Product configuration and inter-firm coordination: an innovative solution from a small manufacturing enterprise

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Abstract

In order to survive, a great number of small companies are forced to offer a wide product variety and often to respond to the market with customised solutions. At the same time, fast delivery is often a key to win orders. As a result, a vital challenge for these companies is to overcome the trade-off between product variety and delivery time, without compromising cost structure. Recent developments in Information Technology made available also for small companies a class of software tools – called product configurators – that promise to reduce this trade-off. This paper reports a case study of the implementation of a product configuration software in a small manufacturing enterprise. The paper highlights that the company enjoyed significant benefits from the implementation of the software, especially in terms of delivery time. Moreover, the case evidences that product configuration software can be proactively used as a tool for improving inter-firm coordination.

1. Introduction

For a long time firms operating in the industrial goods business have been offering a wide variety of products, in order to fulfil the highly heterogeneous demands of their customers. The fast speed at which companies have to react to change and switch to new challenges now dictate that this variety is provided in a shorter and shorter time. This phenomenon has been depicted by McCutcheon *et al.* [1994], who observe that many firms in the industrial goods business are "squeezed" between the request for customised products and the need to ensure high responsiveness in product delivery. Past research on product variety management articulated along multiple directions in exploring solutions to overcome these difficulties. Some scholars concentrated on the flexibilisation of the manufacturing process [e.g.: Kotha, 1995]; others on the rationalisation of the product structure by means of modular design [e.g.: Ulrich, 1995] others on the redesign of logistic processes [e.g. Hoekstra and Romme, 1992]. It is only recently, however, that management research considered the issue of how the "squeeze" between customisation and responsiveness could be reduced by improving the *product configuration process*. By *product configuration process* we refer to the process through which the customer's needs are translated into the product information needed for tendering and manufacturing (typically product cost, bill of materials, production cycle, etc.) The recent attention that management literature devoted the issue of product configuration is also related to the important advances obtained by Artificial Intelligence research [see Mittal and Fraiman, 1989; Soininen et al, 1998; Stumptner, 1997], advances that have been incorporated in a new class of software products supporting the product configuration process, called *product configurators*.

Up to now, however, management literature studies product configurators as tools supporting the technical office in processing product technical information [see Schmidt and Nourain, 1986; Wielinga and Schreiber, 1997]. Indeed, product configurators do not only affect the activities performed within the technical office, as they impact also the sales and manufacturing processes. Therefore, a first aim of the present paper is to study product configuration without a functional lens, in order to gain the whole picture of how product configurators impact the product configuration process. Secondly, past research on product configuration often draws its prescriptions from the study of big and expensive information systems that have been implemented in large multinational corporations, which have the financial means to embark also in risky technological "experiments" [see the study of Digital's X-

Con, Leonard Burton, 1987]. A second goal of this research is consequently that one of exploring how a small enterprise facing the "customisation - responsiveness squeeze" can take advantage of Information Technology in order to restructure its product configuration process.

These two goals are pursued by means of an in-depth case study that has been conducted in a small enterprise operating in the industrial goods business. Due to the lack of a comprehensive management theory dealing with the product configuration problem, the a priori definition of an interview protocol was somehow problematic. For this reason, the interview process has been focused on the mapping of the activities affected by product configuration before and after the implementation of the product configuration software. The interviewed personnel were employed in the sales, technical and production departments. The interviews have been recorded, typewritten and analysed following the prescriptions suggested by Miles and Huberman [1994]. Additional information has been obtained by means of archival documents, quality manuals, company profiles, and interviews with the software house that provided the product configuration software.

The paper is structured as follows. First, the studied company is shortly described, providing information on the business and on some key figures. Then, a description of the product and of the logic that is followed in generating product variants is provided. Then, the main product configuration-related problems faced by the company are discussed. As the implementation of the product configuration is concerned, first a description of the main solutions the company envisaged in formalising its product knowledge, and then the changes in the operational processes and in their performances are discussed. Finally some concluding remarks are made.

2. Company profile

The company that is object of this research is a small manufacturing enterprise, which employs about 45 people and has revenues for 3.8 millions Euro. It manufactures mould-bases for plastics moulding and punching- bases for metal sheet punching. The mould-bases for plastics moulding are the main product of the company, as they account for 60-70% of sales. The company customers are, therefore, mainly firms that mould plastic parts. Specifically, the company focused on middle and large sized customers, working for the auto, home appliances and sports footwear industries. The mould-bases are either normalised or made to the customer's own design, therefore there is little room for differentiating products from those ones of competitors. Low product differentiation, in turn, led to a general alignment of prices among competitors. One of the main ways to differentiate is the level of service, i.e. the capacity of the firm to deliver rapidly to the customer the needed solution. This is even more critical if we consider that a portion of the sales comes from spare parts: the cost of a mould-block has really marginal importance compared to the cost of the production stoppage due to mould-block failure. As a matter of fact delivery speed is an order-winning criterion in this niche business.

3. The product and the generation of product variety

The mould-block is needed to connect the die to the press and, therefore, it works as an interface between a highly variable object (the die) and a fixed object (the press). The mould-block is essentially made of a set of plates that are connected through guide pillars that slide into holes drilled on the plates. In order to allow a smooth sliding of guide pillars and plates, bushes are inserted into the holes drilled on the plates. Other accessories can fit through the plates, such as digging pins, ejector pins, springs, etc. An example of the product is given in figure 1.

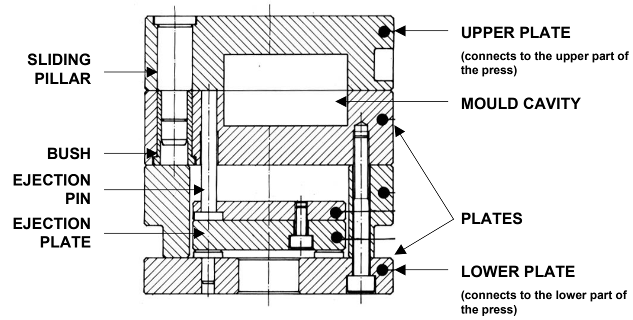

Figure 1: example of mould-block structure

The mould block is a highly configurable product. In fact, the various plates can:

- have different sizes and thickness;
- be combined in different ways;
- be made of different types of steel;
- be connected by different sliding pillars and be passed by different pins, requiring different holes to be drilled and different bushes to be inserted in the holes;
- have different holes pattern, even for a given set of pins and sliding pillars.

The logic that is followed in generating product variants is partially captured by figure 2. For example, variants 1 and 2 share the same top plate, bottom plate and spacer (PF, PS and D) while differ for other intermediate plates as PSX, PI and PX. However, a more careful analysis reveals that the latter plates differ from each other just for the presence of a hole. Similar conclusions can be drawn for products 3 and 4. As a matter of fact, all these parameters generate a huge variety of parts, variety that is mirrored in the more than 10,000 finished and semi-finished product codes that are currently handled by the information system.

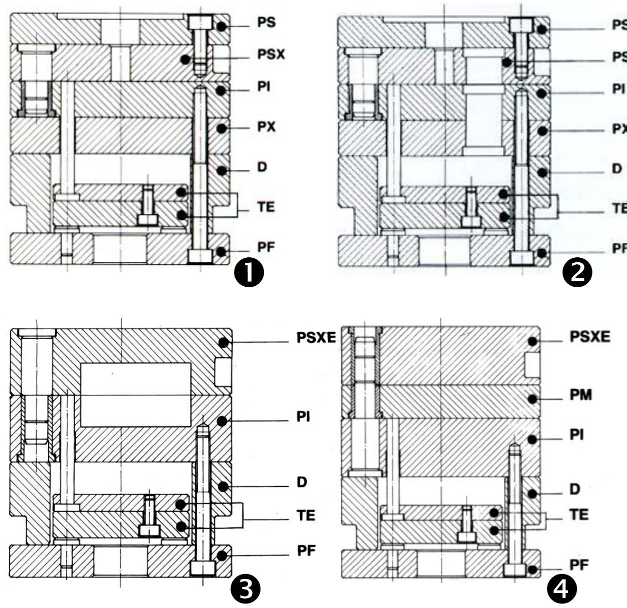

Figure 2: examples of different product configurations

To control complexity induced by the proliferation of final product configuration in the operational environment the companies in this business introduced the concept of normalised mould-blocks. This entails the normalisation of the possible dimensions (height, width and depth) of the plates into a fixed size range, as well as the normalisation of the possible diameters, length and shape of pillars and other sliding parts. However, the possible combination of parts remains high. Moreover, often the customer requires products with specifications that fall outside the normalised size ranges, further increasing product variety.

4. The issue of product configuration

The present section provides a description of the activities triggered by the customer bid and then by the order entry. The aim of this description (see figure 3) is that one of portraying how product variety affects part of the company operations, rather that to provide a detailed snapshot of the tendering and order fulfilment processes.

When a customer is to submit a bid to the company, it refers to its catalogue, first identifying a family. Then, within this family, the customer defines the exact specifications of the needed product. In certain cases, the customer needs products that do not exactly conform to a given product family, for example because of the different sequence of plates, or because of specific plate sizes, etc. In case the product is a "standard" product the customer picks the code from the catalogue, or can derive the exact code by following simple rules defined in the catalogue. In the bid, then the customer includes both the written product specifications and the product code. In case the product is a "custom" product, the customer has to include in the bid also a technical drawing, so that the firm has enough information to prepare the tender.

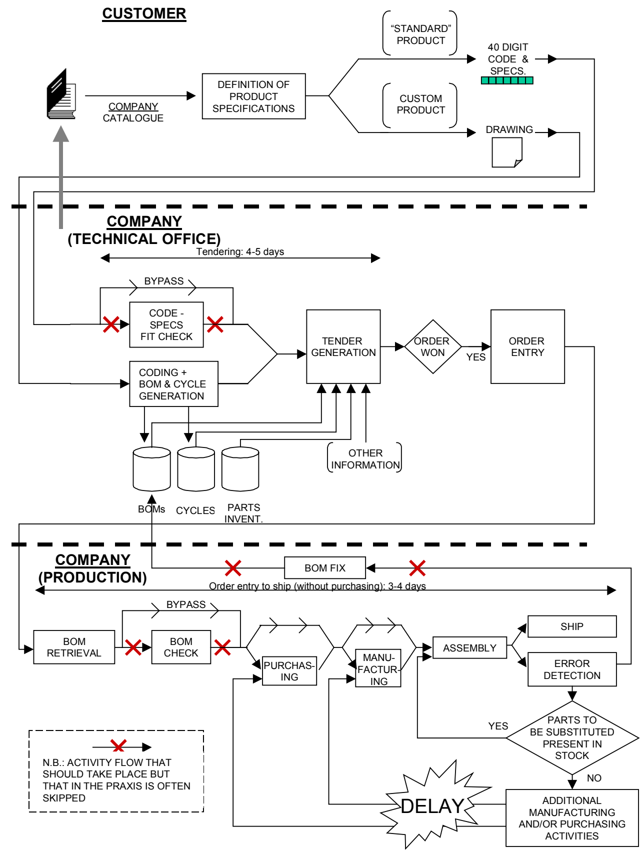

Figure 3: product configuration-related issues for the company

The activities performed in the technical office (which is in charge of product development) once the company has received the bid are different. In case of "standard" products, an employee is responsible for checking the fit between product code and product specifications, because of possible errors in coding or in reading the catalogue. In case of "custom" products, an employee in the technical office is responsible for generating a code based on the received drawing, as well as for creating the product bill of materials and production cycle. This activity is extremely time consuming, as it can take from 20 minutes up to an hour for the more complex products, and as every day the technical office has to process tens of bids. For this reason, the checks on the "standard" product bids tend to be bypassed, as the personnel concentrate on the more demanding task of generating product data for "custom" products. Once all the information needed to make a tender (bill of materials, manufacturing cycle, parts inventories, etc.) are available, the product can be priced and a delivery date (basically dependent upon the presence of the required materials in stock) can be defined. The average time a tender takes the firm is about 5-6 days.

Once the order is eventually won, the responsibility for producing and shipping the product shifts to the production area. Here, the production manager first retrieves and checks the correctness of the bill of materials (BOM). Indeed, due to the many tasks competing for the production manager's time, only rarely he is able to check for the correctness of the bill of materials, as he also has to take care of CNC machines programming (whenever manufacturing activities are needed) and of shop floor activities scheduling. Based on the bill of materials and on the inventories, he issues eventual purchase orders to suppliers and releases the work order on the shop floor. Due to the missing BOM check, errors are often detected only during the assembly operations by the workers. In case the wrong parts are present in stock there are not serious consequences on delivery time, as it is possible to immediately pick them from inventory, perform the needed operations, and assemble them with the other parts. Instead, when the wrong parts need to be substituted by parts that have to be machined or even purchased, then a delivery delay is very likely. According with the company's procedures, whenever an error is detected in the assembly process, the bill of materials should be corrected. However, this feedback loops always fails, even though for trivial reasons. For example, the workers could not have time to make the correction because they are working on the final assembly in order to meet the carrier pick-up time deadline. Alternatively, the personnel in the technical office might not notice the correction in the bill of materials because it is written in the same colour of the printer ink! Consequently, the firm reached an error rate in its bills of materials of approximately 20%.

As a matter of fact the firm – due to time pressure – is forced to skip a set of controls that end up generating errors that at the end negatively affect its capacity to deliver the products on time, thus threatening its competitive position. The apparently obvious alternative of increasing the staff in order to perform all the needed checks is not feasible, as this would increase the product full cost. Unfortunately, this is not a viable solution, as in this business where multiple actors offer similar products the price is given. In synthesis, the company faces a paradox: since time is a vital competitive dimension it is forced to compress and even bypass certain activities, with the result of introducing errors that negatively affect its time performances.

5. The attempted solution: a software to support product configuration

The previous section highlights that the main problem that the company is facing is that one of *ensuring the correctness of product information without reducing product variety* (this is not viable because of the specificity and heterogeneity of customers' needs) and *without increasing too much control costs*. The basic idea that informed the company's approach to the solution of this problem has been that one of automating control activities in the process of product information generation. Given this specific need, the firm decided to implement a product configuration software, i.e. a software tool that is capable of "translating" the customer specifications in all the product information that is needed for tender generation and product manufacturing. Specifically, the company implemented a stand-alone product configuration package that is developed and installed by a software house specialised in serving small and medium sized enterprises. Since a detailed description of the implemented software is out of the scope of the paper we will focus in the remaining sections on the way the product configuration software has been implemented and on its impact on the company's operational performances.

6. Product modelling

The greater issue in implementing the product configuration software has been *product modelling*. In fact, as we anticipated in section 3, the multiplicity of features that can be customer-defined leads to very high product variability. As product variability is not the outcome of irrational consumer decisions, but it arises from the customers' technological needs, then the product model has to accommodate for it. A high variable product model tends to be complex as well, especially when there are many interdependencies among the product characteristics. For example, an ejector pin requires that holes of the appropriate size are bored through all the plates that the pin has to pass. To further increase modelling complexity there was the fact that the product model, to be really useful, should embrace all of the product families, including the non-normalized ones, so that the customer could be driven in the selection of the product family that best fits his needs. The complexity of expressing in terms of rules and formulas the firm's product knowledge initially slowed the project, leading deadlines for the release of a working product model to slip from 3 months to 1 year. The project started to take-off only when an employee was detached from his daily occupations and committed full-time to the development of the product model. Once the system was up and running, of course this person could reduce the amount of time devoted to the product configuration system. A further source of complexity in product modelling is related to the fact that the customer's specifications (e.g. position of holes, surface roughness, etc.) affect not only assembly, but also manufacturing activities. For this reason, the production cycle has to be included in the product model, so that it can be dynamically generated based on the customer specifications. The product model, in the end, allows for the definition of the bill of materials and of the production cycle. These two pieces of information are of capital importance in the tendering process, as they allow for calculating materials and labour costs and, therefore, they allow for product pricing.

Product data (BOM and production cycle) is obtained by linking the generic bill of materials with a *configuration dialogue*, i.e. with a set of questions that are posed to the customer in order to define the exact product specifications. The same set of questions allows for the generation of the product code, which has been shrunk to 11 digits, of which 7 describe the product family and 4 the specific product version (they are assigned sequentially).

Once the company implemented the product model and the related routines for product pricing and coding, it became evident that the work done could easily be used to implement a further feature: the automatic generation of a 2D-CAD drawing of the mould-block by means of a *parametric model*. Although such information was not needed inside the company, it would have been useful to the customer, as it would have sped-up design (drafting) activities and would have given the customer immediate feedback on the layout of a given mould-block configuration.

7. Process and performance change after product configuration software implementation

The definition of a *sales dialogue*, its linkage with the product model in order to obtain the bill of materials, the production cycle and then the product price, as well as the implementation of a parametric model for automatic drafting, have important operational and strategic implications. By studying the changes in the company's operational processes one the product configuration system was up and running, it emerged that these implications affect both the company and the co-ordination between the company and its customers.

As the company internal processes are affected, the implementation of the product configuration software resulted into two different kinds of advantages:

- reduction of manned activities in the tendering process (tendering lead time from 5-6 days to 1 day);
- increase in the level of correctness of product information (almost 100%).

Concerning the reduction of manned activities in the tendering process, this is an obvious consequence of the presence of product models that automatically generate product information. Especially in the case of "custom" products, the coding as well as the BOM and production cycle definition activities disappear. Also the increased level of correctness of product information eliminates the need to perform certain control activities, such as the product code – product specifications fit check in the tendering process or the BOM check before production starts. In practice, since these activities were often bypassed because of rush, then the more correct product information results in less errors to be detected in the assembly phase, and consequently in greater delivery timeliness.

Besides these advantages, the company figured out an innovative way to capitalise on its investment in Information technology by releasing to the customer on CD-ROM an executable product configuration application. As we anticipated in the previous section this application:

guides the customer in defining the product specification through a configuration dialogue;

gives the customer flexibility in defining specific product variants (for example different plate assembly schemes or non normalised plate sizes);

generates a 2D CAD drawing of the mould block that corresponds to the customer's specifications.

The advantages relating to the delivery of the executable product configuration application to the company's customers can be characterised both in terms of operational performances and in terms of customer satisfaction and fidelization. From an operational standpoint, since customers adopt the product configuration software developed by the firm, then product coding, specification description and product drafts are all expressed using the conventions set out by the company. This in turn would reduce the eventual distortions in the company-customer communication channel, reducing the chance of delivering a product that does not conform to the customer needs. At the same time, through the product configuration software the company drives the customer to order objects that fall into its normalised product range. In fact the software tells the customer when he/she is defining specifications that fall out of the normalised product range and that, therefore, are likely to require longer lead times and/or increased costs. Reducing the incidence of products out of the normalised range allows for greater efficiency in production. Adopting a more strategic perspective, the product configuration software represents a way to tie the customer to the company by offering a service that is specifically designed to improve the coordination between the company and its customers in the bidding-tendering process. In fact, the information that is released by the software is tailored on the company internal products and language. Product description, drawings, code are all company-specific, and therefore cannot be used by competitors. The pay-off for the customers, besides the positive effect of better coordination, is the reduced time in generating product specifications and drawings.

8. Concluding remarks

The present paper shows how a small enterprise (45 employees) can afford and benefit from advanced IT applications, obtaining not only a rapid payback of the investment, but a competitive advantage as well. In line with the past research on information systems (see Scott Morton, 1991), also the implementation of the specific software considered in this research – the product configurator – is associated to organisational change, as part of the firm activities inside the technical office changed.

However, the paper suggests that the effects of product configuration software implementation propagate to parts of the company not directly involved in the implementation, such as the production department. Moreover, this specific case study demonstrates that the changes in the workflow induced by the implementation of a product configurator are not confined within the company boundaries, as they can affect also the customers' organisations. The product configurator, therefore, can be seen as an instrument that does not just improve internal working practices, but that improves inter-firm coordination by aligning working practices between the firms involved in the bidding-tendering process. Finally, product configurators may present to customers a configuration dialogue that drives them, as far as possible, towards the specification of product variants which tend to require a low content of really custom features, improving the company's operational efficiency.

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