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Faculty of Business Economics

Master of Management

Master's thesis

The implication of the Engineering To Order department in the success of a firms mass customization strategy in the new product development process

Raafat Jerad

Thesis presented in fulfillment of the requirements for the degree of Master of Management, specialization International Marketing Strategy

SUPERVISOR :

Prof. dr. Pieter PAUWELS

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Acknowledgments

This thesis is the final sprint for my study in the Master of Management: International Marketing Strategy program at Hasselt University.

I had very great time learning about a subject that highly captured my interest. I am fortunate to have this opportunity to discover my subject practically in two different companies within two sectors IT and Pharmaceutcal industry. Writing this thesis not only broadens my knowledge in the field of industrial Marketing but also improves my ability of academic research.

I am greatful to those who have supported me throughout this journey. First, I would like to thank my supervisor Prof. Dr. Piet Pauwels for his valuable time and constructive feedback during the development of this thesis. Second, I wish to acknowledge the help from all the Product Managers and the ETO team for their help in understanding the subject and the challenges. Without them, II would not have been able to complete the research so smoothly. Third, I am grateful for all the encouragement and the support from my family and friends throughout my study.

Raafat Jerad
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August, 2019

Executive Summary

Mass customization is a paradigm which is being recognized as a means to achieve a competitive advantage. Therefore, many companies are striving to reach a great level of mass customization. It has been becoming an increasingly viable model (Jiang et al.2006).

Many researches were conducted for the sake of proving and supporting key success factors for reaching mass customization. Among these researches, those of Ahmad et al. (2010), Wang et al. (2014), Anna S. Cui & Fang Wu (2015). We found these research interesting in a way that they are complementary. However, they were not combined yet in order to come with a complete model to help understanding the path to reach mass customization.

For this reason we propose a new model combining the previous research. The new model includes customization knowledge utilization and customer involvement in the process of reaching mass customization. This model was set up in order to help us understand what is the implication of the Engineering To Order department in the success of a firm's mass customization strategy in the new product development process.

As for the research methodology, our propositions were explored through conducting a deductive qualitative research. We had the opportunity to do an internship in an engineering to order born company which helped us to collect relevant data through different approach (field notes, in depth and informal interviews) and from different sources (ETO employees and product managers). Which was helping in testing the validity of our findings. The data was transcribed and coded manually and via Microsoft Excel. The six phase guide framework of Braun & Clarke (2006) was used to analyze the data. The results support that the ETO unit is first of all have an important implication in enhancing the customization knowledge utilization capability in a company. Second, it have a great attraction on customer involvement.

The structure of this thesis is organized as follows: Chapter 1 introduces the problem statement. Chapter 2 poses the research questions, and chapter 3 encompasses the literature review regarding theories, conceptual models, and hypotheses. Chapter 4 explains the conceptual model and propositions. Chapter 5 explains the research methodology with data collection and results. Finally, chapter 6 and 7 gives the conclusion, implications, and limitations of this master thesis.

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I. Introduction :

Mass customisation might be a paradigm that is recognised as a way to realize a competitive advantage. Producers of consumer goods were among the primary industries to adopt the new paradigm of mass customisation. In fact, they needed to make their products stand out compared to those of their competitors by increasing the variety, thus making their products fit the customers' demands (Pine and Boynton, 1993).

When contrasting the operational formats of mass production and mass customization, Jiang et al. (2006) note some pronounced differences. Mass production, with Henry Ford's Model T as its culmination, has the virtue of economy of scale. Specialized machines run at high levels of utilization in a make-to-stock environment and provide for an overall low manufacturing cost. While mass production can still be successful today in many traditional industries, advances in manufacturing and information technology, as well as rapid shifts in consumer behavior, have led to the adoption of a new value-based manufacturing philosophy. This has resulted in mass customization becoming an increasingly viable model for a broad range of different industries (Jiang et al. 2006). Based on sophisticated consumer interfaces, modular product architectures, agile manufacturing processes and speedy distribution, mass customization fundamentally caters to customer individualism. Within the last decade, many companies have begun to turn to mass customization. From lipsticks to cars, from M&M to chinos, a growing number of products can be customized to a customer's individual taste. Hewlett-Packard has effectively used postponement to realize mass customization in their printer and PC businesses (Feitzinger and Lee, 1997). Levi Strauss launched the mass customization initiative to tailor women's jeans individually for a mass consumer group (Bailey, 2000). The mass customization project at adidas-Salomon AG, "mi adidas", successfully completed its pilot phase involving well over 100 retailers across Europe (Seifert, 2002). The phenomenon of mass customization is also becoming more prevalent in service industries, and individually customized financial, insurance and utility services are proliferating (Victor and Boynton, 1998). Customization is becoming increasingly important to US companies since basic manufacturing and service functions are increasingly being outsourced to companies overseas. The biggest advantage of US companies is their closeness to customers and their ability to cater to the customers' individual needs (Sheffi, 2004).

However, the promise of mass customization comes with potential pitfalls. A mismatch between technology and market demand can result in precisely what mass production is intended to avoid: namely, high cost (Zipkin, 2001). For many firms today, it is difficult to know which strategy to pursue. Indeed, the relationship between market and operational conditions requires careful assessment in each case before conclusive decisions are made (JIANG et al, 2006).

Much research has focused on mass customisation of products that have traditionally been mass produced, whereas mass customisation utilised by engineer-to-order companies has not received much attention in academic research. Issues that distinguish the two different cases are significantly higher complexity for both order fulfilment processes and manufacturing of ETO products. Thereafter, it is another significant difference between the two type of mass

customization strategies. ETO related mass customisation events may last through several stages in the production system instead of a one-time design and/or production change, as is often seen in general consumer goods mass-customisation. Customised engineering processes, different processes in various production stages, and the complexity of engineering tasks are some of the attributes that differentiate ETO type of mass customisation from the traditional craft customisation (Lu et al. 2009).

Design has always been considered as a critical decision factor to the final product form, cost, reliability, and market acceptance (Chen and Wang, 2008). It is also believed that MC can be best approached from design, particularly the up-front effort in the early stages of the product development process (Ben-Arieh et al. 2009). Companies had a close design approach they focus each time on a single product to respond to a single customer need. This designing approach limit the opportunities on finding commonalities in the designs, compatibility with other product, standardization, or modularization among different products or product lines, found by Meyer and Lehnerd (1997). They seek for product diversification in order to satisfy their customers (Marion et al. 2007, Kumary et al. 2009, Ye et al. 2009). Such diversified product designs without commonality not only defeats design efficiency and future extensibility, but also make an MC manufacturing mode impossible (Qu et al. 2011).

In order to decrease the uncertainty and tackle the information needs companies should establish a structural mechanism that will enhance information processing capabilities. In the context of Ahmed et al. (2010) study, modular product design creates increased interdependency between R&D, manufacturing, and marketing functions. Moreover, increased product variety in a MC environment broadens the design, manufacturing, and marketing tasks and various types of demand (product mix) uncertainties (Ahmad et al. 2010). Organizations need pertinent information to make appropriate decisions when confronted with environmental uncertainty (Galbraith, 1974).

As a source of information, customization knowledge utilization relates to the sales process that may be needed to coordinate the product, process, and supply chain decisions (Fedor et al, 2003; Menon and Varadarajan, 1992). Thus, customization knowledge utilization has an important role in the learning process (Wang et al.2014).

In light of the above, the purpose of this study is, first to understand the previous researchs done in order to understand how to reach a high mass customization capability. Second, to investigate whether or not there is a way to propose a new model based on previously supported research models. Then, based on the proposed model, we will try to understand the implication of an Engineering to order unit as an important source of information for the success of a mass customization strategy.

II. Research question

What is the implication of the Engineering To Order department in the success of a firm's mass customization strategy in the new product development process?

To better understand the research question, we asked ourselves the below presented sub questions:
What's the role of the ETO department in the new product development process?
Does the ETO department contribution is necessary to succeed developing new product in a mass customization strategy?

III. Theoretical backgrounds

In this section previous research and concept will be recalled in order to help in addressing the research question of this study.

1. Engineering-to-order

Companies that are customer centric are more concerned about their customer needs and job to be done rather than their product characteristic. This type of companies like Tesla understood that they have to change the chart flow of the new product launch. They understood that it have to start by a concrete willing to pay for a product or service. Thus, having pre-orders from the customers is the most persuasive indicator about a product success. It's an agile and effective way in ensuring the success of a new product. First thing sell then engineer.

Lu, Petersen and Storch. (2009) stated that most ETO companies share various specificities putting them with multiple challenges different from those for mass producing or mass customising companies. The common characteristic between ETO companies is the selling process. For each order for a product, parts, or the product itself, the entire product is reengineered before the sale is made (Caron and Fiore 1995). Figure 1 illustrates the differences in business processes between ETO, mass production, and mass customization companies. It is important to note is that in an mass customization or mass production setup the design and engineering are done before the product is proposed to the customers whereas in engineering to order company it is done after product is sold. Where a mass customised product is often made from predefined components, which are assembled through a preconfiguration, an ETO product will usually include both components that are predefined, and parts that have to be redesigned or even reingeneered. Hence, ETO companies have a characteristic of the combination of a low production volume per product type and a very high degree of customisation. This is illustrated in Figure 2, where these characteristics are illustrated in relation to mass production and mass customization companies. These characteristics have various influence on the sales, design, and manufacturing phases of the product life cycle that are unique to these types of companies (Rahim and Baksh 2003). According to Rahim and Baksh (2003) ETO products are often very complex systems with many subsystems that are often re-engineered for each sales order. For the engineering to order product they are usually expensive, compared to mass produced or mass customised products. Therfore, Customers

asking for ETO products are most often industrial customer in opposition of the mass production or mass customization customers.

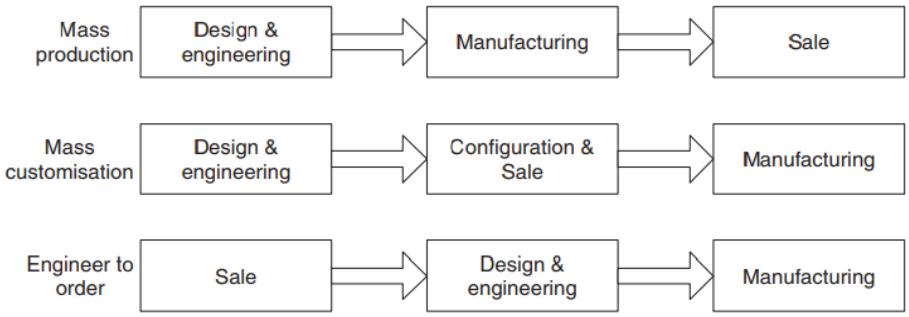

Figure 1 The Sequence of key business processes in MP, MC, and ETO companies. Adapted from Lu, Petersen and Storch (2009).

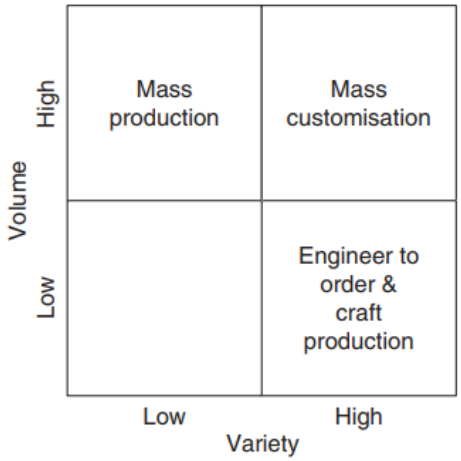

Figure 2 Relationship between volume and variety for different company types. Adapted from Coronado et al. (2004) and Browne et al. (1988).

In relation to the specifities described above Engineered to order company must have different process that are different from other companies. So for each order the ETO companies have a complex engineering work in comparaison to the MP companies. Since the customisation degree is extremely high for ETO products, the customer is very included in the development of its specific solution. The customer often presents the ETO companies with specific technical requirements for the products and is to some extent involved in the design process as well. The designs worked by the engineering to order team have to be validated by the customers before having any more engagement (Rahim and Baksh 2003). This yields a highly complex business process in which the product is defined gradually over time and that often changes organisational responsibility during the project lifecycle. A typology of ETO companies was introduced by Hicks et al. (2001) where a number of British ETO companies were analysed. It was found that the ETO companies could be categorised by their production processes in four groups: (a) vertically integrated, (b) design and assembly, (c) design and contract, and (d) project management. The group where formed based on the manner the production process is implemented. Companies in each group could be impacted by the changes in the market and envirement, thus strategic guidelines where

considered for each os these groups. It also describes the relationships that different ETO companies have with suppliers. In some cases suppliers are even involved in the design of product subsystems, which presents a number of challenges with respect to communication and coordination of design and manufacturing. Hicks et al. (2000) addressed the issue of supply chain management in ETO companies. In their work they categorised the customer interaction into different phases and analysed in relation to procurement decisions. They concluded that general purpose SCM methods could only be applied to a limited extent, and the SCM element with the greatest potential was incorporation of procurement considerations in the early design stages. Related to this work, Hicks and Braiden (2000) analysed manufacturing planning and control in ETO environments using a simulation approach. This study concluded that for a number of case companies, two major factors that could improve manufacturing performance were capacity planning and assembly planning. Based on differences in operations for mass producing companies and ETO companies, Rahim and Baksh (2003) analysed the requirements for product development in ETO versus MP companies. Some of the key areas where ETO companies differed included a higher NPD frequency, higher NPD cost per product, greater customer involvement including extensive customer requirements, and an increased requirement for customer documentation. They present a framework for new product development that takes into account these challenges, but calls for further development of the framework. Related issues are addressed in Dekkers (2006) which introduces a framework for using operations management in the engineering activities related to specific orders by recognising order entry points in the engineering processes. Furthermore, it promote the efficacity of using a modular product architecture to respond to the customization requests. A study by Little et al. (2000) conducted for the ETO sector in Europe concluded that there were a number of generic issues that could be identified for the case companies. These included: Inefficient product configuration or specification in the sales phase, Poor design planning, Ineffective assembly and shop floor scheduling. Hence, these are areas that generally need improvement in companies within the ETO sector Lu, Petersen and Storch. (2009). One important step to improve the performance in the engineering as well as the selling performance in the ETO companies is to efficiently gathering the specification in the sales phase, since this will help improve the hit rate of the ETO projects .

With all the hustle that it comes with, we can understand that ETO companies accept all these challenge in order to reverse the value ladder. Unlike companies using a MP or MC, ETO companies focus more on selling premium products to specific customers who are the more willing to buy the company products. Those customers are ready for a high engagement in the new product design phase in order to get the most out of the premium paied price. Moreover they consider this engagement as a special treatement for the premium paied price. Thus, it yields to a low production volume but a high and accurate information flow coming from the customer. This last is not only interesting for the ETO companies but it’s also the casefor the suppliers of the ETO companies. Having this advantage, suppliers will be more interactive and engaged with ETO companies in order to improve their components. As a conclusion, the ETO companies, by their characteristics, will be found in a strategic central position of information flow with their customers in a side and with their suppliers interested in the final customers’ information. This central and

strategic position inhence the interaction between the ETO companies their customers and their suppliers.

2. Mass Customization

Most of the companies that want to adopt a customer centric strategy thrive to implement mass customization behaviour. They see the shift from the mass production to the mass customization as important in order to enhance their customer centricity. Meanwhile, this shift comes with the challenge of keeping their market share and perhaps extending it. Going from mass production to mass customization, companies have not only to keep their production volume and serve their customers with whatever they are asking but they have also to keep their quality standard and price at the same level they had with a mass production. In a representation this will be climbing a mountain with the assumption that the pressure at the bottom is the same at the top. Without a proper mechanisms and shifting strategy companies though will either fail or die.

Ahmad et al. (2010) stated in their literature review that literature on MC has grown significantly during the past-25 years, so much so that it has been the subject of special issues by various management journals such as Production Planning & Control (2004) and IEEE Transactions on Engineering Management (2007).
They express that MC has emerged as a new paradigm in response to increased demand for customized product at low cost. The concept was introduced by Davis (1987) as another mean for competitive advantage, and was lately defined as the capability of providing customizaed product without affecting its quality or associated costs (Pine et al., 1993; Berman, 2002; Duray, 2002; McCarthy, 2004). Various ways of reaching Mass Customization are suggested by previous researchs, including PM (Baldwin and Clark, 1997), postponement (Feitzinger and Lee, 1997), and process changes (Tu et al., 2001). PM is considered one of the dominant strategies for achieving MC in the literature (Antonio et al., 2007).Ahmad et al. (2010) affirm that the concept of PM has been discussed in the literature for a long time (Star, 1965).
However, the strategic contribution of product modularity for MC was discovered recently (Sanchez and Collins, 2001; Doran, 2005). Baldwin and Clark (1997) suggested that modularity could be an effective strategy to be agile responding to the changing customer requirements and increasing technical complexity. Sanchez (1999) pointed out that modular product design can help to have a large product offer through preconfiguration and address the market need rapidly via standardized platform. Many other researchers have mentioned that modular product design is important to reach a mass customization capability Pine et al., 1993; Feitzinger and Lee, 1997; Duray et al., 2000; Da Silveria et al., 2001; Swaminathan and Lee, 2003; Berman, 2002).However, this literature has been mostly conceptual and case-based, and lacked large-scale empirical verification (Worren et al., 2002).

Ahmad et al. (2010) describe a research that was based on a survey of 303 manufacturing plants in the USA that emphasazed the positive impact of product modularity on mass customization (Tu et al., 2004). In this study, modularity based manufacturing practices are highlighted as a combination of PM, process modularity, and dynamic teaming. The study wasn’t conclusive since

no relationship was seen to be remarquable. Only later on when another study was held, of 251 product development projects from electronics, toy, and plastics manufacturing industries in Hong Kong that they discovered a relationship between product modularity and delivery, flexibility, and customer service (Antonio et al., 2007). However, the same study didn't approve any relationship between product modularity and low prices and product quality. In opposition in what is supported in literature, the study concluded that "Product modularity is not a significant predictor of low price and product quality" (Antonio et al., 2007). Therefore, the effect of product modularity on mass customization, or the effect of product modularity on plant competitiveness, is still not clearly understood.

Although it seemed to have a direct impact on Mass customization, Product Modularity didn't appear to have a significant relationship with quality and prices which represents the mass customization capability. Nevertheless, this mechanism could have an indirect impact in creating or inhancing a mass customization. Using modular product architecture helps to increase the variety of the product and offer more flexibility in configuring the product in order to satisfy each customization demand. Therefore, Product modularity is important to achieve mass customization. However, it can't be enough. Having a modular product could be the start dot to reach mass customization, but additional efforts have to be put for the sake of creating more dots helping companies to get to mass customization. The impact of product modularity on mass customization couldn't be really understood because product modularity couldn't be linked to the low price an product quality. So, more mechanisme have to be created in order to use product modularity advantages and make sure that product quality and low price remaine a priority in juging the mass customization capability or the plant capability.

3. Product modularity and mass customization capability

One thing is sure; product modularity could be a start to reach mass customization. But, it is a challenge in it self because engineering departments have to have in mind that the aim behind designing modular product, is to reach a high mass customization capability. However, engineers are more product centric than costumer centric.Therefore, engineers need to be guided strategically in order to succeed the first step toward a high customization capability.

Several previous studies were considered by Ahmad et al. (2010) in order to understand the relationship between product modularity and mass customization capability. They have stated that Sanchez and Mahoney (1996) characterize modular products as having decomposable systems with a high degree of independence (loose coupling). These connections made possible the assembly of the parts in order to match specific customer requirements (Schilling, 2000). Thus, Product Modularity uses the commonality found in the parts to identify standardization schemes that can be flexibly applied through various product design to create a variety of products cost effectively (Mikkola, 2007). For this reason, Product Modularity is used by many manufacturers to achieve mass customization (i.e. build-to-order) and by adopting delayed differentiation (i.e. postponement) (Venkatesh and Swaminathan, 2003).

Although a postponement strategy customizes products at a later stage of the distribution chain close to the end-user, crucial modular design decisions need to be made early in the product design phase (Swaminathan and Lee, 2003).

Product modularity is the very start of reaching mass customization. As it was concluded, it helps in responding to every customer specific requirement in a hand and using communalities to standardize subsystems in the other hand. Having a high modular product design allow the companies to be very specific serving the customers it is soft and nice. What is more hard and challenging is to keep all this customization effort's cost low in sake of limiting its impact on the price or the companies bottom-lines. Therefore, engineers have to have clear information and guidance in order to design an effective modular product. They need to understand which communalities they have to analyse in order to standardize a sub-assumbly without decreasing the flexibility or the variety of the final assembly which is the product. For this reason, coordination mechanism are necessary for the success of the engineers work in designing modular products and contributing to the success of the company in reaching mass customization.

4. Cross-functional coordination

Each of the department of a company has its own specificities based on the profil and background of its employee. In adequation to this logic, an R&D department will have technicalyenthousiasticprofils; a marketing department has a market oriented profils and a financial and controlling service has a cost driven profis. It's the mission of the management to gather all these profils with their different motivation under the same values, vision and mission which are the company identity and guidelines. Explicitly, companies which seek to reach a high level of customer cetricity through mass customization have to have an awearness about the challenges and the benefits of such a goal. This awearness has to be spread by the top management in the entire organization.

To successfully reach such a goal engineers should not be the only department which is implicated in the product design. Yet, top management has to found organizational mechanism which will allow all the company to contribute in the success of such a drastic transformation.

This organizational mechanism has to leavrage each of the other deparments' motivation in order to implicate them in the efforts of reaching mass customization.

The role of product modularity on mass customization is very important considering Ahmad et al. (2010), study. But, modularity alone may not lead to MC capability (Lorenzi and Lello, 2001). Cross-functional coordination is an important factor that can shed light on how modularity impacts MC (Sosa et al., 2004; Zwerink et al., 2007). The literature have highlited the role of interfuctional design coordination to achieve mass customization (Danese and Romano, 2004), but without giving clearancy to the role of functional coordination have in the relationship between modularity and mass customization is still unclear.

Product design is an extensive and inclusive discipline. Complex product development projects are usually divided into smaller manageable tasks. Those tasks are assigned to the participants of the

project development who have distinctive skills and expertise to complete the assigned tasks in order to optimize problem solving.

However, all the work need to be centrilized in order to make the final solution (Simon, 1969). Therefore, the fundamental challenge in a new product development project is to effectively manage the interdependent problem solving caused by task decomposition. Interfunctional design coordination among design, manufacturing, and marketing functions is essential for meeting this challenge (Fitzsimmons et al., 1991).
Modularity enable companies to design complex products based on deviding the products to sub parts which are called subsystems. These subsystems assembled together build the final products (Baldwin and Clark, 1997). Nevetheless, using such a decomposition for the product and the business process require a high amount of coordination. For example, marketing department, production and sales have to work together and coordinate their work in order meet customer requirements. Each of these department have its own motivation driven by its specificities. Thereafter, marketing department could be driven by responding to all the customers needs, which put the R&D department in hard position. With the same logic, if the R&D department will be able to develop a product, the production department could not be sure about having the ressources to produce the product efficiently. Moreover, these departments uses their proper terminologies specific to their tasks. Interfunctional design coordination aligns functional objectives, breaks down communication barriers, and provides a common language across functional units (Danese and Romano, 2004; Koufteros et al., 2005). Thus, PM requires IDC to foster MC capability.

While the existing literature mostly posits a direct link between PM and competitiveness.
Ahmad et al. (2010) took one step back and tried to understand how PM impacts MC capability, which in turn impacts plant competitiveness. They find that interfunctional design coordiantion fully mediates the impact of PM on MC capability. His finding can be explained by the organizational information processing theory (Galbraith, 1974) which suggests that the information processing capability of an organization must match the information processing need of the task to be accomplished. Organizations have to make strong and right decision when it is in an envirement with high uncertainity. Having a well established structural mechanism can serve as a foundation of the information processing capability that will reduce the uncertainity. In this context, modular product design creates increased interdependency between R&D, manufacturing, and marketing functions. Moreover, mass customization enrich the product variety thus the design.Therefore, it increases the complexity of the tasks of all the departments of the company. It also increase the uncertainity among these departments. The information processing is therefore essential to cope with the created interdependency between units which come along a high level of uncertainity. Interfuctional design coordination foster the information processing capability withing the company. This explanation is in congruence with the literature which emphasizes inter-functional coordination for new product development success (Gerwin and Barrowman, 2002).

Cross interfunctional coordination is the mechanism that should be implemented by top management in order to guarenty that they could reach mass customization. This type of

mechanism helps the company in reaching a high level of mass customization. Practicly, interfunctional design coordination gathers the departments of a company in a same development goal. The information flow circulating between all the company departments make the coordination possible. Yet, the efficiency of this coordination depends on the information processing capability inside the firm. Therefore, companies need to found an internal organization capable of leveraging the information flow in which the compay is sealing. Thus, having a department which could make sure that these informations will be standerdized then processed effenciently is a major part of the interfunctional design coordination. The typology of Hicks et al. (2001) proved it, an engineering to order company have a very special relationship with its suppliers and customer. The position that an engineering department gives to a company helps in shaping an efficient coordination in the whole suplychain from the supplier to the customer groing through the company. Hence, implementing interfuntional design coordination for the mass customization could start with a neucleus of this coordination network. An engineering to order department based on its characteristics would be the greater department to foster inter-functional design coordination since its activity imply the coordination between the customers and the suppliers outside the company walls its important that the ETO department ensure the coordination between all the departments inside the companies' walls.

5. Competitiveness

Obviously, companies strive to be more competitive in the market. This is why they're investing money and efforts. Moreover, being the reflexion of each of the consumers demand, the market demand is defined by multiple dimensions. Thus, a competitive mindset has to be spread in the company in order to turn every cost center into a strategic and competitive center responding to the market demand.

In their literature review Ahmad et al. (2010) followed that the Plants can choose to compete following several aspects. Common competitive priorities pursued by manufacturing plants include aspects such as cost, quality, delivery, flexibility, and innovation (Flynn and Flynn, 2004). However, customers does not make their decision based on only one aspect. For example, a saver consumer focus more on cost but does have a certain level of product quality in mind. This means that a producer need to have multiple aspect of competitivity. Competitiveness has been defined as the company competitveness strengh, relative to its competition, along common competitive priorities (Flynn and Flynn, 2004; Rosenzweig and Roth, 2004; Ketokivi and Schroeder, 2004). Following the literature above, competitiveness is defined as a manufacturer's compliance to common competitive priorities – cost, quality, delivery, flexibility, and development time – relative to its competition.

Yet, in order to be competitive, companies has to first know the market demand priorities then work toward satisfying these priorities. It is clear that multiple strategies could be taken depending on the priorities. These strategies should implicate the entire company departments in order to be efficient. Furthermore, an inside walls leadership has to lead the company effort in order to efficiently coordinate all the departments for the sake of having a competitive outcome.

6. Mass customization and competitiveness

Keeping a high production volume and a high product variety is the challenge of mass customization. Nonetheless, competitivity for firms is determined by two main determinant the first is an inside the firm wall the second is an outside the firm wall. The inside the wall determinant is linked to the costs. Wheras the outside firm wall is linked to the market value, thus the benefits. These two determinants are the reflexion of a firm profitability and efficiency. Nevertheless, firms with a high cost controlling and sophisticated controlling procedures like Amazon, didn't succeeded by only controlling but it has also a high customer centricity. It's n the motto of the company. They are thriving to give to each of there customer the best customer experience. IT leads us to an important determinant of a firm competitivity which the product designs. In order to be competitive the company have to be able to first, accomplish the customers job to be done, then control the costs and keep them minimal.

Product modularity has been identified as one of essential steps in achieving mass customization capability (Duray et al., 2000). Worren et al. (2002) suggests that product modularity proceed the mass customization establishement. Thereafter, the impact of mass customization is larger than that; it helps company to engineer, produce and deliver a large variety of products with a high cost control to make it seem mass production (Tu et al., 2001; MacCarthy et al., 2003). Ahmad et al. (2010) has supported the relationship between MC and plant competitiveness.
A manufacturing plant with mass customization capability need to have a production process which ensure in a hand flexibility in the production varaiety, in the other hand a great cost control (Pine et al., 1993). Huang et al. (2008) refer to mass customization capability as an operational capability of the manufacturing plant which reflect the performance capability of a plant.

Results of the study of Ahmad et al. (2010) show that PM indirectly impacts MC capability which in turn impacts plant competitiveness. That is, the relationship between PM and plant competitiveness may not be a direct one, as suggested in the literature. Rather, this relationship follows the following sequence:

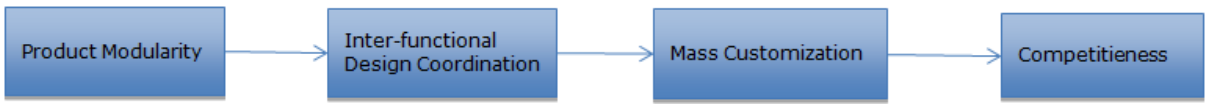

Figure 3 The relationship between product modularity and plant competitiveness. Ahmed et al, (2010)

Understanding this phenomenon needed a large study from various perspective. This is what was done by a study in multi-industry and multi-country data source, thus providing robustness and generalizability of the findings reported. The finding of this study emphisazed the fact that manager should be attentive to implementing an effective interfunctional design coordination in order to make their product modularity effort conclusive and achieve mass customization. The literature has primarily focused on the technical side (e.g. modularization and postponement schemes) of MC (Duray, 2006). An important fact about the results of this study, ignoring interfuctional design coordination can diminish the potential for gaining competitive advantage through product modularity. Manager should initiate organizational mechanisms that ould help in

better processing the information in order to help the company develop dynamic capabilities. These dynamic capabilities are not imitatable and provide sustained competitive advantage (Barney, 1991).

To sum this up, a high mass customization capability increases the competitivity of the companies. Nonetheless, this relationship could only standin one important condition: Interfunctional design coordination mechanism should be implemented in order to better process information across all the functional units. Indeed, it gives the opportunity to implicate the entire functional units under the same development goals. Yet, competitivity has to be build upon an imitatable capability. Thereafter, a dynamic capability has to be instaured in the company in order to have always a step forward in comparaison to its competitors. This dynamic capability could be created by leaveragingtheinterfuctional design coordination mechanism as a great environement to share the knowledge between different functional units. This knowledge will be shared cared and cultivated which brings more ideas on about how to optimize the products designs in order to be able to serve all the customers requests with a controlled and optimized costs.

7. Organizational learning perspective

In order to be competitive firms have to be operationally effective and strategicly dynamic. Especially when it comes to reach a high competitiveness, through a high mass customization capability. Interfunctional design coordination was proved to be essential for mass customization. However instauringinterfunctional design coordination is not finality in itself, but it is just a mean to develope dynamic capabilities which will lead firms to have an inimitatable mass customization capability. In facts, interfunctional design coordination is just a framework in which the company could turn the information shared and processed into an acquired knowledge. It's about using the information processed and collected to learn how to deal with the coming customization requests.
It is a very dynamic and increamentalmechanism which helps the company to increase its knowledge ownership.

Customization knowledge utilization is as important as the modularity knowledge utilization for the mass customization knowledge. Infact, customization knowledge utilizationhelps companies to amplify the role of modularity knowledge for MC Wang et al. (2014). In order to improve the mass customization capability, the R&D employees need to ensure that their knowledge is transferred to other departments. This knowledge harvested from previous development will be transformed to realisable ideas. Such a transformation is called "externalization" (Nonaka, 1994). They need also to understand the functioning of other department in order to know how to transfer the knowledge to them. Thus, R&D personnel need to "internalize" the knowledge of other departments, to develop "operational knowledge" (Mohrman and Mohrman, 1993), a strategic resource that lends a competitive advantage (Hult et al., 2003). In the process of knowledge reuse, new knowledge may be created through knowledge combination (Nonaka, 1994). The resulting knowledge from the customization reuse is a kind of systematic knowledge that facilitates employees' development of new ideas for implementing MC successfully. Coordination was supported to have an important impact on the knowledge combination (Nonaka, 1994). This argument is consistent with Ahmad et

al. (2010), who posited and tested a model in which functional coordination mediates the relationship between product modularity and mass customization. Wang et al. (2014) supported that customization knowledge utilization plays a similar role. Bein able to leverage the customization knowledge foster the transfert of the design knowledge acquired from modularity to other depatments in the company like production, sales and customer support. Shared knowledge of modularity in different functions smoothes the operation of MC and reduces conflicts, allowing firms to respond to customization requirements more efficiently.

It is clear that product and process modularity helps to leavrage the knowledge acquired by previous customization Wang et al. (2014). The standardized interface allow firm to be flexible in to add feature to their product and to modify their production process. Therefore, applying the customization knowledge acquired from previous customization experience to better respond to the customers' requests and better optimize the product lines will be more efficient. Modularity forces companies to combine knowledge acquired from different customers, enabling learning from past customer experiences. In adopting product and process modularity, organizations must develop a deep understanding of the differences in customers' requirements and identify commonalities among these differing requirements (Grunwald and Kieser, 2007). For example, to enhance product modularity, product engineers who formerly worked on product design for different groups of customers will have to work together to understand the key differences in the requirements of those groups, including the identification of their commonalities and differences in terms of product requirements. When a firm redesigns its production processes using standardized modules to quickly satisfy the customized requirements of different groups of customers, a deeper understanding of the customer requirements is gained.

Moreover, it has been proved by Wang et al. (2014) that customization knowledge utilization is essential for MC capability building, as it enables companies to acquire, assimilate, and apply the customization knowledge derived directly from past customer orders. It was supported by many organizational theorist that ascuiring a competitive advantage lies essentially in the extent with which the knowledge is coupled to the process (Fiol and Lyles, 1985). Existing MC studies focus on the customer requirement acquisition or customer involvement (Kristal et al., 2010; Lai et al., 2012; Liu and Deitz, 2011), indicating the importance of customer knowledge. However, using the knowledge in the production business processes was rarely criticized by previous studies. Nonetheless, organizational learning capability have been found achieveable by the uses of knowledge within the company (Zollo and Winter, 2002). Using previous customer requests as source of knowledge acquirement can help to increase flexibility and agility in responding to customer needs. In addition, the costs incurred in searching for and applying new knowledge to meet customization needs can be greatly reduced by extending the use of knowledge from one product line to others (Hernández-Espallardo et al., 2011).

Important implications for manufacturing companies that are mass customizers has been brought by Wang et al. (2014) study. They find that by learning from previous development, companies are most likely better equipped to reach mass customization. In fact, spreading organizational

learning processes in the company helps to turn modularity knowledge into a concreat competitive advantage. Interestingly, their results show that learning from past customization and improving the production process are important in MC capability building. Since the customer knowledge is pertinent information source for mass customization. Companies should consider creating a means of storing knowledge from past customization experiences. Companies have to instaure specific process to reach mass customization. These processes need to be continuously improved in a manner that the knowledge gathered by the production process intervene in fostering this improvement.

Wang et al. (2014) found that companies should develop managerial skills to connect modular design and MC capability. In fact mass customization could it be an automatic result from using the modularity knowledge. Companies should integrate knowledge obtained from different sources. Regarding modularity knowledge, their findings indicate that companies should pay more attention to how modularity knowledge can be used to learn from past customization and improve internal processes.

Consequently, customization knowledge utilization is an indispensable mechanism in accomplishing a high mass customization capability. Moreover, since it provide the dynamism with which the company could reuse the knowledge of previous customization project in actual and future development; this mechanism help the company grow its customization capability and knowledge increamentaly. In facts, the company will be able to learn from its previous customization project then optimize its process and products designs. Research and Development an engineering department will have consistent information and tacit knowledge in which they can optimize the modularity of the products by looking for common areas to standardize and the most customized parts to highly modulate them.

Yet, in order to reach this level of knowledge management and learning perspectives companies have to consider means of accumulating and storing such a consistent knowledge. It has to be a mean that make sure the knowledge accumulated from previous development is first, every time increamented with the new knowledge from the new development, second, is spread through all over the departments implicated in the mass customization strategy, last but not least, it has to be able to understand and identify the new information that can be processed and turned to customization knowledge. It is clear that such a mean has to be an entire department. It has to be a structure that is basically implicated in all the customization projects, and have access to the whole company organization. This department has to orchestrate the information processed and turn it to knowledge to manage in the company. A department as such with the qualification to lead the customization knowledge utilization in a company couldn’t be other than the engineering to order department.

8. Implication of the customer in the New Product Development

The first goal in developing new products has to be better serving the customers. For that reason firms should develop a mechanism allowing them to onboard customers in the new product

development mechanism. Moreover, the relationship between the company and its customers must be deeper than a relationship between a seller and a buyer since the customers are the users who are co-creating value with the company. Some of the company understood that they have a great deal in participating the customers in the product development. Some of them went more far in giving them the complete freedom of innovating by their own (Hoyer et al. 2010; Von Hippel and Katz 2002). It's clear that having the customer implicated in the product design not only provides a more knowledge about the way the customer co-create value with the company but it also involve the customers in designing product responging efficiently to their needs. Sometime these needs are not obvious to the company and have to be proved from a customer perspective.

However, since the implication of the customers is not granted and has to be deeply understood, Anna S. Cui & Fang Wu. (2015) found that many studies have been conducted to understand the motivation of the customers in being involved in the new product development process and their ability to contribute to the company product development efforts. This focus didn't bring attention to the readiness of the company to implicate the customers in their new product development process. Anna S. Cui & Fang Wu. (2015) argue that very few studies have taken the firm's perspective to look at the organizational mechanisms needed to facilitate customer involvement (Foss et al. 2011). Recent research argues that external collaboration with customers and the firm's internal organizational processes are closely interconnected in the process of value co-creation (Grönroos and Voima 2013; Hillebrand and Biemans 2004). Internal organizational mechanisms implemented by the company are essential in framing the co-creation project in which the customers are embedded to (Van Doorn et al. 2010; Foss et al. 2011), for example, improving customers' perception of the involvement process to motivate customers (Auh et al. 2007; Balka et al. 2014) or guiding the customer to learn in order to prepare them to be active contributors (Hibbert et al. 2012).

Therefore, companies have to understand the level with which they want to engage with their customer in implicating them in their new product development process. It is the starting point in order to know what organizational mechanisms they need to establish in the company. Thereafter, with a suitable organization companies could benefit from the customers involvement by efficiently managing the knowledge born from such a collaboration.

Three forms of customer involvement in innovation were proposed by Cui & Wu. (2015): (1) customer involvement as an information source (CIS), (2) customer involvement as co-developers (CIC), and (3) customer involvement as innovators (CIN). Their framework helps to better understand the distinct mechanisms of the three forms of customer involvement and sheds light on when each form is likely to be used and when it is more beneficial. It connects customer involvement with existing theories and offers opportunities for integrating different streams of research on specific forms of customer involvement.They conceptualized the three forms of customer involvement as different ways of managing knowledge in innovation. The key inputs to the NPD process are market knowledge regarding customers' needs and technological knowledge used to develop product solutions to meet those needs Thomke and von Hippel (2002). Typically,

need information resides with the customers, while the firm is equipped with technological knowledge. Therefore, the market knowledge rregarding the customers' needs and the technological knowledge have to be centralized in the new product development unit (von Hippel and Katz 2002).
For each of this proposed form of customer implication, the engagement of the customers is different in the combination of the market knowledge and the technological knowledge. Therefore, when a customer is involved as an information source, the company has to have the assets that allow it to collect the information from the customers by doing market research studies evolving traditional tools like focus groups and market surveys in order to get the information on the customer' needs. Then, the company uses its technological knowledge to develop products responding to these customers' needs (Jeppesen 2005; Nambisan 2002).

When it comes to involving the customers as a co-developer, the customer contribution in the market information as long as the technological knowledge is quite equal and pertinent.
Customers are considered as part of the new product development team and they are engaged tightly with the company in the new product development (Bogers and Horst 2014; Jeppesen 2005). The development is made inside the company and the customers are involved in the new product development process as partners. They are in in tight collaboration which makes the customer bring both information about its need and solution on about how to better satisfy this need (Lilien et al. 2002). Although, it seems very tempting the company must bring a lot of attention to a couple of important matter. Firtst, framing the development projects to make sure that the aim of it is loud and clear. Second, managing the relation with the customers (Mahr et al. 2014). Thiskind of implication has a very high interaction between the company and the customers since it place the customers within the new product development process of the company (Hoyer et al. 2010).

Lastely, companies could also make its technology and knowledge available for use by the customers. This is what is done when the company choose to involve the customer as an innovator. Therefore, it will follow the lead of the customer's development. This means that the company gives the entire responsibility of having the information needs and creating solutions responding to these needs to the customers. The company will not interfeere the customer's problem solving process, it will only observe and give support when it comes to its technological or internal assets (Nambisan 2002; von Hippel and Katz 2002). Companies then are in an exploration journey in which they are seeing their customers coming with problems or opportunities that could not be easy to sense. More interestingly, is that they are also coming with solutions adapted to the companies' available technology.

Bring in up rear; the implication of the customers in the new product development process depends on the aim of the company behind having this relationship. The customer involvement as an information source is the simplest and the most traditional relationship. It brings information to work with but it keeps the relationship between the customer and the company very transactional with a high responsibility from the company side in designing a product responding to the

consumer need. The customer involvement as co-developer is partnering with the customer and shares the responsibility and risks in developing a product suitable to its needs. It's having the customer on boarded in the new product development process by combining their information need and the company technological assets and so more, in order to come up with customized solutions. Although, this last seem to be the kind of relationship that efficiently delivers outcomes, it is not simple to apply it when companies can not distinguish a problem to solve. Then, envolving the customer as innovator helps the company in exploring opportunities and discovering hiding problems. When the company is making all of its technological assets available for customers, this helps to have efficient solutions adapted to the available technology designed to respond to the customers needs. These different types of customer engagements require different organizational mechanism to be able to make them happen. Consequently, managers have to shape internal processes ready to take the most out of each of the customer type of involevement.

9. Interfunctional coordination and customer knowledge utilization

Involving the customer in the new products development has to be preceeded with the implementation of organizational mechanisme that thrive the collaboration between the customers and the company. As different type of customer involvement in the new product development process has different level of responasbility from the company side, the company have to implement organizational mechanisms that are adequate to each type. Interfuncional design coordination is one of the organizational mechanisme which can be implemented in order to make the company ready to involve the customers in the new product design coordination.

Anna S. Cui & Fang Wu. (2015) describe interfunctional coordination as the degree of communication and collaboration among different functions in an organization (Narver and Slater 1990). It is an important organizational mechanism that facilitate knowledge sharing (Grant 1996). When customers are involved in NPD, the firm's ability to coordinate across functions influences how well customer knowledge can be utilized and how effectively NPD employees can coordinate with customers during the knowledge management process. In CIS, interfunctional coordination is essential for the acquisition and utilization of customer information because information learnt from customers needs to be disseminated within the firm and combined with technological knowledge to develop product solutions (De Luca and Atuahene-Gima 2007). NPD research widely recognizes the importance of coordination among functions such as marketing, manufacturing and R&D (Sethi et al. 2001). Firms with strong interfunctional coordination are better equipped to engage in CIS. In CIC, interfunctional coordination enables NPD employees to more effectively coordinate with participating customers (Bogers and Horst 2014; Fang 2008), which is crucial for knowledge sharing in the joint problem solving process (Fang et al. 2008; Moeller 2008). In a firm with more experience of coordinating across different functions, NPD employees are likely to have developed common knowledge and an appreciation of diverse perspectives, which helps them to better understand customers' insights (Salge et al. 2013) and be open to unique inputs (Jespersen 2010; Stock 2014). This helps to improve the quality of interaction between NPD employees and the customers, and facilitate the integration of customers into the collaborative NPD process (Jaakkola and Alexander 2014). Research has found that

interfunctional coordination can help the firm better manage its relationship with customers (Brattström and Richtnér 2014). Thus firms with strong interfunctional coordination are better equipped to use CIC. Moreover, because the need to coordinate with customers increases the complexity of NPD management in CIC, interfunctional coordination is more important for CIC than for CIS in which customer interaction is relatively limited. In CIN, the the interfucntional design coordination have to be implemented in order to foster the utilization of customer innovation. Because CIN shifts the task of NPD to the customers, it does not require interfunctional coordination in the search for product solutions. Instead, CIN requires the design of customer friendly innovation platforms, which needs both technological knowledge and a good understanding of the customers and thus necessitates effective coordination between marketing and technical functions (Bogers et al. 2010; von Hippel 2001). To ensure that customer-designed products can be efficiently manufactured, CIN also requires production knowledge and thus involvement of the manufacturing function. Therefore, a well established coordination mechanism between all the departments can facilitate the utilization of CIN. However, in CIN the limited amount of customer interaction reduces the need to coordinate with customers (Thomke and von Hippel 2002).

Substantially interfucional design coordination is needed when the company plan to engage in a tight collaboration with its customer in the new products development process. It helps to spread the same goal and terminology across all over the company department which will increase the confidence of the customers in the capability of the company in developing new products. Therefore, when a company think about involving the customer as a co-developer it needs to implement interfunctional design coordination not only to show its readiness to have the customer onboarded in the new product development process but also to be able to take its responsibility in the new product development projects.

IV. Conceptual model & Hypothesis

Using modular product architecture helps to increase the variety of the product and offer more flexibility in configuring the product in order to satisfy each customization demand. Therefore, Product modularity is important to achieve mass customization. However, it can’t be enough. Having a modular product could be the start dot to reach mass customization, but additional efforts have to be put for the sake of creating more dots helping companies to get to mass customization.So, more mechanisme have to be created in order to use product modularity advantages and make sure that product quality and low price remaine a priority in juging the mass customization capability or the plant capability.Therefore, engineers have to have clear information and guidance in order to design an effective modular product. They need to understand which communalities they have to analyse in order to standardize a sub-assumbly without decreasing the flexibility or the variety of the final assembly which is the product. For this reason, coordination mechanism are necessary for the success of the engineers work in designing modular products and contributing to the success of the company in reaching mass customization.

Cross interfunctional coordination is the mechanism that should be implemented by top management in order to guarenty that they could reach mass customization. This type of mechanism helps the company in reaching a high level of mass customization. Practicly, interfunctional design coordination gathers the departments of a company in a same development goal. According to Ahmed et al. (2010) the information flow circulating between all the company departments make the coordination possible.Yet, the efficiency of this coordination depends on the information processing capability inside the firm. Therefore, companies need to found an internal organization capable of leveraging the information flow in which the compay is sealing.

To sum this up, a high mass customization capability increases the competitivity of the companies. Nonetheless, this relationship could only stand in one important condition: Interfunctional design coordination mechanism should be implemented in order to better process information across all the functional units. Indeed, it gives the opportunity to implicate the entire functional units under the same development goals. Yet, competitivity has to be build upon an imitatable capability. Thereafter, a dynamic capability has to be instaured in the company in order to have always a step forward in comparaison to its competitors. This dynamic capability could be created by leaveraging the interfuctional design coordination mechanism as a great environement to share the information between different functional units.

Nevertheless these informations need to be turned into a knowledge enriching the company capability to customize. This knowledge will be shared cared and cultivated which brings more ideas on about how to optimize the products designs in order to be able to serve all the customers requests with a controlled and optimized costs.

This is why we found the model of Ahmad et al. (2010), incomplete. A new model should consider the implication of the customization knowledge utilization and the customer knowledge utilization as two important mechanisms to reach mass customization and competitiveness.

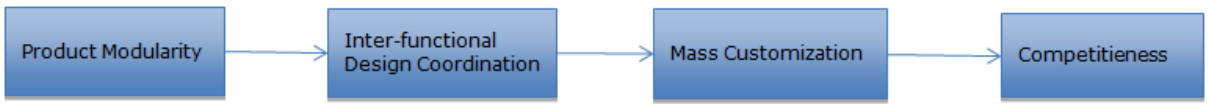

Figure 4 The relationship between product modularity and plant competitiveness. Ahmed et al, (2010)

In order to be competitive firms have to be operationally effective and strategicly dynamic. Especially when it comes to reach a high competitiveness, through a high mass customization capability. Interfunctional design coordination was proved to be essential for mass customization. However instauringinterfunctional design coordination is not finality in itself, but it is just a mean to develope dynamic capabilities which will lead firms to have an inimitatable mass customization capability. In facts, interfunctional design coordination is just a framework in which the company could turn the information shared and processed into an acquired knowledge. It's about using the information processed and collected to learn how to deal with the coming customization requests.
It is a very dynamic and increamental mechanism which helps the company to increase its knowledge ownership.

Consequently, customization knowledge utilization is an indispensable mechanism in accomplishing a high mass customization capability. Moreover, since it provide the dynamism with which the company could reuse the knowledge of previous customization project in actual and future development; this mechanism help the company grow its customization capability and knowledge increamentaly. In facts, the company will be able to learn from its previous customization project then optimize its process and products designs.

Yet, in order to reach this level of knowledge management and learning perspectives companies have to consider means of accumulating and storing such a consistent knowledge. It has to be a mean that make sure the knowledge accumulated from previous development is first, every time increamented with the new knowledge from the new development, second, is spread through all over the departments implicated in the mass customization strategy, last but not least, it has to be able to understand and identify the new information that can be processed and turned to customization knowledge.

The customization knowledge utilization thus is certainly importante to reach a high mass customization capability. However we criticize the model proposed by Wang et al. (2014) in conceptualizing the mediating role of the customization knowledge utilization between the product modularity and mass customization capability. We propose that customization knowledge utilization have to be preceeded by interfunctional design coordination in order to prepare organizationally the company to create and accumulate knowledge out of the customization projects over time. Therefore, we propose that interfunctional design coordination should be a mean to the customization knowledge utilization.

Substantially interfucional design coordination is needed when the company plan to engage in a tight collaboration with its customer in the new products development process. It helps to spread the same goal and terminology across all over the company department which will increase the confidence of the customers in the capability of the company in developing new products. Therefore, when a company think about involving the customer as a co-developer it needs to implement interfunctional design coordination not only to show its readiness to have the customer onboarded in the new product development process but also to be able to take its responsibility in the new product development projects. However, when it comes to co-developement projects the company need to have a great argument to convince customers to get invested in this kind of projects. This attraction could be generated by the company knowledge about customization and its readiness to achieve the new product development project safe and sound.

Therefore, we suggest that the direct relationship between the interfunctional design coordination and the customer involvement supported by Cui and Wu (2016) should be mediated by the customization knowledge utilization.

Based on these critics and suggestions we propose the followed model. We are going to investigate:

- The relationship R 1 between the interfuctional design coordination and customization knowledge utilization.
- The relationship R 2 between the customization knowledge utilization and the customer involvement.

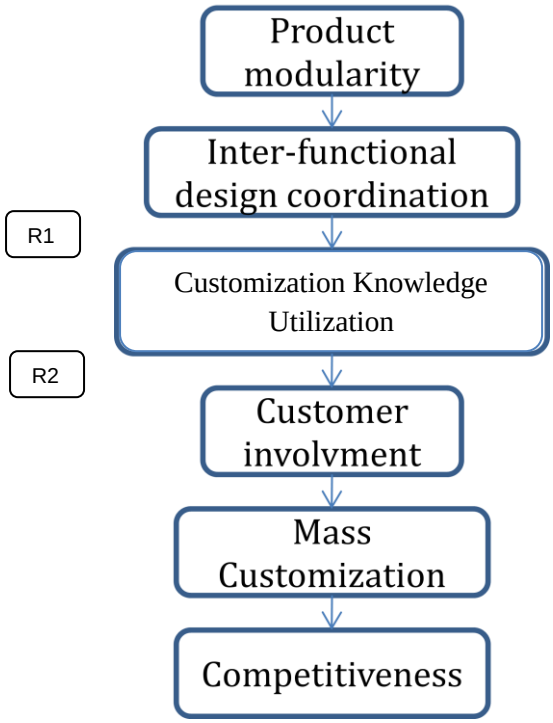

Figure 5 The proposed theoritical model based on the previous researchs

According to Rahim and Baksh (2003) the customer engagement is the highest when it comes to developing engineered to order product. In this sort of development the customers come with specific technical requirement and they are also involved in the designing process. This last could only finish after the customer approve the design once. Having a high new product development frequency and customer involevement which sometime also bring the need of extensive confidential information and documentation, we chose to explore this model in an ETO born company. This exploration could be relevant since the same company is looking for ways to reach a high mass customization capability.

The typology of Hicks et al. (2001) proved it, an engineering to order company have a very special relationship with its suppliers and customer. The position that an engineering department gives to a company helps in shaping an efficient coordination in the whole suplychain from the supplier to the customer groing through the company. Hence, implementing interfuntional design coordination for the mass customization could start with a neucleus of this coordination network. An engineering to order department based on its characteristics would be the greater department to foster inter-functional design coordination since its activity imply the coordination between the customers and the suppliers outside the company walls its important that the ETO department ensure the coordination between all the departments inside the companies' walls.

V. Research methodology:

The aim of the study has been to ascertain the beliefs of the relationship between the variables depicted in the framework shown in Figure 4. We conducted a study in a company which manufacture single use disposables for biopharmaceutical drugs producers. It is a subsidiary of a german group. It was founded in France then acquired by the german group. It is an ETO born company. It used to produce only customized products. After it was acquired it has also developed Standardized products and Configurable products. Thus, the company has three kind of products:

Standard products called STO
Configurable products called CTO
Customized products called ETO

The study was conducted in this company which is a top 10 ranked company in manufacturing single use disposables for biopharmaceutical industry. According to our first informations from the company, it has been brought to our attention that the company challenge is to automate its manufacturing lines in order to increase its production capacity. Since the company figures show that the portion of customized products (ETO) is more important than the Standard and Configurable products, it is not simple to find the right compromise in order to keep a high level of customization and increase the production capacity by automating the manufacturing facilities.

An internship was carried out dyring six monts in the Engineering to Order deparment in order to be emersed in the company. Joining the ETO team of the company has allowed having a complete participation by becoming a member of the group. The position was an ETO Project Leader.

ETO Project Leaders are responsible of any customization development asked by the customers on an existing product category. They receive the customization request from the Sales Representative, and ideally from the Application Specialist who is technically helping the sales Representative.Then; according to the Request For Quotation they prepare the Quotation of a project. When it is validated by the client, they engage the actual development of the customized product. Their work ends with the shiping of the first serie to the customer.

This internship helped us to collect data as a participant observer. Thus, we were able to participate in naturally investigating events and collect valuable insights from other ETO project leaders. From these 6 months of emersive experience we could collect field notes and informal interviews.

We wanted to address another target which is concerned about the new product development process. For this reason we chose to interview the Product Managers this company.

Product Managers are responsible for the profitability of the products they manage. Therefore, they are the first decision making unit in the process of a new product development or products withdrawal. Product managers receive informations from the research studies and the feedbacks of the Sales Representative and application specialists about future scope of new product development. Then they submit their NPD project to the NPD committee which will decide whereas they give it a Go or not.
In order to explore the implication of an ETO departement, in the success of the mass customization strategy, we conducted a series of in depth interviews with product managers. We contacted 5 Product Managers with different product line complexity who agreed on discussing with us. With each Product Manager, one hour meeting was held in the company offices.

In depth interview technique is a qualitative method of data collection that is used when the issue of the investigation is a complex phenomenon, which may not be easily unraveled through surface responses, hence requiring exhaustive probing (Fontana and Frey, 1994). Unstructured in depth interview was used in this study. In this technique, the interviewer does not use a discussion guide or preset questionnaire to conduct the interview; on the contrary, the researcher asks the informant few causal surface level (ground mapping) questions to understand the extent of the phenomenon, thereafter depending upon the responses elicited, further questions are extemporized by the researcher to comprehensively understand the phenomenon in depth. This form of interview technique is especially useful when the researcher has no pre-existing knowledge about the phenomenon. Additionally, this type of interview helps to delve deeper into the latent context behind socially sensitive phenomena which individuals are not very comfortable to talk about (Boyce and Neale, 2006). Since the study involved asking interviewees about their relationship with their colleagues involved in the new products development process in a French plant, we had to take into consideration the collectivisme aspect of the French culture; in depth interviews helped us to probe deeper into our respondents' perceptions.

1. Data collection

Field notes and informal interviews:

During six months a memo was filled with field notes including observations about the behaviour and the interaction of other department with the ETO department and the behaviour of the ETO project leaders in usual days. This memo has been filled with not only a diary content but also with informal interviews which are discussions with the team member giving important insights able to

help in addressing the research questions. It has also been enriched with observations generated from the participation to special events having a tight implication with the searched question.

In-depth interviews:

We also developed an interview guide that included open-ended questions to lead the In-depth interviews with the Product Managers. It starts with questions regarding the new product development strategy, then questions about the methodology of developing new products. These topics were guiding the discussion in order to get to the ressources and tools that are being used in the new product development process. The three topics are organized under the following Table 1. The interview was designed to elicit information and responses on the implication of the ETO department in the success of a firm's mass customization strategy. The questions were developed after spending 2 months observing the different units involved in the new product development process and the ETO unit.

Strategy of New Product Development	Methodology of New product development	Ressourcesand collaboration Tools

Table 1 Discussion topics

2. Analysis

In this part we will analyse the field notes collected during the six months internship a long with the informal and in-depth interviews.

Analysis of the field notes:

During the internship we noticed details about the interaction of the different departments in the process of an ETO project.

Coordination between the departments involved in the ETO process:

A serie of training was scheduled to prepare our integration of the ETO department. This training was meant to meet all the other departments which work with the ETO department in manufacturing customized products. These departments are the local and global quality, the data management department, the procurement department, the logistics department, the engeneering department, the Marketing department represented by the product managers and application specialists, the R&D department and the workforce specialized in assembling customized products.
It seemed that all these departments are very knowledgeable about the customization process.
Each of these departments has a specific task to deliver to the ETO Project Leaders.

For exemple, in the process of an ETO project, when the customer ask for a customized product, the sells representative invite the Application specialist who reports to the product managers to help the customer to fill the Request for Qutotation and draw a sketch of the customization requested. The data management make sure to create the designs of the parts that will be used by the ETO project leaders to creat the customized assembly. They also make sure that the designs will be stored and attributed specifically to each customer.

The ETO prepares a quotation and a primary design. The global quality check legislation about each created design and the local quality take care of the quality check testing of the chemical materials and the physical properties of the assemblies. In case of there is a new tool which need to be engineered to assemble the parts, the engineering departments are involved to help with that. The logistics department gives a state of the parts in the stock. The R&D department are counciled in order to not leak designs that could be pattended.
After the customer approves the final designs the logistics department and the procurement make sure that all the parts will be available for the first serie manufacturing. The manufacturing department schedule the assemblation of the customized product by assigning the assembly line and making available the special workforce trained to manufacturing the ETO products.
Although, the ETO has its own jargon for the customized project, it seemed that it could spread it through out all the different departments that work closely with them in designing a customized product. This was made possible because the ETO project leaders lead all the other department in successfully achieving the customization project. They centralize the work of other departments, coordinate between them and facilitate the process of delivering the customers what they want.

For exemple, along with the Data management department, they create the Technical Drawing for the customer and the Technical Drawing for Manufacturing. These two technical documents have to be verified and signed by the global quality department. Thus, the global quality department understand the meaning of TDcus and TDman. Moreover, the logistic department knows that they have to send the TDcus along with the first series documentation.
In the daily company life, we noticed that the ETO are very close to many other departments. In fact, they have lunch usually with the data management team. Once a week they have a lunch with the quality departments. They also organize the company afterwork and invite colleagues from other department like the engineering and the R&D.
The relationship between the ETO project leaders and the sales representative:
The purpose of the internship was to spread awearness among the sales representatives about the process of making an ETO product. Sales representatives are revenue driven. Threfore, they are more motivated in selling ETO products which have a better margin than pre-engineered product (standard) or configurable products. They also want to satisfy all their customers' request to keep them from going to the competitors since the market is very competitive; hence, they propose to help them with customized solutions. The dilemma is that the ETO department receives a lot of customization requests with a low hit rate. Customers ask the sales representatives to have customized products, and then engage in the co-development process with the ETO project leaders in order to have a first design. Then when it comes to validate the design in order to make a pre-order, they abort the project. During our participation to the backlog meeting we understood that the sales representatives want to show off the knowledge of the company in designing customized product and when customers request to have such a product they can't say no. Moreover, they encourage them to engage in this type of development. Nonetheless, the first steps before having a pre-order are time and resource consuming from the ETO department side. For this matter, we were assigned to spread the awearness of the costs associated to such a development. It helped us to understand the relationship between the ETO project leaders and the customers. It seemed

that most often the decision making unit from the customer side are technical oriented. Therefore, after getting in touch with the assigned ETO Project Leader and the Application specialist who bring technical support to the sales representative, they only get back to this last for price negociation, contract and administrative matters.

Service based approach:

The ETO business unit manager has understood that the work that they have been doing has to be sold in a better way. She understood that she have to increase the investement from the customer side in order to decrease the project abortion and increase the hit rate of the ETO projects.

She has organized a three days training to the two ETO offices of the company. The purpose of the training was about the service based approche. We were taught about how to sale each step as a service a part changing the designation of what is designed from customized products into customized solutions. The implementation of what we learned was'nt about making the customers pay for each step. But it was more about showing the customers the value of what we're doing for free. This approach is meant to encipher the skills of the ETO project leaders and their colleagues from other departments.

ETO Project Leaders mobility:

We noticed that although they have the technical support of the field specialists and application specialists, the customers ask to have the ETO Project Leaders visiting their sites to exchange about possible customized solutions. This mobility allowed one of the project leaders to be promoted to be a key account manager and to two of her colleagues to be promoted to Field ETO specialists. This position was created to have project leaders who have more flexibility to delocalize the co-design from the company site to the customer site. An important fact that we noticed is that two of the first 10 employees of the company are working with the ETO team. One of them was a part designer when he started, the second was an assembler in the assembly line.

Analysis of the informal interviewsand the in-depth interviews:

In order to analyse the data, we used a theoretical thematic analysis which is a deductive approach. Our analysis was based on Braun & Clarke (2006) framework which provides a six phase guide framework for this kind of analysis. Braun & Clarke (2006) distinguish between a top-down or theoretical thematic analysis, that is driven by the specific research question(s) and/or the analyst's focus, and a bottom-up or inductive one that is more driven by the data itself.Our analysis was driven by the research question and was more top-down than bottom up.The six phase guide framework of Braun & Clarke (2006) is as following.

Step 1: Become familiar with the data,

Step 2: Generate initial codes,

Step 3: Search for themes,

Step 4: Review themes,

Step 5: Define themes,

Step 6: Write-up.

a. Step 1: Become familiar with the data

In this phase we started to organise our data in a meaningful and systematic way. We coded the data in order to reduce lots of data into small chunks of meaning.

We were concerned with addressing specific research questions and analysed the data with this in mind – so this was a theoretical thematic analysis rather than an inductive one. Given this, we coded each segment of data that was relevant to or captured something interesting about our research question. We did not code every piece of text.

b. Step 2: Generate initial codes

We approached the data with specific questions in mind that wewished to code around. We were coding to identify particular (and possibly limited) features of the data set.

We had initial ideas about codes when we finished Step 1. For example, one statement that kept coming from Product Managers is that they don't get informations about ETO development project and customization requests.

Since the data set was not large, the coding was made by hand initially, working through hardcopies of the transcripts with pens and highlighters. It has been copied then to Microsoft excel in order to make the themes identification easy for the next step. Appendix 2 presents the coded extracts.

c. Step 3: Search for themes

Codes were examinated and some of them clearly fitted together into a theme. For example, for the informal interview, it has been brought to our attention several time that the company is known by its customized products and this is why the customization request are very high. We have put these under an initial theme called, Customer perception.

Theme: Customer engagement	Theme: Internal coordination	Theme: Customer perception	Theme : Customization specialization	Theme : The company engagement
Increase the level of investment of the customer	**Sub-theme** Active coordination	The company known by its ETO capability	High level of technicity and specialization	Commitement and availability of all the departments
Creating the trust with other customer	Facilitate the role of other departments	High demand for the customization products	Other department knowlegable about ETO process	Worry about the profitability of the BU
Relocation to the Customer site	Organize recurent meetings	Ask for free consultancy	Learning from and using previous developed designs	Full engagement with the key account
Uses of the customer ressources	**Sub-theme** Passive coordination			
	Make sure that other departments know the process and terminology			

Table 2 Preliminary themes for the informal interviews

For the in-depth interview we had several codes that related to coordination and collaboration for product development. We collated these into an initial theme called coordination for NPD.

At the end of this step the codes had been organised into broader themes that seemed to say something specific about this research question. Table 2 and table 3 shows all the preliminary themes that are identified in Extract 1 and Extract 2.

Theme: Information sources	Theme: Coordination for NPD	Theme: ETO Caracteristics	Theme : Coordination for customization projects	Theme : Positioning
Information sources for NPD	Coordination for a NPD	ETO mission	Collaboration with the customers	Sales rep Perception of ETO products
Information recieved from the ETO	Information sources for NPD	Sales rep Perception of ETO products	internal coordination for customization projects	
Apreciation in case of having ETO product project informations			Information recieved from the ETO	
strong believe in the uses of ETO information in the NPD process			Apreciation in case of having ETO product project informations	
			strong believe in the uses of ETO information in the NPD process	

Table 3 Preliminary themes for the in-depth interviews

d. Step 4: Review themes

During this phase we reviewed, modified and develop the preliminary themes that we identified in Step 3.The table 4 and table 5 show the final themes that we have found out.

From table 2 we noticed that the customer engagement and the company engagement could fit under a theme called the relationship with the customer. We did this because for the codevelopment project we find in hard to specify the engagements of each part since the two party are engaged in the development of the customization products.

Theme:Relationship with the customer	Theme: Internal coordination	Theme: Customer perception	Theme : Customization specialization
Sub-theme Customer engagement	**Sub-theme** Active coordination	The company known by its ETO capability	High level of technicity and specialization
Increase the level of investment of the customer - Creating the trust with other customer- Relocation to the Customer site	Facilitate the role of other departments	High demand for the customization products	Other department knowlegable about ETO process
Sub-theme The company engagement	Organize recurent meetings	Ask for free consultancy	Learning from and using previous developed designs
Commitement and availability of all the departments	**Sub-theme** Passive coordination		
Worry about the profitability of the BU	Make sure that other departments know the process and terminology		
Full engagement with the key account			

Table 4 Final themes for the informal interviews

From table 3 coordination for NPD and coordination for customization project were put together under a same coordination theme. Simply put, the coordination for NPD project has two sides, one is done internally without envolving the customer, and the second is implicating the collaboration with the customer going through the ETO team.

Theme: Information sources	Theme: Coordination	Theme: ETO Caracteristics	Theme : Positioning
Information sources for NPD	**Sub-theme** Internal coordination	ETO mission	Sales rep Perception of ETO products
Information recieved from the ETO	Coordination for a NPD	Sales rep Perception of ETO products	
Apreciation in case of having ETO product project informations	Information sources for NPD	Information recieved from the ETO	
strong believe in the uses of ETO information in the NPD process	**Sub-theme** colaboration with customers	Apreciation in case of having ETO product project informations	
	ETO mission	strong believe in the uses of ETO information in the NPD process	
	Information recieved from the ETO		

Table 5 Final themes for the in-depth interviews

e. Step 5: Define themes

The identified four overachingthemeswere used in designing a final thematic mapsthat illustrates the relationships between themes.

These maps will help us in understanding the relationship between themes for the two type of interviews that were done. Creating themes out of the codes not only helped us in norrowing the main collected idea, but it also brought us a clear attention to the overaching themes. The relationship between these themes is supported by the number of time codes relating these themes were linked and emphisized by the interviewee.

For exemple related to "the company known by its ETO capability" was always related to "the High level of technicity and specialization". The "Facilitate the role of other departments and organize recurrent meeting" is linked to "other department knowlegable about ETO process and terminology". We draw the following thematic maps based on these type of relationship.

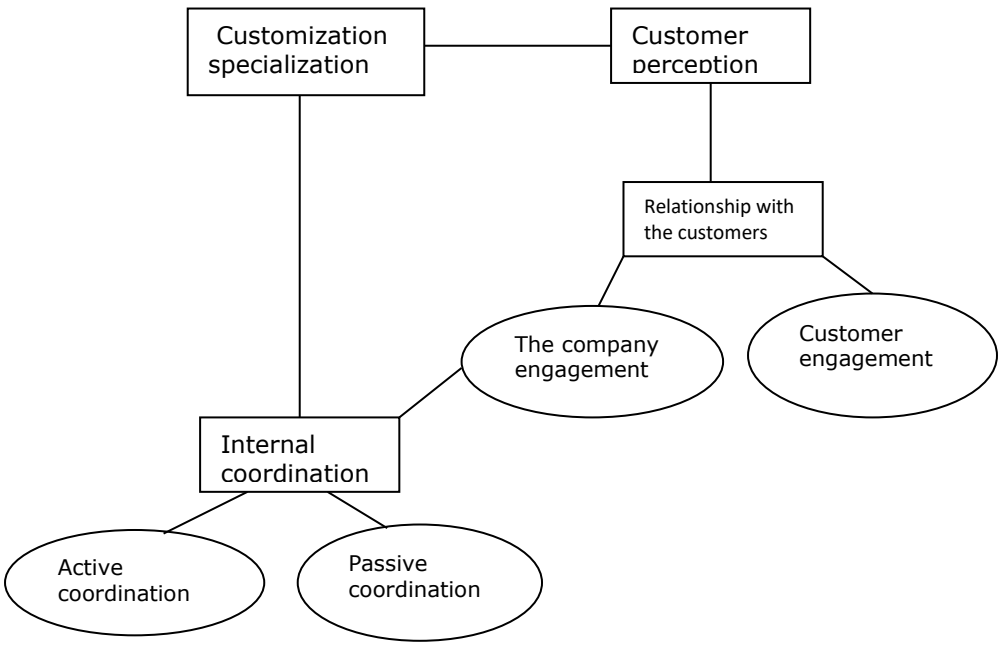

Figure 6 Thematic map of the informal interviews

As exemple from the codes that we had from the product managers interviews the "information received from the ETO" was mentioned when they were talking about the ETO characteristics, the internal coordination and the information sources. The positioning of the company is also highly related to the ETO caracteristics. Following that logic, ETO caracteristics theme is related to the information sources, positioning and internal coordination themes.

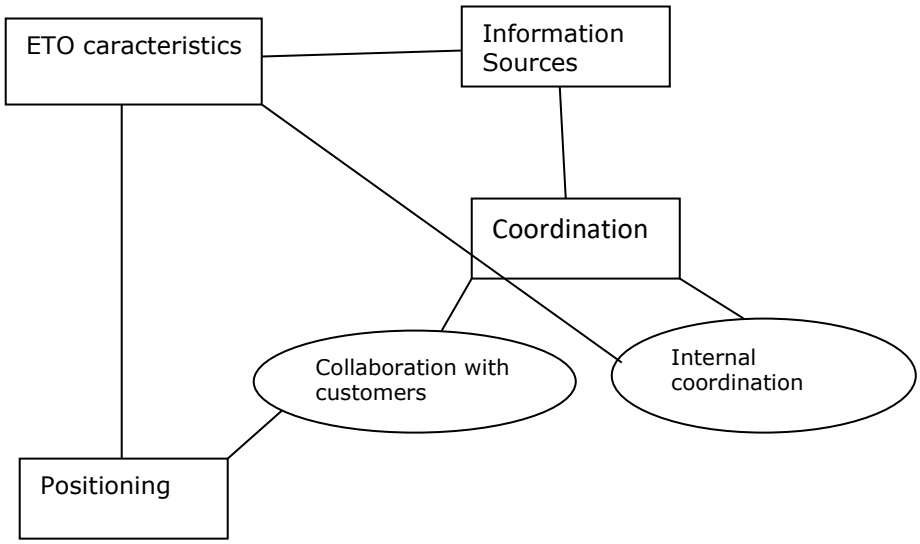

Figure 7 Thematic map of the in-depth interview

3. Results

The engineering to order project leader have an important responsibility in the interfunctional design coordination in the company. They lead the customization project and take the responsibility of involving every department who need to be implicated in this type of project. Although they have their own terminology and a distinct process in the company, the coordination with other department has taught these last to be knowledgeable about the terminology and specific task of each phase. The importance of details in the customization projects and the level of technicity required to successfully design customized products has also an implication in the investment of other department in understanding the full process of the ETO projects and mastering the terminology. Moreover, despite the complexity of designing a customized product, the fluidity of the process seems to be tightly linked to the internal organization in the company.
Each of the department implicated in the ETO project have one or more member who are very knowledgeable about the customized product development process. Therefore, they can spread this knowledge with a high proximity and an instant support to their colleagues in the department.

The customization capability that the company have, seems to have a high attractivity on the customers. Sales representatives bring up this capability to their customer in order to always give them a solution. Although the company have a large choice of standard product pre-engineered and a tool to configure pre-configured products, the temptation of having a customized solution is

more attractive for the customer. It is because usually the issues are very technical, so that the decision making unit are essentially the technical staff of the customer. Thus, they are more interested in engaging in technical co-development eventually to gain knowledge and expertise.

Even though customers are also invested in the co-development of their own product, the customization unit (ETO department) suffer from receiving many customization requests.
The technical staff from the customer side consider that the time spent interacting with the ETO department, regardless of the achievement of the project or not helps them to increase their expertise and gain more knowledge. Ever since it is interesting to see that the Business Unit manager understood that they have to increase the level of investment and risk from the customer side by valuing the implicated cost of co-designing. We understood that the customization knowledge that the company have is the most important trigger that leads the customers to get involved in the product development. This knowledge is apparently so looking for, that the Business Unit Manager, thought about leveraging it before even that customers pre-order product.

Interestingly the ETO project leaders team contain 2 of the first 10 employee of the company. One of them is technically a specialized designer and the second is an assembler. We suppose that it is very important to the team knowledge because they spread the accumulated knowledge during their experience. Moreover, the team effort of increasing the hit rate of their project led them to increase their involvement by giving more visits to the customer. The aim of that, is to delocalize the co-designing phase in order to increase the investment and the risk of the customers.

It has been clear from the thematic map of the informal interviews that the internal coordination is the bases for the customization specialization. In fact, the customization project involves almost all the department of the company. So it is important that a high level of information exchange and knowledge of the terminology and process will be maintained. In order to succeed these type of project all the department have to have a clear understanding about their tasks and challenges that may be faced. The coordination is extendable even to the controlling department. It is necessary that they exchange information with the customization unit so that they can calculate a cost price and a recommended selling price to give to the sales representative.
We understood that the coordination process is maintained actively by organizing meeting with all the department in the company. Those formal recurrent meeting are important in order to keep the coordination process going. It helps to solve complex issue to the coordination of the customization projects which in turn facilitate the work of other department and increase their investment. It is also maintained passively by making sure that other departments master the uses of the customization terminology. For example, when introducing a new process for the customization project, ETO team leaders have to look after the well implementation and uses of the new process. It is the same case with the introduction of a new part or tool.

The high level of coordination and understanding between all the departments within the company along with the high level of technicity of the customization unit, increase considerably the level of customization specialization of the company. The customization unit lead on the customization

project tend to be very smooth when a high level of coordination exist. ETO project leaders can then count on the implication and the devotion of their colleagues from other department to predict possible issues that may appears for a requested customization project. In fact, the customization specialization is linked to the automation of the customization process. It brings more efficiency for the customization project. This capability is related to the experience of the Engineering To Order department in customizing products under the customers requests. Having the experience of customizing products not only increase the competence of the customization unit by learning from previous designs, but it also help to teach the other departments by exposing them to many cases.

Being highly specialized in customized project seems to have a great consideration from the customer side. In fact, customer value the customization knowledge of the company and prefer to have their customized product rather than choosing a standard product. Although the price of the customized product is higher than standard product, the customer request a customized product because they trust the customization capability of the company. Usually the need is requested by the technical staff, who are technically motivated and don’t consider the cost brought with such a request.

Consistent with the results of our field notes, when the customer request for a customized product, it engage the company and the customer in a relationship of co-development. The technical staff of the customer is involved in this co-development and put from his time and application knowledge in order to co-design and co-develop a customized solution for its problem. In the other hand, the customization unit from the company side, is invested with it’s time and the time of other department implicated in this co-development. Sometime the customers have also to involve other departments. This relationship is a balance between the customer involvement and the company involvement. Yet, the customers appreciate getting involved in the customization projects, especially when it is done with a company who has a great knowledge of the customization. The reason is that the customer is more tempted on learning new things from the company. If it doesn't more matter to the customer to achieve the customization project, it is really important to the customization unit, in order to increase their hit rate and concretize all the customization project which are being held. The company investment is so high that a customization project aborted is considered a waste of time and the cost of it will weight directly on the ETO business unit. In order to find the right balance between the customer involvement and the company involvement, the customization unit found a way to increase the investment and risk from the customer side.

The interviews with the product managers were clear and consistent about the challenges that the company is facing. They are also supportive to the field note and the informal interview with ETO project leaders findings. The company positioning is rooted to the collaboration with the customers and the ETO characteristics. The company aims to offer premium products through standard and configurable product types and it offers the flexibility of engineering a customized product through

its ETO unit. Nevertheless, the customers are more asking for customized products rather than pre engineered products (standard and configurable types of products).

M.L respondent [A] a Product manager said ***"Customers are usually pushing to have their customized product even for a premium price . "***

Their customers seem to profit from the efforts that are being made by the company in order to reinforce its position. They want to enjoy and leverage the customization knowledge capability of the company.

E.V respondent [E] a Product manager said ***"....position as one of the leaders in the worlds, it is hard for us to say no to the customers for customization projects. "***

The collaboration with the customer was therefore linked to the positioning of the company. This collaboration is brought by the customization service that the ETO unit is providing. In fact, being known by its customization unit, when the company engage in a customization project it involve the customer in a co-development relationship.

E.V respondent [E] a Product manager said ***"ETO project are codevelopment project between the customer and our company, starting with the definition of the User Requirement Specifications and ends with the shipment of the first series. Thus, the level of collaboration between the company and the customer is very high".***

Significantly it emerged that the opportunity of collaborating with customers could enhance the new product development process. It has been found that the internal coordination within the company is missing the ETO contribution in order to have an efficient new product development coordination process. While, the coordination is very high in designing customized products, the Product Managers find that they could increase their coordination with the ETO department in order to use the customization knowledge in the new product development process in their category line.

M.L respondent [A] a Product manager said ***"I don't have an exact number of the total customization requests…. I would appreciate to have this information with little more details. For example: statistics about what are the modules that are being asked to be customized and the reasons of the customization request. "***

The Product Managers receive a pool of information regarding market forecasts, sales force and application specialists' feedback. These information are collected from the market. Usually form market research and direct feedback from the Application specialists and the sales representatives about their customers needs. It helps them to make their decision about the new product development in their category line.

G.L.C respondent [B] a Product manager said ***"...the marketing research report which is done with the contribution of our R&D department and the feedback that we get from Application or Field specialists, reveal that I have to develop a new product in order to satisfy the sensed market need."***

The product managers emphasize that the pool of information received is important but most of the time doesn't make them competitive since it is based on accessible information. The ideal situation for the Product Managers is to have detailed informations about the customization requests in their product category. The product managers describe the previous customization projects and customization requests as a great source of information for them in the process of making decisions for the new product development.

S.C respondent [C] a Product manager said ***"I believe that this kind of information could be very helpful in our process of defining a new product development project. …and I believe that this could be a very relevant source of information. "***

The implication of the ETO unit in the new product development was revealed to be helpful in designing more successful common platform. Especially when it comes to their product which are highly modulable. It is hard to decide whether to standardize a part and include it in the common platform or let it modular. Product Managers are conscious that they are missing the opportunity to analyse previous designs in making their decision regarding their products. Analysing this type of information can bring them insights about which are the parts that aren't very requested to customize so they can include them in a standard platform in order to develop new product which could bring more satisfaction to all their customers and decrease the complexity of their product.

K.M respondent [D] a Product manager said ***"Information about previous customization requests could help us in analysing the fit of our product platform with the market need and obviously based on this analysis we will try to improve our platform."***

VI. Conclusion and implications

This study set out with the aim to explore the implication of an ETO department, in the success of the mass customization strategy. Our work contribute to the existing research regarding mass customization in several ways.

First of all we proposed a new theoretical model for mass customization. Our model uses previous research done by Ahmad et al. (2010) in order to explain the relationship between product modularity and mass customization thus competitiveness. We judge that this model presented is incomplete and missing two important constructs. We enriched it based on the model proposed by Wang et al. (2014) which indicate the mediating role of customization knowledge utilization between product modularity and mass customization, to introduce the customization knowledge utilization in our new model. We have also upgraded the first model of Ahmad et al. (2010) based on the research of Cui and Wu (2016) which propose that customer involvement mediate the relationship between interfunctional design coordination and the product performance. In our proposed theoretical model we include the customer involvement as a mediator between customization knowledge utilization and Mass customization. Therefore, the proposed theoretical model is consistently combining the findings of the three mentioned researchers previously done.

Second, we had an immersive experience of six months in the engineering to order department of a company which is concerned about the mass customization. Since we were a complete participator in the customization unit of the company, we could collect very pertinent field note and informal interviews. During this experience we were assigned to cultivate the awareness of the sales representatives about some aspect of the customization projects process. It helped us considerably to have a clear and detailed view about each subprocess in the customization project processes. Moreover, through the interaction with some sales representative we could have interesting informations about the customer perception of the customization capability of the company. Therefore, the finding of this work are based on field information with a full participation as a customization project leader. Hence, the finding of this work are a clear reflection of a practical reality.

Last but not least, the validity of our qualitative study was tested through two types of triangulation. In fact, we used three methods to collect our data. During the six months internship we could notice and observe many facts very important to our study. These information was used as field notes. It has brought us relevant insights about the subject of our research.We have also collected informal interviews. It has been possible since we were part of the customization unit team. The data were collected during the usual work in the team and each time was incremented with new inputs regarding a new situation. Therefore, the data is accurate and very relevant. The third method of information collecting was the in-depth interviews. These interviews were done with product managers. The employees responsible of the new product designs. Therefore, having a structured interviews with them helped us in collecting precise information about important matters for the new product development. Not only that, but they also gave us their point of view about what should be done. Collecting structured information didn't interfere with our curiosity about looking for their point of view about things that have to be improved in the company. Their opinion helped our understanding of practices that could help to improve the new product design process. Using these three different methods to collect data helped us to test the validity of our qualitative research through the method triangulation. Moreover, the fact that the data was collected from two different groups in the company helped also in testing the validity of our data.

We have collected the data from the engineering to order project leaders, who are responsible of the customization projects and the product managers who are responsible of the profitability of their product line. These two groups particularly captured our interest because the first is specialized in customization and the second in standard product development. Therefore, collecting the information from these two groups is not only important to validate the data but it is also important to help us develop a comprehensive understanding of the implication of the ETO in the success of a mass customization strategy.

With respect to the research question, several affirmations were brought to our proposed theoretical model.

First, the interfunctional design coordination was found to have a direct relationship with the customization knowledge utilization. In fact, it is important that a high level of information

exchange and knowledge of the terminology and process is maintained between all the departments involved in a customization project. All these departments have to have a clear understanding about their tasks and challenges that may be faced. The coordination is extendable even to the controlling department. It is necessary that they exchange information with the customization unit so that they can calculate a cost price and a recommended selling price to give to the sales representative. When the interfunctional design coordination is well implemented, other departments can learn the customization terminology and the distinct process of the customization projects. This will help them to be knowledgeable about the terminology and their specific task in each phase. Having a great level of understanding of the process and terminology have an important implication in the investment of the other department in utilizing their customization knowledge. In fact, establishing an internal organization in the company that foster the information exchange has been found necessary for such a process. It is important that the knowledge is spread with a high proximity and an instant support could be brought to each department facing a new issue. All this is done in order to make all the department in the company, implicated in the customization process count on the implication and the devotion of their colleagues from other departments to predict possible issues that may appears for a requested customization project. In fact, the customization knowledge utilization is linked to the automation of the customization process. It brings more efficiency for the customization project. This capability is related to the experience of the customization unit in customizing products under the customers' requests. Having the experience of customizing products not only increase the competence of the customization unit by learning from previous designs, but it also help to teach the other departments by exposing them to many cases.

Second, the customization Knowledge utilization was found to have a direct relationship with the customer involvement. In fact, the customization capability that the company have, seems to have a high attractivity on the customers. Being highly specialized in customized project seems to have a great consideration from the customer side. In fact, customer value the customization knowledge of the company and prefer to have their customized product rather than choosing a standard product. Although the price of the customized product is higher than standard product, the customer request a customized product because they trust the customization capability of the company. Usually the need is requested by the technical staff, who are technically motivated and don't consider the cost brought with such a request. The technical staff from the customer side consider that the time spent interacting with company experienced with customization projects, regardless of the achievement of the project or not helps them to increase their expertise and gain more knowledge. The customers appears to have a great deal from being involved in the customization project by companies who have a great level of expertise. Any interaction between the customer and the company is a balance between customer engagement and the company engagement. Each engagement from a side bring a profit to the other side. For this reason, when a company have a high level of customization knowledge utilization, customer will be more tempted in getting involved in a co-development project in order to profit from the knowledge of the company.

Thirdly, although the product managers coordinate already with other departments to have consistent information about new products that need to be developed, they have emphasized that information about previous customization requests and current customization requests can help them to monitor the success of the new product developed: If there is many customization request for a giving product, that means that the product isn't satisfying the market an several improvement are needed to make it have a better fit with customer attentes. Therefore, information about the customization request is an important pool of knowledge about the market feedback. With leveraging such informations companies could cope with increased uncertainty through another mean of information collecting including the direct relationship with the customer.

Therefore, the interfunctional design coordination doesn't implicate only departments which have an active role in the customization process. But it is necessary to implicate all the departments of the company in order to use the company customization knowledge of the company and leverage it to continuously improve the company process and competitivity.

Practically, product managers are the decision making unit about the necessity of developing new product or upgrading an existing product. They do so based on informations gathered by the market researchers along with the sales representative and application specialist feedback which have a direct contact with the customers need. Especially when the products are highly modulable, it is hard to develop products that could satisfy and respond efficiently to all the customers due to the important number of assembly possibility. For this reason, the uncertainty behind developing standard product with the aim to respond to all the customers needs is very high. Thereafter, the company have to individually customize its standard product in order to make them fit their customer need. The customization unit receive customization requests from each customer and treat it independently to cover its demande. The effort and cost behind this is very high but the customization requests themselves give an important idea about what are the subsystem that are the most asked to customize and more importantly, it gives an idea about the subsystem that are less asked to be customized. Here is a great information for product managers who could use this information to decrease the complexity of their product by standardizing the part who are less asked to be customized. We suppose that it will help them to create standard platform, who are the nucleus of their product and decrease the complexity of their product customization. Moreover, decreasing the complexity of the customization have a great impact on decreasing the customization costs. Defining effective standard platform enhance the company efficiency to automate its production facility in order to produce more with less. Besides, it could also customize its platforms more efficiently and make them fit the customers' need. Consequently, the company will enhance its mass customization capability and gain more competitiveness in its market.

Lastely, mass customization is the objective of each customer centric company. It is very tempting to be able to respond to all the specific customer needs and keep the costs low and under control.

However, despite the company record of single or individual customization (ETO), there is a great deal of effort that need to be put in order to implement an interfunctional design coordination within the company. Starting from the organization in itselfs, to teams interaction and process and

tools provided, the interfunctional design coordination seems to be a dynamic capability which continuously need to be improved. It also foster the customization knowledge utilization, another dynamic capability which is incremented by the experience of the company of the customization project and the extent with which all the department of the company interact to successfully achieve the customization project. It is important to mention that interfunctional design coordination provide tools, means and process to the employees of the company to learn from previous customization and to increase each time the customization capability of the company by utilizing the customization knowledge acquired from previous customization. Customers can notice such a capability. In fact, customization knowledge utilization is when well implemented embedded in the company processes and tools such for example the ERP of the company. The attractivity of such a dynamic capability on the customer is very important because it foster the customer to engage in codevelopment project with the company. Hence, the company will gain more experience through more customization projects and can use the knowledge of these customization project to improve its mass customization capability.

VII. Limites and direction for future research

Despite the efforts that has been made in order to explore the thesis research question, the findings are subject to a few limitations.

First of all, the study was conducted in an only one company. This was limiting the number of participants to our data collecting methodes. It had also an impact on the variability of the responses. In fact, we think that it is interesting to expand this work to other companies. We believe that more respondant from different companies could increase the validity of our finding.
We also, believe that we should be including the sales and applications specialists in order to cover a broder image.

Second, the findings relie on responses collected in a company in a very specific sector: Single-use disposables for biopharmaceutical institution and drug producers companies.
It is a cutting edge technology for which professionals like the Biophorum Operational Group are still searching for improvement to standardize its process. Therefore, this study does not have input from a sector in which mass customization is already practiced. We believe that the stady have to be generalized to other sectors in order to improve the generalibility of our finding.

Third, this study could only explore the theoretical model proposed by combining several previous researches through several qualitative approach. Although, the results were triangulated to test their validity, we believe that a quantitative study is still important to ascertain the findings and to fully support the proposed model.

Therefore, there is many future researchs that could be done following this study. A more generalizable qualitative study could be done in order to explore more generally the proposed

theoretical model and a quantitative study could also be relized in order to empiracly support the proposed theoretical model.

Last but not least, a more advanced study could be using engineering to order projects and product information and apply the "two stage platform development method" developed by Qu et al. (2009). It will give the possibility to know whether or not these informations are efficient in producing embryonic product platform. Therefore, it will empiracly and practically ascertain the implication of the ETO unit in the mass customization strategy of companies.

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IX. Appendice

Responses	Codes
the sales representative send us a request for quotation, ideally he/she have to do this with the support of the Application specialist. The requests land in our backlog, which is discussed on a daily basis in the backlog meeting. During that meeting each request is assigned to an ETO project leader depending on the workload, the specialization of each project leader and the level of customization. The project leaders are each of them specialized in a product line and we have two type of customization hard and soft customization.	High level of technicity and specialization
ETO products involve many departments in the company. Being an ETO project leader is in a hand co-develop the customized product with the customer and in the other hand lead the internal work by facilitate the role of each of the other departments involved in an ETO project and in the other hand lead the internal work by facilitate the role of each of the other departments involved in an ETO	Coordination with the customers facilitate the role of other departments
We start by receiving the request for quotation which include a description of the use case or sometime a sketch. Then if everything is clear we design a first design and send it to the customer approval. Most of the time customers only know why they need a customized product but they don't know what they need exactly. So it is our job to help them define their need and then design it together. Sometime it take a lot of time to us to work with the customer and design the best customized product because we need to check for exemple quality regulation or logistic feasibility with internal departments and the customer departments before proposing our recommendation. These checks are important because once we are giving recommendation about a design we should be able to honor it. What is hard in our work is that sometime the customer abort the project and doesn't make a pre-order. It is a waste of time for us and the other department which has been	Codevelopment with the customers Commitement and availability of all the departments Customization specialization Worry about the profitability of the BU
We are seen as a very specialized technical staff in customization and the company was founded on such a level of skills. The company didn't have a standard product at it foundation, it was only engineering customized product to its customers. This is why we have a great image in the market with our ETO products. ...because the customer wants to have their own product. Sometime it look like we're giving consultancy to the customer on what's the best product to use. We can smoothly lead this type of project since all the other departments have a great knowledge about our process and terminologies. Until now we have been able to design approximately 9000 designs per year. So sometime customers customization request can be similar to a design that we have developed by the past. It's important that all the ETO project leaders know about the customization projects going on in order to echange information and help each other because we don't have a tool to detect similarities between customization project. We have a weekly meeting with the quality insurance department in order to solve the customer compliance after the first serie is shipped. a weekly meeting with a logistic colleague who is in	Customization specialization The company known by its ETO capability Passive coordination Other department knowlegable about ETO process Learning from and using previous developed designs Active coordination
The customization requests that we receive is so high that we thought about a strategy to reduce it. Our concern isn't about the number of the requests but it's more about increasing our hit rate. We thought about increasing the investment from the customer side, so now for each project that we think will take a considerable time to develop, we will highly recommend that it should start with a prototype. If the customer will pre-order the developed product the price of the prototype will be deducted from the order. If the customer abort the project it must pay for the prototype. In this way we think that the customer will think twice before being engaged with us in co-developing a	Worry about the profitability of the BU High demand for the customization products Level of investment of the customers
We are more invested with our key account. We visit them spend some days in their location and work closely with them and our key account management team in co-developing product. In fact, we know that they will be ordering all our development. The new created position of the field ETO project leader will be to visit the customer under the Application Specialist demande in order to define the need and co-develop a solution in situ then get the customer pre-order before coming	Full investment with the key account because they trust them Creating the trust with other customers by the relocation to the customr site

Table 1 codes of the informal interviews

Topic	Responses	Codes
What is your new product development strategy	We aim to offer premium products for our clients. Our mission is to identify the market needs and the challenges that our customers are facing in producing drugs, in order to develop products that help them being competitive in the market.	Company positioning
What is your NPD Methodology	Sometime the marketing research report which is done with the contribution of our R&D department and the feedback that we get from Application or Field specialists, reveal that I have to develop a new product in order to satisfy the sensed market need. We start by presenting the project scope to a Go No Go NPD committee. - In case of a Go the R&D starts developing the product with the collaboration of the Quality and Operation Departments. In case of a Go the R&D starts developing the product with the collaboration of the Quality and Operation Departments.	Information sources for NPD Coordination for a NPD
When does the ETO unit intervene in new project development process?	Actually they don't intervene in the new project development process….when a product is already on the market and customers are asking for a customization in an already commercialized product. Although we are making a lot of efforts pushing sales rep in commercializing standard and configurable products, the ETO products are still the more demanded products. As we are trying to reinforce our position as one of the leaders in the worlds, it is hard for us to say no to the customers for customization projects. When a customer ask for a hard customization project, we have a Go No Go committee which include PM of the concerned category, and ETO Project Leader from the marketing department Engineering , Quality units and the AS and Sales concerned by the deal. If the project have a Go, The only informations that I will get about ETO product performance is the sales figures. If it is judged as a soft customization by the ETO team, no GoNoGo committee is needed and I will also have only sales figures as informations as it concern my product category. Knowing that ETO product selling process is long and complex, Sales representatives propose standard or configurable products to their customers as a first solution. Even though it is the case, customers are usually pushing to have their customized product even for a premium price . In this case Sales rep are usually in the customer side and challenge the company in order to get an ETO product in a convenient lead time.	ETO mission Internal coordination for customization projects Information recieved from the ETO Sales rep Perception of ETO products
Do you have any suggestion to improve your methodology	I don't have an exact number of the total customization requests received by the engineering to order unit for my product category. But I would appreciate to have this information with little more details. For example : statistics about what are the modules that are being asked to be customized and the reasons of the customization request. I believe that this kind of information could be very helpful in our process of defining a new product development project. ETO project are codevelopment project between the customer and our company,starting with the definition of the User Requirement Specifications and ends with the shipment of the first series. Thus, the level of collaboration between the company and the customer is very high and I believe that this could be a very relevant source of information. Information about previous customization requests could help us in analysing the fit of our product plateform with the market need and obviously based on this analysis we will try to improve our	Appreciation in case of having ETO product project informations strong believe in the uses of ETO information in the NPD process Collaboration with the customers

Table 2 codes of the indepth interviews