advantageous for mass customization. These methods and techniques have originally been developed for highly-customized professional systems, in particular medical imaging equipment. The chapter introduces mass customization as a business strategy that aims at satisfying, in a timely and cost-effective manner, the various needs of different customers. For that purpose, a system architecture is needed that supports two different kinds of variability: Variability in space provides a range of different products where each addresses the specific needs of an individual customer; and variability in time allows the products to evolve and thus meet new requirements. In defining such an architecture, two issues should be considered. One is how to anticipate the most likely changes in the external business environment, and hence in the customers' future needs. The other is whether the architecture can address these changes effectively.

Chapter XI (*Research Issues in Knowledge-Based Configuration*) gives an overview on the current research issues in the domain of knowledge-based configuration technology. Knowledge-based configuration systems have made their way into industrial practice. Nowadays, all major vendors of configuration systems rely on some form of declarative knowledge representation and intelligent search techniques for solving the core configuration problem, due to the inherent advantages of that technology: On the one hand, changes in the business logic (configuration rules) can be accomplished more easily because of the declarative and modular nature of the knowledge bases, while on the other hand highly-optimized, domain-independent problem-solving algorithms are available for the task of constructing valid configurations.

As the development has not come to an end as, in a world that becomes increasingly automated and wired together, constantly new challenges for the development of intelligent configuration systems arise, this chapter provides a view on future research issues: Web-based configurators are being made available for large heterogeneous user groups, the provision of mass-customized products requires the integration of companies along a supply chain, and configuration and reconfiguration of services becomes an increasingly important issue, just to name a few. Finally, this chapter summarizes the state of the art, recent achievements, novel approaches, and open challenges in the field of knowledge-based configuration technology.

Chapter XII (*Mass Customisation of Services and Processes Based on Fuzzy Cognitive Maps)* draws on the theory of Fuzzy Cognitive Maps to propose a modeling approach for mass customization of services. The proposed model integrates concepts from service quality, and customer preferences with business process and IT capabilities models. The model presented in this chapter is, to the best of our knowledge, the only fuzzy service model for mass customization that provides the means to consider the business objectives for service customization, associates them with specific business areas, and suggests opportunities for mass customization. In contrast to other service design and management approaches, the proposed model is dynamic, exhibits flexibility and responsiveness to environmental changes and customizability to specific organizational contexts, and allows the development of planning scenarios.

Chapter XIII (*Applying Service CAD System to Value Customization)* introduces a new concept, value customization, to increase the level of customer satisfaction. It presents methodologies and practice for designers to customize value in a service in industrial operation based on the discipline of Service Engineering. Service Engineering aims at creating more value largely by knowledge and service contents rather than just materialistic contents. Specifically, an information system named Service Explorer, an implementation of the methodologies, is applied to an Italian accommodation industry. After the appli-

cation, five redesign options such as introducing a new service system with cash-back and a system of renting various goods were generated. Through this, the effectiveness of Service Engineering for value customization is suggested. This chapter addresses the importance of identifying value to be provided with specific customers based on their particular requirements, which has only briefly been discussed in researches of mass customization. In addition, both service activities and physical products can be crucial to realize value. Several further research issues such as general design methods for value customization were also identified.

This book provides the latest research results in the field of information systems for mass customization. This book describes the state-of-the-art, innovative theoretical frameworks, advanced and successful implementations as well as the latest empirical research findings in the area of mass customization information technology. Furthermore, new concepts and methods for successful mass customization are presented (like Scenario- and Knowledge-based approaches). The main objective is to bridge theory and practice, on the one hand, and to fill research gaps and answer open questions, on the other hand. The book improves the understanding of the problems that are encountered during the conception of information systems for mass customization. Furthermore, it provides solution approaches for the mitigation of these problems and simultaneously highlights new directions for future research. Therefore, it is not only a must for researchers and graduate students but also provides practitioners with the latest application-oriented results.

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