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The main challenges for manufacturing companies in implementing and utilizing configurators

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ABSTRACT

Companies providing customized products increasingly apply configurators in supporting sales and design activities, thus improving lead-times, quality, cost, benefits perceived by customers, and customer satisfaction. While configurator advantages have been substantially investigated, the challenges of implementing and utilizing configurators have less often been considered. By reviewing relevant literature, the present study first categorizes the main challenges faced by manufacturing companies when implementing and utilizing configurators. Six main categories of challenges are identified: (1) IT-related, (2) product modeling, (3) organizational, (4) resource constraints, (5) product-related, and (6) knowledge acquisition. Second, through a survey, the importance of those categories of challenges is assessed, and the specific challenges within each of those categories are highlighted. Finally, it is investigated whether the importance of the main categories of challenges varies according to a number of potential context variables. The results of the survey, which studies manufacturing companies that use configurators in providing customized products, offer new insights into the importance of these categories of challenges. The findings contribute to the research on manufacturing companies' utilization of configurators and will raise awareness of the main challenges associated with their implementation and use.

1. Introduction

In today's business environment, customers increasingly demand customized products with short delivery times, adequate quality, and competitive prices [1,2]. As one means of responding to those demands, mass customization strategies have attracted increased interest from both practitioners and researchers. Mass customization refers to an organization's ability to provide customized products and services that fulfil each customer's idiosyncratic needs without considerable trade-offs in cost, delivery time, and quality [3–5]. An important factor in achieving this ability are configurators, which are information systems that support the specifications of the product configuration as well as the creation and management of configuration knowledge [6]. Configurators can support interaction with customers directly or through a salesperson, thus presenting the offered products, collecting customer requests, and producing quotations [2,7]. Configurators can also support the translation of commercial product specifications into product documentation needed to produce the required product variant (e.g., a bill of material and production sequence) [2,7]. Some configurators support both commercial and technical processes while others support one or the other [2].

The benefits of configurators in supporting commercial and technical processes have been deepened by academic literature [2,7–24]. The use of configurators is notable in this: it reduces lead times [8–10,19], improves the quality of product specifications [7,10–12] and products [13,14], improves costing accuracy and product profitability [20], preserves product knowledge [7,16], reduces routine work [2], improves the certainty of delivery [7,10,17,19], augments the product-related and experience-related benefits perceived by customers [21–24], and increases customer satisfaction [7,10,18]. However, the challenges companies face in implementing and using configurators have not been addressed to the same extent as the benefits derived from the use of configurators, given the tendency in the literature to highlight successful uses [25]. A number of projects involving the adoption of configurators do fail [2,25]; in such cases, diminishing benefits derived from company resources and innovation efforts. Further, even companies that have managed to implement and utilize configurators have faced, and are still facing, various challenges. The empirical studies of these challenges are mainly based on case studies [6,7,10,14,20,26–29] and are based on surveys only to a limited extent

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[30–32]. Though some limited indications of the importance of the described challenges are given in some studies [10,20,25,26,30–32], a direct comparison of the importance of different challenges has not yet been provided.

The limited understanding of challenges and, more importantly, the importance of the challenges in implementing and utilizing configurators restricts the help that managers can find based on research results in reducing the difficulties their companies encounter in exploiting configurators. To move further in this direction, it is necessary to continue to explore for unknown challenges and—even more importantly, given the status of knowledge on this issue—to explore the relative importance of known and unknown challenges. The knowledge that can be gained through this kind of investigation will provide precious insights for the future development of theories on the mechanisms that prevent or mitigate the negative effects of the challenges under consideration. The present study aims to bridge this research gap by addressing the following research questions (RQs).

RQ 1. What are *the main categories of challenges* faced by manufacturing companies when implementing and utilizing configurators?

RQ 2. What is the *level of importance of each category* of challenges faced by manufacturing companies when implementing and utilizing configurators?

RQ 3. Which *specific challenges within each category* do manufacturing companies face when implementing and utilizing configurators?

We address these RQs by means of an exploratory survey designed based on what knowledge is already established in the relevant literature. To comply with the exploratory nature of the research, we have used open questions answered through phone interviews. To comply with the necessity of comparing the relative importance of the challenges already known, we used closed questions sent by email.

The remainder of the paper is structured as follows. Section 2 presents the relevant literature base. Section 3 explains the research method, and Section 4 presents the results of the research. Finally, Section 5 discusses those results in relation to the RQs and the existing literature and presents the conclusions of the study.

2. Literature review

As this paper considers the challenges of implementing and utilizing configurators rather than the algorithms or technologies used to make those configurators more powerful, the literature review reported on hereafter focuses on managerial rather than technological challenges. The considered publications are presented by combining chronological order and the groups of researchers involved. In this way, the reader can get a rough description of the evolution of the discussion on the challenges under consideration.

When reporting the configurator case of Digital Equipment Corporation in 1989, Barker et al. [14] described strategic/business challenges, technical challenges, and human resource/organizational challenges. *Strategic/business challenges* relate to cross-functional business needs that are traced to the implementation of configurators for enhancement of business processes, requiring support from top management. The identified *technical challenges* include underdeveloped commercial configuration software with limited functionality; application challenges in aligning the system with frequent product updates and launches of new products; scope expansion of the system; and the size and complexity of the configurators. The managerial issues implied by these technical challenges include the development of an explicit understanding of the software architecture, time-consuming training of new configuration experts, and prioritization of configurator maintenance without limiting the development of supporting tools for the configurators. Finally, *resource/organizational challenges* concern the awareness of key players and roles requiring organizational changes.

Tiihonen et al. [30], in 1996, published a study based on a survey of 10 Finnish industrial companies (answer rate 5.6%) to assess the "state of the practice" in product configuration. The deeply studied companies have not yet implemented configurators, but almost all of them were planning to do so at the time of the study. They identified the following five problems areas in product configuration: the economic importance of product configuration, the product configuration task, product configuration processes, long-term management of product knowledge and configurations, and interfaces with other systems and processes. By focusing on knowledge-based systems that can be used to model configuration knowledge, the authors identified the following issues: configuration knowledge (which is often not systematically documented), configurators' ability to support parametric components, geometry, and product configuration (e.g., to generate 2D and 3D drawings of parametric instances), customer requirements at different levels of abstraction, the level of automatic operations (where it is not always desirable to automate the complete process), long-term management of configurators' models, semi-configurable products, and finally, market areas that the configurator should support.

In another paper published in 1998, Tiihonen et al. [31] went deeper into the main challenges of long-term configurator projects by using the same 10 Finnish industrial companies analyzed in the previous study [30]. The authors underscored that long-term management of product knowledge is a challenge: difficulties in maintaining the configuration models have been the cause of configurator project failure. After a successful introduction of a configurator, it is meaningful to encourage its use by the entire sales force (i.e., those who sell configured products) and integrate it into retailers' IT systems. This wide adoption improves the front-end processes of a company system-wide. If retailers, however, are unwilling to acquire or use a configurator, integrating automatic and manual configuration processes is a challenge.

Ariano and Dagnino's [26] 1996 study related to a furniture manufacturing company in which a primary challenge was that too few employees understood the structure of the configurator. This caused difficulties when the only employee who fully understood the structure left the company. Additionally, when the main sponsor of the projects left, the company failed to further develop the system because of a lack of support and resistance to changing established work practices. The company lacked the expert knowledge needed to expand the system and was unwilling to allocate the required resources despite the known benefits. An overall lack of commitment from the company was, therefore, the main challenge in relation to the implementation of the configurator.

In 2000, Felfernig et al. [33] found that the complexity of configurator software development requires highly technical expert knowledge and that the knowledge base must be adapted continuously because of changing components and configuration constraints. Additionally, the development and maintenance time for configurators is strictly limited as the configurators need to be aligned with product developments and companies' offerings. To overcome these difficulties, a Unified Modeling Language (UML) is proposed as an approach to provide more formal descriptions of application domains. The approach is evaluated both in private telephone switching systems and in the automotive industry.

Also in 2000, Aldanondo et al. [34] described two kinds of expertise needed to develop a configurator: industrial expertise and configuration expertise. This knowledge is especially required in companies providing highly customized products, such as furniture, electronics cards, and power stations. The authors reported, however, that it was too time-consuming to train people to become experts in both areas. People with industrial knowledge do not usually develop the configurators, and industry knowledge is often distributed among various employees, making it difficult to develop a comprehensive understanding of both areas (i.e., configuration and product expertise). Furthermore, other challenges included representing the underlying structure of the configurators' models and finding a logical way to ask the customers