Product Configuration Activities in SMEs and their Digitalization: Preliminary Results of a Survey Study

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Abstract. The presence of customization in manufacturing small and medium enterprises (SMEs) is widely known, as is the competitive pressure that even they have to deal with. We also know that there are examples of successful applications of product configurators in SMEs, even in quite small ones. However, we do not know the extent of the presence, in SMEs, of the various product configuration activities or the intensity of their digitalization. The present study offers some preliminary results of research aimed at gaining further insights into product configuration activities in SMEs. Specifically, the present study provides preliminary empirical results gathered in a sample of 18 Italian SMEs. It emerges that configuration activities are frequently present in manufacturing SMEs and that there is high potential for their digitalization.

1 INTRODUCTION

In the last three decades, more and more customers have required products that closely satisfy their specific needs, leading to an increase in product variety and customization by companies (see [1], [2], [3], and [4]). Consequently, even small and medium enterprises (SMEs) in the manufacturing sector must offer product variety and customization to obtain and maintain their competitive position on the current market [5].

Offering product variety and customization implies a number of particular activities (e.g., those of the configuration process) and in general increases the complexity companies have to deal with. The management of product variety and customization is facilitated by the use of some supportive software applications (e.g., product data management [PDM], customer relationship management [CRM], and product configurators) [6]. Implementation of these kinds of software applications is often referred to as digitalization in recent literature (see [7] and [8]). For SMEs, it is often difficult to adopt and subsequently maintain such software applications due to the lack of financial resources and the scarcity of both IT staff and other specialists (see [9] and [10]).

The literature provides few examples of successful implementation of product configurators even in small SMEs (see [11] and [12]). Besides these sparse examples, we do not have information on the extent of the various product configuration activities in SMEs. Moreover, the intensity of digitalization of these configuration activities in SMEs remains unknown. Consequently, researchers do not know whether SMEs are a business context where configurators are diffusely adopted or have the potential to be diffusely adopted. This is important information for researchers because SMEs are a context with specific characteristics; for example, their improvement initiatives towards mass customization are constrained by limited human and financial resources [13]. If configuration activities are heavily diffused across SMEs, then it becomes important to investigate the digitalization of the configuration process and, in particular, the application of configurators because configurators have shown a capability to support great improvements in the configuration process. If the application of configurators in these SMEs is limited, then it is necessary to investigate why. Eventually, this investigation will discover that configurators that better fit SME characteristics need to be developed or that advancements of mass customization enablers that favor the application of configurators, such as part standardization and product modularity, need to be pushed [13]. Altogether, these research efforts could support the development of mass customization implementation guidelines specifically for SMEs and the technological development of configurators more suitable for SMEs.

The present study's objective is to gain more insights into product configuration activities, namely the extent of their presence in SMEs and the intensity of their digitalization. The research plan is to gather information on product configuration practices from a sample of 100 Italian SMEs. Unfortunately, the data collection has been interrupted by the COVID-19 pandemic. For that reason, the present study provides preliminary empirical results gathered in a sample of only 18 Italian SMEs. In considering the figures reported in the present article, the reader is advised that sometimes the reported numbers are percentages and therefore they never refer to the targeted final sample but refer only to the current sample of 18 companies.

Preliminary results show that configuration activities are frequently present in manufacturing SMEs. Also, although the current level of digitalization is not negligible, the companies have shown significant intention to further develop their digitalization, especially in some specific configuration activities.

The rest of the paper is organized into five sections. Section 2 presents a short review of the relevant literature. Section 3 provides details of the method used for gathering information and describes the sample, while section 4 reports the results of the study. Finally, Section 5 discusses the results and provides suggestions for future research.

2 THEORETICAL BACKGROUND

The configuration process is frequently present in companies that offer high product variety. It includes "the set of activities from the collection of information about customer needs to the release of the

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product documentation necessary to produce the requested product variant" [6, p. 143]. The configuration process generally includes several configuration activities that refer to three main groups: characteristics specification, component association, and configured product evaluation (see [14] and [15]). Please consider that these activities can be done in different sequences. In addition, there could be several cycles so that both customers and company personnel can go through these (or some of these) activities several times before arriving at a customer order or even before arriving at a quotation.

The first group of configuration activities regards the specification of product characteristics appropriate for a given customer. It includes the communication of options to the customers either in reply to their enquiries or as the proactive initiative of a salesperson or a sales application. The customers select the characteristics that satisfy their needs, and their choices are collected and stored. Product characteristics can be selected with the help of sales personnel or independently by the customers [16]. In both cases, it is necessary not only to collect all the needed product specifications but also to assure they are compatible [11]. This compatibility should ideally be assured while customers are choosing their product characteristics. If that is not possible, it can be done at another time, but if there are incompatibilities, the customer may be called to reconsider his/her choices. Sometimes this specification process leads to one or more product characteristics that are not already predefined by the company. In this case, the offered product space may be enlarged to satisfy the request for the new unforeseen product variant.

The configuration activities of the second group—component association—aim to identify the product components necessary to fulfil the product characteristics chosen by the customer and to establish relationships among these identified components. These configuration activities eventually (e.g., in the case of a new product characteristic) need to identify components that are not already predefined by the company: this is at the borderline of the scope of the configuration notion. Consequently, ad-hoc engineering of new components is required [11].

Finally, the third group—configured product evaluation—concerns evaluating the compatibility of all selected components and goal satisfaction (i.e., whether the configured product satisfies customers' needs, including their time and economic constraints) [14]. Notably, configured product evaluation can lead to changes in the original selection of characteristics and/or ad-hoc engineering. Once the necessary components and the relationships between them have been determined, operative instructions for product variant manufacturing are generated. Actually, the company may find alternatives in terms of components and production sequences that satisfy a given customer request with different impacts on costs and delivery lead times. Price determination is usually included in the configuration process, and it is crucial product evaluation information for the customer. Sometimes, the delivery lead-time is considered or partially considered. Therefore, the configuration process can include the determination of terms of delivery, a description of the product or service (e.g., technical drawings, charts, images, a user manual) and other aspects, some of which are useful for evaluating the product.

Notably, the configuration activities can differ across companies [11], and, as a consequence, the outputs generated by these activities can vary among companies. Specifically, the configuration process may result in all or some of the following outputs: quotation letter with price [11]; product cost [17]; product code (see [12] and [18]); bill of materials (see [17] and [18]); production cycle (see [19] and [20]); technical drawings (see [21] and [22]); product image [23]; or usage manuals [21].

3 METHOD AND SAMPLE DESCRIPTION

3.1 Method

To gather information from SMEs, we developed a questionnaire with several sections, each dedicated to a specific set of issues. This questionnaire starts with the overall company characteristics, such as number of employees. Then it considers the company's main commercial and operative characteristics, such as kind of customers and market response modality. Subsequently, it asks for information on the company's ability to fulfill personalized orders, considering both the performances that define this ability and the enablers that underpin this ability. At this point, the context of interest is clear, so the questionnaire moves to the issue of digitalization. First, it asks for some brief information on the overall digitalization of the company, such as the presence of enterprise resource planning (ERP), commercial presence on the web, customer relationship management (CRM), and use of product data management (PDM)/product lifecycle management (PLM). Finally, it goes into detail about configuration activities and their digitalization. Notably, the present paper focuses on these configuration activities and their digitalization; however, it also uses some information on the overall digitalization of the company and, in order to describe the sample and specify the context, some information on the overall company characteristics and its commercial and operative context. We deliberately limited our analyses to this set of information in order to focus on a specific aim. Obviously, a number of additional interesting questions arose, but in our research process we need first of all to gain an overall picture of the configuration activities in SMEs and their degree of digitalization; after that we will go in deeper analyses.

The questionnaire was designed to be completed by one respondent with overall knowledge of the company during one-on-one meetings with the company's representative. If he/she did not have all the information needed, other informants were contacted by the respondent to collect the needed information.

The questions used to collect the needed information are provided in the tables that report the results of the study (see Tables 2–8). This decision was made to facilitate reading this paper.

The answers provided during the interviews underwent a first check during the same interview. However, this control was a light one since the presence of the interviewer was thought to get answers that were as complete as possible. Challenging the respondent too much would have been counterproductive. We performed a more accurate control later. This check highlighted issues of missing data and some possible issues of coherence between answers. We excluded questions that had observations with possible coherence issues from the present article. However, we included questions with some missing observations. We planned a second interaction with respondents to control the potential coherence issues and issues related to missing information. We will do that when we have more than 50% of the sample on hand. In this way, we will be able to detect more potential coherence issues and avoid going back to the respondents more than once. In addition, when we go back to companies with

some preliminary results, this will stimulate collaboration. We are confident that we will be able to perform this second interaction with companies before the Configuration Workshop 2020, at least for the 18 observations used for the present article. During our presentation at the workshop, we will be able to provide reliable statistics on the number of product families and the number of product variants. Currently, these figures are affected by too many non-responses and even though they make sense, we are not sure they correctly describe our sample.

3.2 Sample description

3.2.1 Company size

According to the European Commission classification system, all companies in our sample are SMEs (i.e., they have fewer than 250 employees; see Table 1). More precisely, the data reported in Table 1 show that 83% of the companies are defined as small companies (fewer than 50 employees), and 17% are medium companies.

Table 1. Company size

No. of employees	No. of companies	Percentage of companies
1–19	7	39%
20–49	8	44%
50–250	3	17%
TOTAL	18	100%

3.2.2 Kind of customers and distribution channels

The companies in our sample sell products equally for final consumer use (business to consumer) and for industrial applications (business to business). The data reported in Table 2 indicate that the turnover derives mostly from direct selling and that less than 20% of the turnover is realized through intermediaries.

Table 2. Turnover split

How is your turnover split?	Mean* (%)
% Products for final customers	**42.0**
% sold directly to final consumers	33.8
% sold through commercial intermediaries	8.1
% Products for business customers	**49.7**
% sold directly to final business clients	43.0
% sold through commercial intermediaries	6.7
% Products made for third parties (not own products/parts)	**8.3**

* The mean is calculated on the 12 SMEs that provided an answer.

3.2.3 Degree of customization

Table 3 summarizes the questions and responses regarding degree of customization. The results reported in Table 3 indicate that:

- 93% of the companies receive orders for some functionality to be designed ad hoc. In particular, half of the companies receive more than two-thirds of their orders for functionality to be designed ad hoc.
- 47% of the companies receive orders with options selected. In particular, a quarter of the companies receive 25–50% of their orders for products chosen as a combination of options in the catalog.
- 60% of the companies have no orders for final products already defined in the catalog.

Table 3. Customization degree

Which percentages of customer orders belong to the following categories?	0	1–24	25–49	50–74	75–100	Mean *
	%	%	%	%	%	%
Product orders for which the customer asked for new functionalities that required ad–hoc design	6.7	26.7	13.3	6.7	46.7	55.9
Product orders for which the customer chose by combining predefined options present in the catalog without asking for new functionalities	53.3	13.3	26.7	6.7	0.0	16.1
Product orders for which the customer found the final product already completely defined in the catalog	60.0	6.7	0.0	13.3	20.0	28.0

* The mean is calculated on the 15 SMEs that provided an answer.

The fact that 93% of the sampled SMEs have engineer to order (ETO) orders, whereas only 47% have some configure to order (CTO) orders (only 7% have CTO in more than 50% of their orders and not a single one is CTO for more than 75% of their orders) does not threaten the validity of our sample for studying product configuration practices. This is for two reasons. The first is that an ETO company could redesign its product space to increase the use of CTO. Sometimes, even the introduction of configurators helps to reduce the percentage of ETO orders. Second, the application of a configurator can improve the configuration activities in an ETO process. The notion of partial configurability introduced by Forza and Salvador [11] supports this point. Let us take as an example a request for a machine with one feature to be engineered to order and all other features that are chosen from a predefined list. In this case, a configurator could automatically produce an incomplete bill of material and calculate the cost related to the part of the bill of material that is automatically generated. Obviously, the configuration process cannot be completed automatically; however, the gains in cost, time, and quality can be huge. An example of such a configurator is provided by Forza and Salvador [24].

3.2.4 Modality of response to customer demand

We asked for each company its market response modality. Table 4 reports the results from the analyses of the collected answers. These results are quite informative and indicate that:

- 82% of orders go through the technical office. Therefore, compared with Table 3, 72% of orders with new functions or orders with combinations of predefined options and 10% of final products already defined in the catalog pass through the technical office;
- 16% of orders are fulfilled from stock and, therefore, do not involve production. By comparing this with Table 3, it emerges that out of 28% of orders for final products already defined in the catalog, 16% are made on forecast and 10% are made on order.

Table 4. Activities included in order fulfillment

Which percentages of customer orders belong to the following categories?	**0**	**1–24**	**25–49**	**50–74**	**75–100**	**Mean* %**
	%	**%**	**%**	**%**	**%**	
Customer orders that pass through the technical/R&D department for technical control or design activities	0.0	12.5	6.3	6.3	75.0	81.6
Customer orders fulfilled with products made on sales forecast (and not "to order")	68.8	0.0	18.8	0.0	12.5	15.9

* The mean is calculated on 16 SMEs that provided an answer.

A comparison of figures reported in Table 4 with figures reported in Table 3 shows that both configured and catalog products pass through the technical office. This seems like a suspicious discrepancy, but it is not. While it is justifiable for configured products in the absence of a configurator, it does not seem justifiable for products completely defined from the catalog. However, as reported by Forza and Salvador [7], it could be that all orders pass through the technical office because a note on an order for a standard product could lead to a change in the product and, more specifically, could even lead to an ad hoc engineered product. This is an organizational solution to address the limited individual technical competence of sales personnel and the willingness to deliver quality to the customer.

Furthermore, the fact that 82% of orders go through the technical office while only 56% of orders have new functions indicates that on average 26% of the orders are processed by the technical office. With the use of a configurator with appropriate functionalities, the technical office could be bypassed, leading to gains in cost and answering time. This is a conservative estimate of the potential applicability of configurators in the considered sample because if we consider the possibility of managing partial configurability, the potential of applications is much greater.

4 RESULTS

4.1 Presence of activities

In the questionnaire, 11 configuration activities have been proposed, namely: selecting product characteristics [11, 24], determining price [11], generating the bill of material [11, 17, 18 24], generating the production cycle [11, 19, 20], determining the cost [11, 17], generating technical drawings [11, 21, 22], providing a product image (rendering, photo, sketch) [11, 23], generating a product code [11, 12, 18, 24], providing usage instructions [11, 21], specifying characteristics that are not predefined [11, 24], and identifying components that need ad hoc engineering [11, 24]. The answers provided for each of these 11 configuration activities are summarized in Figure 1. It emerges that each one of them is present, on average, in 80% of the companies that gave a response.

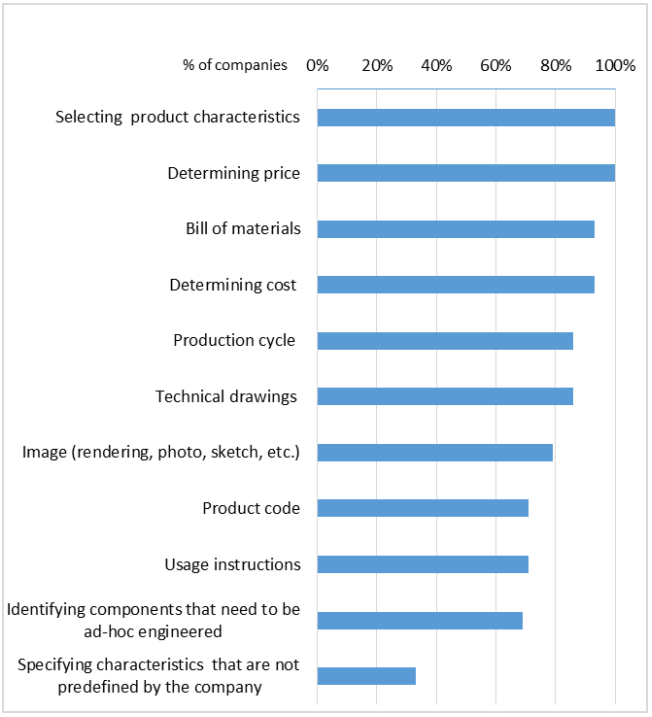

Figure 1. Presence of each configuration activity in SMEs

Figure 1 shows that all participating companies specified that they perform the selection of the product characteristics appropriate for the customer and determine the price during the configuration activity. Furthermore, more than 90% of companies answered that they generate a bill of materials and determine costs during the configuration activity.

We also analyzed the number of configuration activities performed in each SME. All companies indicated that they conduct at least 5 configuration activities, while the median number of activities present for a company is 9 (Figure 2).

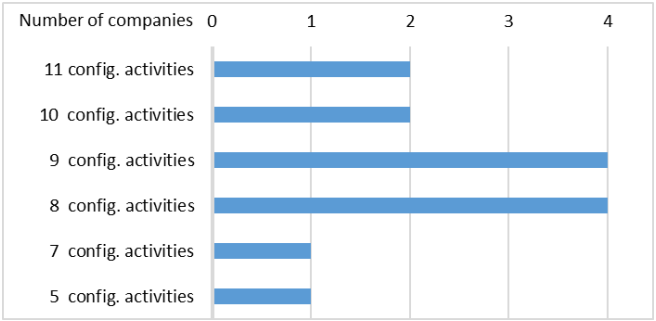

Figure 2. Number of configuration activities per company

The information reported in Figure 2 is important because it is an indicator of the complexity of the configuration process. More configuration activities imply requests for more functionalities in a configurator and greater implementation efforts. One could argue that this is not relevant because the incidence of configured to order orders is not very high. Again, we should consider the possibility of automating partial configurability. Therefore, this information significantly contributes to characterizing the specificity of the configuration context of SMEs.

One further word is needed regarding the activity of selecting the product/service characteristics/functionalities appropriate for the customer. This activity is usually carried out by sales personnel (71%), while 29% of companies indicated that this activity is carried out by the client alone.

4.2 Digitalization level of SMEs

The presence of ERP, MRP, PDM/PLM, and CRM software applications is used to comprehend the overall digitalization status of manufacturing companies that offer customized and/or a high variety of products (Table 5). It was noted that:

- The considered companies have a high presence of ERP (78%), where ERP is defined as a management information system that integrates business processes (i.e., sales, purchases, warehouse management, accounting, etc.). Obviously, these ERPs in most cases are not huge applications such as SAP®. Notwithstanding, their use signals the presence of business process integration supported by software applications: a first step in digital integration has been performed by SMEs.
- The considered companies also tend to have a strong commercial presence on the web (72%). The majority of the companies use their commercial presence on the web to present their products (69%), to collect contacts (54%), to receive requests for offers (34%), to produce offers (31%), and to receive orders (31%). The row data show that the commercial activity on the web differs from one company to another.
- The core of software production management support (MRP) is present in 53% of the sample. Keeping in mind that a number of companies do not need an MRP because they have an extremely limited number of purchasing materials, these findings can be considered a good level of digitalization.
- The adoption of CRM is not negligible (45%). This percentage is even more interesting given that some of these companies work for third parties or with a limited number of customers.
- Finally, the adoption of PDM/PLM is 39%, which is not low considering the complexity of these systems. This percentage shows the willingness of these companies to offer excellent support for product technical data management.

We also explored whether the level of digitalization depends on the size of the company. We saw that companies with less than 20 employees have less digitalization than companies with less than 50 employees, which, in turn, have less digitalization than those with between 50 and 250 employees. On average, digitalization in SMEs with more than 50 employees is double that of SMEs with less than 20 employees. We provide these figures to signal that there is variability in the level of digitalization that should be investigated once the full sample is available.

The presented data indicate, in general, considerable levels of digitalization. Of course, this does not mean that this digitalization is effective, but it does indicate that the considered companies have a significant openness to digitalization.

Table 5. Usage of software in companies

Which of the following software and hardware technologies does your company use?	**Mean% ***
ERP (enterprise resource planning)	77.8
Commercial presence on the web (use of own website or someone else's platform, e.g., Facebook, for commercial activities)	72.2
MRP (materials requirements planning)	52.9
CRM (customer relationship management)	44.4
PDM (product data management) or PLM (product lifecycle management)	38.9

* The mean is calculated on all 18 SMEs because all of them answered each question

4.3 Digitalization of configuration activities

Configuration activities are also significantly digitalized in the participating companies. Figure 3 reports for each activity how many companies declared that it is digitalized and how many declared that it is not digitalized. On average, each configuration activity is digitalized in 58% of SMEs (Table 6 column 3 last row).

When the sample is completed, we will investigate whether the digitalization level of configuration activities varies according to company size or other contingencies. We made a preliminary rough analysis of the distribution of the digitalization of configuration activities across companies. We calculated the percentage of digitalized configuration activities out of the total number of configuration activities present in each company. For these rough analyses, we hereafter report (in the text and not in the tables) numbers that support the possible presence of contingency effects. Data show that 50% of SMEs have digital support for more than two-thirds of their configuration activities, while 20% of SMEs have digital support for less than one-third of their configuration activities. In addition, data show that larger SMEs (>20 employees) report higher digitalization of configuration activities than smaller SMEs (<20 employees). We do not comment further on these data because they need a much deeper investigation (an investigation that considers not only digitalization but also some of the available context variables), which in turn requires a bigger sample.

For each configuration activity, we asked each SME whether it feels the need to improve the digitalization of this activity. Table 6 reports the results of this enquiry in column 4. Despite the fact that the various activities are digitalized, on average, in 58% of the SMEs, the need to improve existing digitalization is perceived, on average, by 48% of SMEs (see Table 6, column 4 last row). It is interesting to note that a number of SMEs felt the need to improve the digitalization of some activities that are already digitalized. This result suggests that in the future, besides greater digitalization,

we can also expect to see better digitalization of configuration activities in the SMEs.

To try to gain additional clues about the future level of digitalization for each configuration activity, we calculated a desired level of digitalization (see Table 6 column 5) using the answers regarding the presence of each configuration activity, its actual digitalization, and the declared need to improve its digitalization. A company is counted in the numerator of this percentage when it digitalized the row activity or expressed the need to digitalize this activity. Each company is counted only once in this numerator. The percentage is calculated on the total number of companies that have the row activity. This percentage represents the desired level of digitalization: part of the desire is already satisfied, while part is reasonably expected to be satisfied in the future. Therefore, this percentage also provides an indication of the level of digitalization we could expect in the future. Likely, it refers to a near or at least not too far future since the part not yet digitalized is estimated based on an actually perceived need and not on a generic possibility of digitalizing something. The results of this analysis are that the average level of digitalization of the configuration activities is expected to grow from 58% to 74% if all companies digitalize activities for which they said they feel the need to do so.

Notably, selecting the product/service characteristics/ functionalities appropriate for the customer has a low percentage of digitalization (Table 6). Interestingly, this low percentage is almost the same when the selection activity is carried out by sales personnel (25%) and when it is done by clients on their own (20%; Table 7). However, it is interesting to note that all companies where this activity is carried out by clients expressed a desire to digitalize it (Table 7).

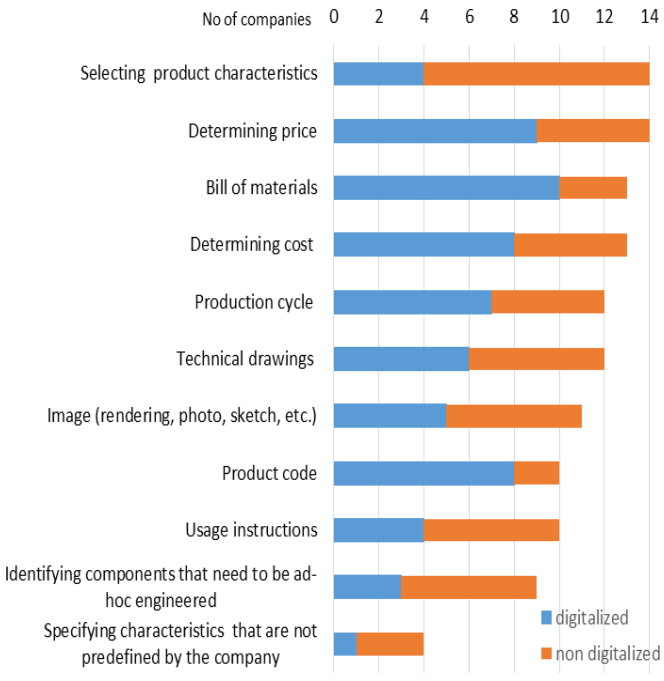

Figure 3. Level of digitalization of configuration activities

Table 6. Presence of activity, level of digitalization, and need for further digitalization

Configuration activity	Presence of activity (%)	Actual digitaliz. (%)	Need to improve digitaliz. (%)	Desired digitaliz. (%)	N tot *
Selecting the product/ service characteristics/ functionalities appropriate for the customer	100.0	21.4	21.4	42.9	14
Specifying characteristics/ functionalities requested by the customer that are not included in those predefined by the company	33.3	75.0	75.0	75.0	12
Identifying which product components/groups of the bill of materials, if any, need to be ad-hoc engineered	69.2	55.6	77.8	77.8	13
Generating/determining a new product/service configuration requested by the customer:					
its product code	71.4	80.0	40.0	90.0	14
its bill of materials	92.9	76.9	46.1	84.6	14
its production cycle	85.7	58.3	41.7	75.0	14
its price	100.0	69.2	57.1	78.6	14
its cost	92.9	61.5	46.1	69.2	14
its technical drawings	85.7	50.0	33.3	75.0	14
its image (rendering, photo, sketch, etc.)	78.6	45.4	45.4	81.8	14
its usage instructions	71.4	40.0	40.0	60.0	14
Mean	*81.1*	*57.6*	*47.6*	*73.6*	

* N tot. represents the number of SMEs that answered the question for the row configuration activities

Table 7. Presence of activity, level of digitalization, and need for further digitalization

Selecting the product/servic characteristics/ functionalities appropriate for the customer:	Presence of activity (%)	Actual digitaliz. (%)	Need to improve digitaliz (%).	Desired digitaliz. (%)	N tot
activity carried out by the client alone	28.6	25.0	75.0	100.0	14
activity carried out by salespeople	71.4	20.0	56.0	67.0	14

5 DISCUSSION AND CONCLUSIONS

We considered a small sample of SMEs (see 2.3.1). As far as we know, this is the first effort to describe the product configuration practices in SMEs. Therefore, even contextual information such as the sample description adds to the current knowledge. Half of the SMEs in our sample produce products for industrial applications, while a large portion of the other half produce them for final consumers (see 2.3.2). Almost all companies accept orders for products with new functions that require ad hoc design; half accept orders for products obtained by combining only predefined options, and more than half of the sample has no orders for final products already defined in the catalog (see 3.2.3). In line with this customization strategy, only a small part of their turnover is

realized through intermediaries, while more than 80% is realized through direct selling (see 3.2.2). Interestingly, more than 80% of orders pass through the technical office; however, one-third of the companies have at least some orders fulfilled with products made to stock (3.2.4). Given these characteristics, our sample of manufacturing SMEs is characterized by mixed customization strategies with a strong presence of deep customization.

Given the above reported characteristics of the sample, it is not surprising that almost all the provided configuration activities were found in the considered sample (see 4.1). Some activities, in particular, are present in 80–100% of the considered SMEs, namely, selecting product characteristics, determining price, determining cost, producing a bill of materials, determining production cycle, producing technical drawings, and producing an image of the chosen product. In the considered SMEs, the product configuration process is complex, with many outputs. Thus, these manufacturing companies, though small, have to deal with great complexity due to the product customization strategy they adopted. Digitalizing the configuration process in these companies could free up considerable technical resources from the product configuration process during the order definition and/or order fulfillment processes.

Corresponding to the complexity induced by product customization, these SMEs present a digitalization status that is advanced as regards ERP and MRP, commercial presence on the web, CRM, and PDM/PLM (see 4.2). This does not mean that this digitalization is effective, but it does indicate that the considered SMEs are significantly open to digitalization. However, this claim deserves further reflection, since we have yet to deepen the analysis with a full sample. Our current grasp of our sample and data leads us to think that this statement will hold.

Even though the configuration activities are significantly digitalized, the level of digitalization differs vastly across activities (see 4.3). While determining the product code and producing the bill of materials are highly digitalized, other configuration activities, such as selecting product characteristics or producing images or technical drawings, are much less so. In this respect, there is a considerable gap between the current digitalization of the selection of product characteristics and what digitally oriented customers are increasingly requesting. Why this is so? This is a research question suggested by this result.

The gap we have highlighted is likely not unknown to these SMEs since the data show that they feel the need to further digitalize configuration activities (see 4.3). In fact, even though configuration activities are also significantly digitalized, this level of digitalization is expected to grow to 74% if all companies modify the activities for which they believe there is a need. In particular, all companies where the activity of selecting the product/service characteristics/functionalities appropriate for the customer is carried out by clients declared that this activity is to be further digitalized. To signal the strength of this trend, there are some cases that demonstrate the willingness of some companies to digitalize this activity and transfer it to customers, even in cases where it is not currently performed by customers. The fact that 72% of them have a commercial presence on the web and that 44% have a CRM and 53% have an MRP suggests that they have the bases to do it. However, many other things should be considered to determine whether they are mature enough for this step. This is another question for research that this result indicates as timely.

One important issue that emerged is the fact that the considered manufacturing SMEs follow mixed customization strategies with a high presence of deep customization. Almost all companies accept orders for products with new functions that require ad hoc design; half accept orders for products obtained by combining only predefined options, and more than half of the sample does not receive orders for product variants completely defined in the company's catalogs (see 3.2.3). In this context, the notion of partial configurability [11] is a crucial notion. Through this notion, it is possible to bring the benefits deriving from the use of configurators to these SMEs. Without this notion, in many cases, the use of configurators would not be justified, due to the relatively small portion of configured to order orders. The implication for configurators is that functionalities such as those that allow a partial commercial and technical configuration are highly important. It would be a mistake to think that these companies have limited interest in a configurational approach. In all likelihood, it is exactly the contrary. Through the configurational approach [11], they could reconsider their product space and their way of responding to the market. Using configurators that support some fundamental activities, they could increase their awareness about their product space and manage it in a better way.

A second important issue is associated directly with the SMEs' insight into their product space. Interestingly, the questions that yielded the highest number of missing data were those related to the size of the companies' product space. Respondents found it extremely difficult to provide responses for number of families, number of end product variants, and numbers of new end product codes introduced per year. We will go back to most of our sampled SMEs again to get these answers. This is not the first time we have had this experience with these kinds of companies. This issue is problematic for research because the information is important to characterize the context. However, we have also learned that this knowledge is available and is shared in a company when the configurational approach is implemented. From this consideration, we argue that the lack of this information may be used as an indicator of the status of evolution in managing product variety in a company, and, as researchers, we could probably use it in our explanatory models.

Another issue that emerged regards the way the configuration process is split between front and back office. The fact that even part of the orders that are fully defined in the catalogs have to pass through the technical office is something that has already been noticed by Forza and Salvador [11]. However, this is the first time it has emerged from a survey study. This phenomenon deserves further research to understand its causes. It could be that even the introduction of a sales configurator would not solve this issue because without certain individual competencies in the sales personnel, a final check from the technical office is needed. This is only one of the possible conjectures, but it should be enough to call researchers to reflect on it at least a little bit.

The picture that emerges from this partial sample is interesting and encouraging for product configuration researchers. If the same results emerge from a wider and more representative sample, this would indicate that product configuration activities are present in SMEs and are not simpler than those in bigger companies. On the contrary, due to the need to address partial configurability and due to mixed customization strategies, they could be even more difficult. Likewise, resources are more constrained in SMEs, and the volume of activities is lower. It is more difficult to have the required resources to introduce product configurators, and when they are introduced, the gain is likely lower because the smaller size leads to fewer configurations per year. In order to identify

ways to overcome these issues, we think the research should consider identifying less expensive product configurators appropriate for SMEs, appropriate implementation processes, contexts that are more appropriate for digitalizing configuration activities, and the possibility of splitting the introduction of configurators into smaller packages that are affordable for SMEs. Researchers of product configuration are called to investigate in these directions.

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