Technology Matters

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When new technology reshape innovation

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ABSTRACT

Management of innovation is an important issue for firms and being good at this may be the deciding difference between death and survival. This paper argues, based on 12 case studies, that new technology influence the innovative capability of firms and disturbingly the process appears not to be managed in the sense that aims, instruments and resources are unclear.

It is observed that new technology is adopted with a limited scope and focus – often to solve a particular technical problem e.g. the quality of specification are too low. For a single reason a new technology is introduced within the firm, which over time becomes a source of innovation.

However, through adoption of this new technology firms engage in a mutual learning and forming process where the firm learn by using the new technology. When learning, the firm and the new technology is mutually formed as the firm tries to adopt and develop the elements of the new technology they see fit for their purpose. In this process the firms also adapt their existing technology to the new technology thus forming a new hybrid technology.

The technological and organisational learning process happens over time and translates into strategic learning. As the possibilities of the new hybrid technology are recognised a new strategy based on the new hybrid technology is formed trying to exploit its advantages.

The paper uses a number of case studies in firms implementing product configuration systems to substantiate these claims. It has been observed through these interviews that product configuration systems are being implemented to solve a particular problem only later to become a significant part of business processes. Product configuration systems over time become a central element when innovating new products.

1 Introduction

Innovation, be it process or product innovation, is the source of increasing productivity and wealth in society. Thus innovation is a major concern at both the national and firm level. Many scholars have been and still are interested in understanding innovation from a variety of perspectives and levels of aggregation.

This paper reports preliminary findings from the project for Product Models – Economics, Technology and Organization (PETO[1]), which contradicted the intuitive hypothesis that new technology is chosen and implemented as a managed process and the effect on the firm is well understood before hand. The intuitive hypothesis is based on the fact that resources are limited and firms as rational behaving entities are expected to put their resources to their best use. This, in turn, implies that different investment alternatives be scrutinized and those delivering the best expected return on investment selected.

However, there are forces pulling in the opposite direction towards quick decisions based on poor insight into the nature of the technology and its possible consequences. Some technologies are far from simple and perhaps better described as an empty box, for the firm to fill. Such technologies require substantial effort from the adopting firm to make it fit existing products and routines. If the adopting firm have no prior experience with such a technology it is difficult if not impossible to predict how such technology will match their organisation. Naturally a substantial effort will lower the level of uncertainty but such resources are not always present. In the process of choosing between several technologies the resources spent on each technology is even lower and decisions will be based on a simple understanding of the positive effects of the technology. However, complex technologies that affect and perhaps fundamentally change processes within the firm and this in turn change the innovative capabilities of the firm. This leads us to propose the following claim:

It is our claim that new technology is introduced in a firm as a simple tool based on a clear understanding of the positive and specific effect on the firm. It is further our claim that the introduced technology, as an unforeseen side effect, influence the innovative capability of the firm.

The paper will substantiate the claim with empirical evidence from 12 of case studies of Danish firms having implemented a specific technology[2]: Product configuration systems. Thus the question focuses on how this particular technology influences innovation, if at all. The second question is focused on how effects on the product configuration technology, over time, are integrated into the firms' strategy.

Extensive qualitative interviews have been conducted with employees at different levels in these firms. This paper does not presume to present the one true answer to the questions

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[1] The PETO project is financed by the Danish Technical Scientific Research Counsel.

[2] In this paper technology encompasses devices, organisation and procedures required to use the technology.

posed. It is, however, noteworthy that similar experiences can be drawn from a number of these 12 different firms, which operate in different markets.

Section 2 briefly describes what a product configuration system is and section 3 explain the methodology used. In section 4 the empirical evidence gathered is presented beginning with a brief overview of the participating firms. The cases which provide supporting evidence for our claim is presented first and those cases that do not are presented secondly. The procedure for both is similar and begins with a description of the problem and reason for investing in a product configuration system. Next the consequences and implications for innovation are explained and a conclusion is offered in section 5.

2 Describing Product Configuration Systems

A product configuration system is a computerized model of a product, which allow a sales person or customer to interact with the model and thereby choose the (configure) the desired components for this particular product. A product configuration system contain knowledge about the individual parts of the product and what variants of a part that are allowed to go together. For instance a product configuration system (PCS) for a bicycle will contain knowledge about the different sizes of frames, wheels, and various colours and their relationship. When a sales person configures a bicycle the PCS automatically ensures that the right size of wheels is added to the frame along with other items directed by the particular frame.

Product configuration systems can be designed with various levels of detail depending on the intended purpose. It is meaningful to adopt a distinction between 1) a tender configuration system and 2) a production configuration system. A tender configuration system is a PCS designed to produce a tender for a particular type of projects. Most often tender configuration systems are found in heavy engineering companies where the cost of producing a tender is very costly and a significant proportion of the tender contain the development of a product variant not previously developed. In the opposite end of the scale we find the production configuration system, which has complete knowledge regarding the product and its components down to the last spacer. Such systems are often linked to the company ERP system allowing a configured product to be directly produced. The PCS then feed a configuration to the ERP systems thus allowing for automation in the process of creating bill of material, routing, and inventory etc

A firm can be characterised as consisting of three distinct processes: 1) Product development, 2) Order handling and 3) Manufacturing as illustrated in Figure 1. We limit out focus to the development and order handling process and the relation in between.

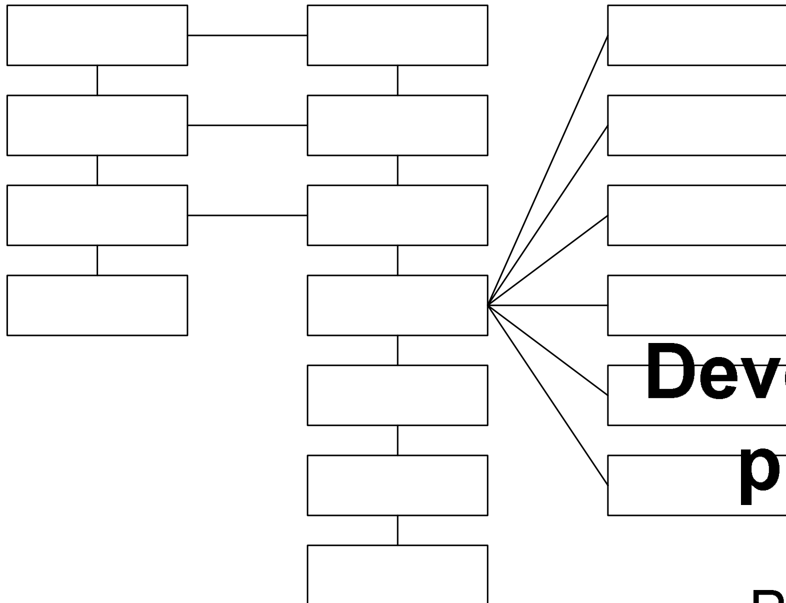

Figure 1: The process of a firm (Hansen 2003, from Barfod & Hvolby 1997).

Without PCS a customer enters in the top of the order handling process by contacting the firm. Sales personal and the customer enter into a dialogue with the intent of producing a product specification. If the product specification is outside normal parameters the product has to be modified to fit the customer's wishes. This is a costly procedure as the sales person has to contact product development who will make the proper adjustments. Regardless of how small these modifications are, they have to follow the process of making product modifications. This includes making new drawings, bill of material and specifying the modified production process. All of these activities include approximations by the involved staff as they try, to the best of their abilities, to match the customers need to a specific product. Often the process is a reoccurring iteration between customer, sales, product development, and production. This is complex process where responsibility for the process is changed back and forth between the involved departments. All too often required information to specify the product was not gathered in the first place resulting time consuming follow-up questions, which could and should have been avoided. The questions do consume a whole lot of time but they halt the process of producing a specification and so do all the iterations between development, production etc.

The purpose of a PCS is to automate a substantial amount of these iterations by creating a system that allows a sales person to specify a product in dialogue with the customer. If the desired product can be specified by the product configuration system all the usual back and forth between departments is eliminated and the specified product can be produced when the customer has accepted the offer made by the firm.

A product configuration system extends the range of standard products and makes it possible to configure these at a low marginal cost. Without PCS limited experience of sales people result in only a limited variation of the possible configurations being sold. With PCS it is further possible to support the actual sales process by allowing the PCS to make choices regarding configuration based on functional requirements. For instance, if one was to configure a truck and the customer required a specific capacity the PCS would allow only configuration which satisfy the capacity requirement. Naturally a product configuration system does not support arbitrary configurations and the firm must choose which products and components to enter into the model. The possible number of configurations offered by the model becomes a subset of the configurations offered by the company, as illustrated in Figure 2.

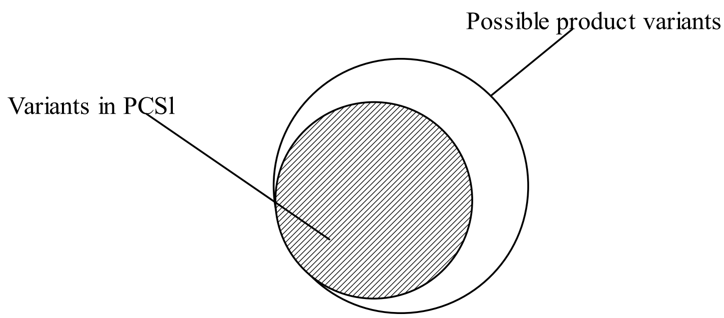

Figure 2: Possible product variants in a product configuration system is a subset of all product variants offered by the company.

While this may sound like the solution to many of our productivity problems it must be observed that there are significant problems with PCS or perhaps more specifically the implementation of PCS. It is evident from several implementation projects (Riis 2003, Hansen 2003, Hvam 1999) that there are significant costs associated with the implementation, and realizing benefits is dependant on several factors other than mere technical issues. Implementing PCS requires above all very specific insight into the product configuration process. It is imperative to know how and why a sales person or production employee configures a product as they do. What are the criteria for choosing one component in favor of another and this knowledge is most often tacit. But in order to develop a PCS this knowledge has to be made explicit and products must be grouped into different categories and the possible variation of elements specified.

For some firms this knowledge is tacit to the level where one is astonished that products are actually being produced. This observation is typically associated with firms producing one-of-a-kind products or small batches and is not related to firm size. Firms engaged in mass production typically have very explicit knowledge regarding their products as reducing the cost of a single part is important when competing on price.

Theoretically product configuration systems are part of the mass customization debate. Here we define mass customization as consisting of by two dimensions (Duray et al. 2000, p.607): 1) The basic nature of customisation, and 2) The means for achieving customization at or near mass production costs. The basic nature of customization refers to the observation (op. cit.) that variety in itself does not constitute customization At some point the configuration process the customer must provide input to the product specification. The means for achieving mass customization at or near mass production costs are essentially economics of scale as a consequence of modularity of the product.

When dividing a product into a number of distinct modules and making sure that some of these modules span more than just a single product it becomes possible to achieve economics of scale. Product configuration systems fit in the second category as a means for achieving customization at little marginal cost. However, it does not follow that the cost of producing the different variants will be the same. As Pine (1999, p196) notes: "The best method for achieving mass customization – minimising costs while maximising individual customization - is to create modular components that can be configured into a wide variety of end products and services", which is also recognised by Duray et al. (2000, p608). While it is easy to design a product configuration system around a fully modular product, it is not a necessity, and it is possible to design a product configuration system for a non-modular product. The latter product will not see the cost advantages of modularisation, and the process of creating the configuration system will also be more complex due to idiosyncrasies in the individual product variants.

3 Methodology

The research reported in this paper is but one result from the "The Product Models, Economy, Technology, and Organisation" project (PETO). The PETO project is studying the process and effects of implementing product configuration systems, which so far has received little attention by scholars. Most of the literature on PCS is centered in the mass customization debate and focuses on the technical aspects of configuration. However, research is emerging, which take into account more than just the technical issues and in particular Forza & Salvador (2001 & 2002) has offered insight into the economic consequences of PCS. Still the organizational perspective is relegated to an anecdotal level and general and long term effects are not discussed.

As no other interdisciplinary studies on PCS have been conducted, an explorative and hypothetical deductive approach was selected. Based on knowledge on product configuration systems a number of hypotheses was deduced for each of the economic, technical, and organization perspectives. This was then transformed into a questionnaire populated with questions directed at: 1) The specification process before and after implementing product configuration systems, this is the foundation for understanding the changes induced by implementing a product configuration system; 2) Technical issues of the implemented product configuration system; 3) Economic issues and 4) Organizational issues. The questionnaire was designed to document the order acquisition chain before and after implementing PCS. The questionnaire consisted of 196 questions of which 47 were directed at economic issues, 33 at technical issues, 97 at organizational issues, and 19 regarded the specification process. The questions were designed to be both closed and open ended questions, in the latter case leading respondents to elaborate and explain certain positions (Jacobsen 1996:111). The open ended questions were used deliberately to allow some degree of exploration in the interview process, and respondents were allowed to pursue their line of thought before being interrupted and directed towards the question. Concluding questions were used to confirm and summarize the meaning of open ended questions.

17 firms among the members of the Danish Association for Product Modelling[3] were approached and 13 firms agreed to participate in the study, however, one of the 13 firms did not have PCS implemented and was interviewed only because they had rejected to implement PCS. Thus 12 firms with product configuration system experience were subject to qualitative interviews using the developed questionnaire.

Firms were asked to provide individuals of the following categories: 1) Sponsor, 2) Technician/programmer, 3) User, and 4) The project leader. These four roles were chosen, as they would theoretically represent all organizational levels of a product configuration project.

The interviews were intended to be conducted with a single respondent at a time, allowing for a detailed interview with personal opinion expressed. To help establish a minimum level of trust, respondents were provided with a written and signed statement expressing that the information would remain anonymous and certainly not shared with their colleagues.

However, in some cases it was not possible to conduct individual interviews, and a group interview was the only option for having the specific firm participate in the study. It is expected that these interviews to some degree fail in uncovering problems with the product configuration system and the implementation process, which are due to personal differences. Group interviews have a tendency of expressing consensus among the respondents.

In all interviews multiple investigators (Eisenhardt 1989:538) were used to ensure complementary opinions and insights and to enhance confidence in the findings. During all interviews two investigators were present, and on some occasions even three and four investigators found their time to participate in the interviews. The combination of multiple investigators and open ended questions is very powerful, if investigators deliberately keep silent to pressure respondents into answering. On many occasions this was the deciding factor for getting a meaningful answer. The interviews were taped and subsequently transcribed, which was followed by a condensing procedure for extracting the meaning of the interviews (Kvale 1994:189).

4 Empirical Evidence

12 firms have been interviewed all of which had or was in the process of implementing PCS. The participating firms have all been promised to remain anonymous and we shall refer to them as firms A through L. The cases will be divided in two groups: Those offering evidence supporting our claim and those not. Two of each type of cases will be presented in detail and the remaining eight cases will be briefly summarised.

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[3] See www.productmocels.org.

Firms A and B manufacture production plants and single orders are often seen in the 100 Million Euros range. Firms A and B are large and old firms with a lion's share of their market. Both firms are engaged in heavy engineering and the bulk of their resources are spend on engineering hours. Firms C to G consist of firms which, which all has a history of being mass producers. Firms C and D produce consumer goods and firms E, F and G are industry suppliers, the turnaround in this group range from 12,5 to 600 Million Euros. Firms H to L are firms which are batch producing firms, which allow the firms to modify the product specifications. The turnover in this category was between 22 and 550 Million Euros.

4.1 Cases Supporting our Claim

Firms supporting our claim are: A, B, E, F, I, and J.

4.1.1 Firm A

Firm A is a heavy engineering firm which implemented PCS for two reasons: 1) Maintain key knowledge within the company and 2) Make the product specification process more efficient. Firm A is in a situation where a significant number of the key staff is due for retirement within the next 2-5 years and much of their knowledge is not documented. As this staff is highly specialized engineers this is a potential threat for the company. Heavy engineering firms is characterized by the fact that a specific tender for must be produced for each single client. Firm A has further observed that the number of tenders produced for each order is rising and is currently 33 tenders' per order. Firm A is currently in the final staged before putting their PCS into productive use. However, the experience is that firm A has developed a PCS which meet the original criteria and thus Firm meet the first part of our claim.

It is, however, apparent that the product configuration system will have unforeseen effects on the innovation system in firm A. Before PCS most product development was a direct result of customer requests and when similar products has been developed a number of times they were regarded as standard products. PCS is now envisioned to be an integral part of product development where new models are developed within the product configuration system before customers express a need for the product. This also changes the role of development from reactive to proactive and new ideas for products must be generated using other sources of inspiration than customer input. Firm A support the second part of our claim by demonstrating that PCS has induced a change in the perception about how products are developed. PCS is not believed to be a central part of future product development and this was not envisioned in the beginning of the project.

4.1.2 Firm B

Firm B, implemented PCS with the purpose of reducing the amount of resources required for the production of a tender. In firm B a tender requires an average of 2500 engineering hours and such workload often drain the firms resources in times where many customers approach. Firm B has traditionally dealt with this situation by estimating the probability of getting the deal and rejected others. However, it appears that the procedure for predicting the customers to address is not functioning as a review of past orders and estimates revealed less than 50% hit rate - in other words they felt it impossible to make a prediction. This called for a tool, which could automate the process of generating a tender and allow the firms to produce tenders for all interested potential clients.

Firm B went through a development process where the actual work processes and products were analysed and documented (see Riis 2003, p.186 for a general description of such an analysis). The product configuration systems were implemented and firm B experienced that the PCS was able to deliver the expected benefits. Firm B experienced that a tender of higher quality i.e. more precise in responding to specific customer wishes, could be produced in an average of 190 engineering hours compared to the previous average of 2500 hours.

Thus, firm B support the first portion of our claim: A tool has been selected and implemented for a specific purpose of automating the tender producing process. Firms B also went through a significant process of restructuring the organisation and their perception of their products, which was not anticipated.

Firm B is perceived as an engineering firm and proud of it. Consequently it is has been corporate culture to cater for the individual customers by producing a product which was tailor made. If the customer needed a grinder 7.5 meter in length the customer would get it regardless of the 8.0 meter grinder developed just last week. When a number of customers had requested similar products the product would slip into the catalogue as standard product. Such development has significant implications for the costs of the product and when department A changed their grinder department B and C etc. would have to adjust accordingly and this is very costly but consequences was invisible to department A.

In the process of developing PCS it became necessary to break the product in to categories based on production capacity of the product. Consequently the various departments were asked to deliver estimated costs for a variety of their components, such as the grinder. It became chokingly clear that some variation in cost was not tied to whether the grinder was 7.5 or 8.0 meters and actually a majority of the need for grinders could be satisfied in just three different models. This was done for all of the components in the product and it was possible to configure the PCS to produce a tender based on a information proceed by the customer in the first interview. The tender produced could then serve as a basis for further negotiation.

Once delivered the individual departments were forced to deliver components which complied with the specifications and this resulted in a significant modularisation, which is changing the perception of how to develop the product. Departments now think in modules, which are structured according to an overall design of the factory e.g. capacity of the plant. This change is a fairly recent event and has happened during 2002 and 2003. For this reason it is not possible to clearly identify the effects on innovation from modularisation. It does however remain clear that the nature of innovation has changed. Before PCS innovation was part of every order but now PCS ensure that the same modules are used many times. It is not clear what the source of innovation will be now and no alternate means of stimulating innovation has yet been determined. Therefore we can fear that innovation is slowed down with possible negative long term consequences. The conclusion is that innovation is affected but it is not yet possible to determine how and what the consequences are.

4.1.3 Firm E

Firm E needed a tool to reduce the turnaround-time for specifying a new product variant and succeeded in achieving a reduction from 6 to 1 day.

Firm E was force to change their product development practice from reactive to proactive. Before implementing PCS customers would demand changes made to an existing product e.g. improved resistance to high temperature conditions. The development department would then make the proper modifications and after seeing the same demand the product would become a standard product. Now, the development department act proactively and predefine a number of variations when developing a new product

4.1.4 Firm F

Firm F experienced that the quality of product specifications was too low and needed a tool to validate product configurations. PCS was implemented as a tool to improve the quality of specifications and it was a great success as the number of faulty specification has dropped from 25% to 0%, measured as the number of production halts due to faulty specifications - quite remarkable. This supports the first part of our claim.

Before implementing PCS most product configurations had to pass through the product development department for validation. After implementing PCS most of the validation is done using the PCS and now product development can actually focus on developing new products. In the situation a product configuration is not validated through the PCS it must be validated in the product development department. There are both advantages and disadvantages to this change. The obvious advantage is that the majority of product validation is now done automatically which has resulted in lower turnaround time. The disadvantage is that the product development department is rarely presented with odd customer requests generating fewer ideas for new products. There has also been a change in focus in product development. Product development now focuses primarily on cutting costs and new models are often a redesigned version of a previous model e.g. the model is a direct replacement in terms of size and quality but significantly cheaper due to changes in assembly and production routines. Another change is the facts that firm F now only embarks on developing a radical new design or product if such a product is backed by a customer who is willing to be part of the development and buy a certain amount.

These are all changes to the innovation process which has been facilitated by the product configuration system and we conclude that firm F supports both the first and second part of our claim.

4.1.5 Firm I

Firm I implemented PCS as an integrated part of a new ERP suit and needed PCS specifically to establish a clear overview of the product range. Firm I had a history of producing tailor made products for individual clients. Firm I produce a product, which is a productive resource for the customer and the yield of the product is directly related to its height. Needless to say customers demand the highest product available. However, the same relation does not exist between production cost and height, which has lead to a number of unpleasant surprises in terms of lost profit. The combination of PCS and ERP has resulted in a more managed production process where only valid products can be configured and sold.

The use of PCS has lead to insight into the structure of all the different models produced by firm I. It has been discovered that there are significant potential for modularization e.g. a cooling system of equal effect is not the same for different models. The result has been different housing and cooling hose systems, which further makes it impossible to share parts between models. The overview provided by the PCS has resulted in a move towards a more modular type of development whereas earlier the process has been typically integrated product development, which supports the second part of our claim.

4.1.6 Firm J

Firm J produces equipment to be used on trucks and the product has to be configured to particular type of truck used by the customer. The functional characteristics of the product also have to be specified and naturally there are many restrictions between the functional and structural specifications. Before implementing PCS only a single individual was able to thoroughly validate product specifications and calculate a price.. In most instances sales staff would pass a product specification for validation and it would contain no errors but occasionally errors were detected. It also happened that products were validated and later in the production stage it was realized that product simply could not be produced. An increase in the number of orders resulted in the person doing the validation and price calculation becoming overloaded leading to prolonged response time. Firm J choose to implement PCS as a means of overcoming this particular situation and PCS was to ease configuration and allow sales staff to determine the actual price. This supports the first part of our claim.

The PCS, however, also had a significant effect on the process of innovation. Before PCS products were developed in the same pace as customers desired variants not part of the standard products. The innovation process was typical integrated product development in the sense that functional innovation was specifically tied to the structure of a product. Thus, when a new customer demanded the same functionality but to be used on different equipment the product had to be developed all over again.

PCS had the effect that the existing range of products was systematically divided into a number of product families. In the process of doing so it was discovered that on many occasions the same functionality was provided in different ways i.e. the bill of material was not at all similar. At first this was just noted but not acted upon. After making the PCS available for both sales and product development a common understanding of the different product families evolved. The PCS provided a clear overview of the different products and their parts and this over time resulted in product developers beginning to apply a modular approach to new functionality. A modular approach has the distinct advantage that a specific functionality is no longer are tied to a specific product structure. This advantage becomes further pronounced when using PCS as the PCS immediately allows a feature to be used across structures as long as a particular structure has the required interface.

The change in product development strategy was not anticipated but indeed welcomed due to the inherent cost savings from not having to develop for a specific structure. Thus, this case also supports the second part of our claim.

4.2 Cases Not Supporting our Claim

Firms C, D, G, H, K and L do not support our two claims.

4.2.1 Firms C and D

Firms C and D are both manufacturing products in which the element of design is very important. Sales are driven by product design rather than functionality and specific features. These firms have deliberately decided design to be the governing factor in product development. This becomes evident in the organisation where the PCS department is involved only after the product has been developed and then only to build a model, which allows for easy configuration. These two firms also had long term experience with PCS in which case it cannot be ruled out that product development has been affected in the past although the respondents denied this. This leads to a conclusion, although based on only two firms, that when design is a dominating parameter it is possible to use PCS as a specific tool which can be implemented and managed without unforeseen consequences for innovation.

4.2.2 Firm G

Firm G implemented PCS as a tool with the single purpose of improving intra company sales and allocation of production resources. Firm G long time ago implemented PCS within their ERP system allowing sales staff to easily configure and allocate production resources to the order at hand. When firm G was interviewed they were in the process of implementing a new PCS as a replacement. In the new PCS all production resource across subsidiary companies has become available to all allowing easy allocation of resources. As the products already were configurable no new insight has been gained in the process. It is possible that the original PCS implementation has had significant effects on innovation although it cannot be substantiated.

4.2.3 Firm H

Firm H produces uninterruptible power supply systems and introduced PCS as a general concept for selling their products. Product configuration and allowing customers to be part of the configuration process is considered the core of their strategy. Product innovation is undertaken in the product development department and the configuration department program their PCS the moment a new product or variant has been released. Modularisation is also a core concept in firm H although it has been motivated from production and development rather than from configuration. Firm H emphasized modularisation and take great care to develop products that can be produced and assembled as cheap as possible. One example is a product family which has to major variants, which has 110 components in common. Variant 1 requires 25 additional components and variant 2 requires 46 additional components. While not motivated by configuration such product strategy is a perfect match with configuration as the required division into product families are already done in the development stage. Thus, firm H does neither support the first, nor the secondary claim.

4.2.4 Firm K

Firm K implemented PCS with the sole purpose of being able to make sense of an enormous amount of product variants. Firm K differentiates their product by offering custom sizes and not just a number of standard sizes. This results in an enormous number of variants and since the product produced by firm K has a very long lifespan, which is currently around 40 years for one product line, the possible number of variants is very large. PCS has not influence the number of variants, nor the product innovation process. Product innovation is driven by long term changes in the market and not possible modularisation. It would appear that firm K like firm C and D is driven by design but also give priority to reducing costs. PCS reduce costs by streamlining the specification process and producing ready to produce specifications.

4.2.5 Firm L

Firm L manufactures electric distribution boards for industry use and implemented PCS in order to allow customers to do their own configuring using a web browser. The general idea was to increase productivity by letting the customers do some of the work, so in this sense there was a clear objective for the project. Firm L succeeded in developing a PCS fulfilling the goals and it has not been possible to detect changes in production or innovation as a consequence hereof. In fact, it was part of the purpose that the sales department was to use the configuration system, which never happened. The sales department feels that the configuration system provides too many constraints and therefore they continue to use the old ERP based system.

5 Conclusion

This paper stated the claim that new technology is introduced in a firm as a simple tool based on a clear understanding of the positive effect on the firm. It is further our claim that the introduced technology, as an unforeseen side effect influence the innovative capability of the. The claim was tested against experience from a project analysing 12 Danish firms having implemented product configuration systems.

Six of the analysed firms support the claim and all exemplify that technology is chosen as a solution to a specific problem and the consequences are not completely understood. In all of the supporting cases PCS changed the order acquisition process making it more streamlined. The benefit was lower turnaround time and consequently higher productivity. PCS inspire modular thinking in the sense that in order to use PCS a model of the products had to be programmed into the system. Some firms went through a formal process for developing such a model and others just programmed their products one by one into the system. Regardless, all firms have experienced an increasing focus on modular development as compared to integrated development. Modular development has the advantage that discrete modules can be replaced without having to redesign the whole system. Needless to say this has positive effects on productivity. However, it is not possible to predict if these changes will have a long term positive or negative effect on the firms.

Of the analysed firms whom did not support our claims it is interesting to observe that three of the firms (C, D and K) produce products, for which design is the perhaps the most important issue when developing new products. These firms have implemented PCS to support the sales process, which in turn has had spill-over effects into production planning but not product development. Firms L, G and H all had different reasons for implementing PCS. Firms L and G already had experience with similar technology and both product and production processed appeared to match PCS.

Based on the evidence presented it appears that complex technology indeed do influence innovation and the six supporting cases where innovation has been influenced this was not anticipated.

6 References

Davis, Stanley, 1987, “Future Perfect”, Addison-Wesley.

Duray, Rebecca, Peter T. Ward, Glen W. Milligan, William L. Berry, “Approaches to mass customization: configurations and empirical validation”, Journal of Operations Management 18 (2000) 605-625.

Empirical evidence from the PETO project (Product Models – Economics, Technology and Organisation). More than 30 interviews are planned and in the process of being conducted in Danish companies. Currently 9 interviews have been completed.

Edwards, K, Lars Hvam, Morten Møldrup, Niels Møller, Jørgen Lindgaard Petersen, Jesper Riis. 2003 “Teoretisk Foranalyse”, The PETO project, Department of Manufacturing Engineering and Management, Technical University of Denmark.

Eisenhardt, Kathleen M., 1989, “Building Theories from Case Study Research”, Academy of management Review, Vol 14, No.4, pp.532-550.

Faltings, B. and Rainer Weigel, 1994, “Constraint-based knowledge representation for configuration systems” Technical report No. TR-94/59, Department D’Informatique.

Forza, Ciprane and Fabrizio Salvadore, 2002, “Product configuration and inter-firm co-ordination: an innovative solution from a small manufacturing enterprise”, Computers In Industry 49 pp. 37-46.

Forza, Cipriano and Fabrizio Salvadore, 2001, “Manageging for variety in the order acquition and fulfilment process: The contribution of product configuration systems”, Int. J. of production economics 76, pp. 87-98.

Hansen, Benjamin Loer, 2003, “Development of Industrial Variant Specification Systems, Ph.D. thesis, Department of Manufacturing Engineering and Management, Technical University of Denmark.

Hvam, Lars, 1994, “Anvendelse af Produktmodelering – set ud fra en arbejdsforberedelses-synsvinel”, Ph.D. Dissertation, Driftteknisk Inistitut, Technical University of Denmark.

Hvam, Lars, 1999, “A Procedure for building Product models”, Robotics and Integrated Manufacturing.

Jacobsen, Jan K., 1997, “Interview – Kunsten at lytte og spørge”, Hans Reitzels Forlag (in Danish).

Kvale, Steinar, 1997, “InterView”, Hans Reitzels Forlag (in Danish) translated from English: Nake, Bjørn, 1994, “InterView”

Pine,B. Joseph II, 1999, “Mass customization – The New Frontier in Business Competition”, paperback, Harward Business School Press.

Riis, J., 2003, (In Danish) “Fremgangsmåde for Opbygning, implementering og vedlige-holdelse af produktmodeller”, Ph.D. Thesis, Department of Manufacturing Engineering and Management, Technical University of Denmark.

Silveira, Giovani Da, Dennis Borenstein and Flávio S. Foglitto, 2000, “Mass customization: Litterature review and research directions”, Int. J. of production economics.

Schwartze, S., 1996, “Configuration of Multiple-variant products”, BWI, Zürich.