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Implications of Personalization Offers on Demand and Supply Network Design: A Case from the Golf Club Industry

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Abstract

Competitive, open and global markets render the consumer more demanding towards manufacturers' offers. In the past, firms could be competitive by providing value in quality, price and quick delivery. In the new economy, with the coming of e-business, the personalization of products becomes a key competitive factor. Manufacturers need to develop capabilities to fulfill these personalization needs while still respecting price, quality and service. This is an enormous challenge since there are many possible personalization offers that a firm could propose, up to the extreme of delivering a distinct product to each client. An initial step towards developing the appropriate personalization offers and capabilities is the identification of the potential personalization offers and how they affect the key processes within the demand and supply network. The paper presents a framework comprising of eight personalization options that can be combined to form a complete personalized offer. It then contrasts their impact on the demand and supply network. It exploits the industry of golf irons for illustration purposes.

Key Words: Mass customization, Personalization, Supply chain design, Golf club industry

1. Introduction

In several markets today, competitive advantage lies in the ability to offer comprehensive personalized offers. Many firms have the ability to customize products but rarely with competitive pricing, delivery delay and quality. It is even rarer to find firms able to offer several customization levels simultaneously. The main objective of this paper is to demonstrate the various personalization levels valued by customers, and how each has a particular impact on a firm's key processes throughout its demand and supply chain.

The golf industry provides a suitable context to illustrate the variety of personalization levels. The relative simplicity of the manufacturing processes in making golf clubs makes it accessible, while being complex enough to illustrate the impact of personalized offers. Although sales of golf

equipment has doubled to 2.4 billion US\$ (SRI International, 2002) since 1990, the number of golfers grew about 5% to about 30 million golfers, hence supporting the demand for personalization. This has largely been explained by the advances in technology which provide customized products highly valued by customers (May, 2002).

The paper first reviews the literature to contrast personalization as addressed in this paper from the conventional mass customization concept. We then present the golf club industry which serves as the context in which to demonstrate our personalization framework. The eight levels of personalization are then illustrated for the offer of iron golf clubs. The paper then shows how the personalization offers affect key processes in the demand and supply network. It ends by illustrating how offers can influence resource requirements and concludes with research avenues.

2. Personalization Offer Framework

Prior to the mid-1980s, most manufacturers were custom producers with long lead times or mass producers of low cost products with short lead times (Duray, 2002). Due to the evolution of management practices and technology, on one hand custom products have been made more efficiently and, on the other hand, mass producers began to offer more variety. In the late 1980s, Davis (1987) suggested manufacturers would be able to offer the best of both worlds through “mass customization” (MC). In fact, the 1990s saw various forms of MC where slightly customized products were offered at mass production prices and delivery delays (Pine, 1993). What has surfaced from the literature is that customer involvement and modularity in the production process was a necessary condition to label a firm as a mass customizer. The basic idea of modularity is to produce standard components at mass production costs so that these components can easily be combined to offer a wide variety of customized products. This point of view is reflected by Duray *et al.* (2000) who proposed four mass customizing types: fabricators, involvers, modularizers and assemblers. Based on a survey of 126 firms, they developed their framework by determining the degree of customer involvement and modularity at the design, fabrication, assembly and customer stages within each firm. Fabricators involved customers and modularization in the early stages as they were closest to traditional customizers. Contrarily to fabricators, assemblers involved customers and modularity late in the production stages as they were closer to traditional mass producers. Involvers do implicate customers early in the production stages but they only adopt modularity in late stages. Lastly, modularizers do implement modularity early in the production stages, but customers are only involved in the late stages. Duray *et al* (2002) claim that each of these four types

of mass customizers has preferred manufacturing systems or capabilities to fulfil offers, and that certain implementation approaches exist to attain each type of mass customisation offer.

Similarly, Alwis *et al.* (2001) propose that firms should pick between five mass customising strategies in function of where the consumer effects production (decoupling point), these strategies being pure standardisation, segmented standardisation, customised standard, tailored customisation and pure customisation. However, not all firms have completely switched to mass customising. Kotha (1995) and recently Duray (2002) have shown that both mass production and mass customising can co-exist in the same facility.

Montreuil and Poulin (2002) have taken a broader view of firm’s customization offers to customers, suggesting to move the focus from the extreme concept of mass customization to the more generic and open concept of *personalization*. According to this concept, when firms design their offers to the market, they decide on the appropriate combination of personalization levels in each market segment, in function of their capabilities, the market and client needs, and shareholder interests. Table 1 summarizes the Personalization Framework proposed by Montreuil and Poulin (2003) that builds on their initial five-option framework (Montreuil & Poulin, 2002).

Personalization Option	Characteristics
1. Popularizing	Limited number of product to match a wide variety of customer needs, for those who want off-the-shelf products. Focus on evolving the popular product mix in line with evolving customer needs.
2. Varietizing	Extensive mix of products to satisfy almost all customer needs. Retailers pick those they want to offer off-the-shelf and rely on quick delivery from the distribution network for fast delivery of the others.
3. Accessorizing	A limited set of core products matched with a wide array of accessories. Final assembly of accessorized products performed to order either by the user, the retailer or a fulfillment center.
4. Parametering	Customer defines the desired product through the setting of parameters and the selection of options. He is guided through the specification process. Manufacturing is strictly to order.
5. Tailoring	Product designed/engineered to customer needs. The customer is closely involved in the product realization process.
6. Adjusting	Product adjusted to customer needs after usage. Distributed information systems capture customer feedback.
7. Monitoring	Product is replaced by more adequate product as the customer needs evolve, ensuring continually a best-fit product. This involves regular and interactive customer feedback.
8. Collaborating	Client is viewed as a collaborator with an open dialog. Expert field systems interact with clients, seeking to continually optimize client return

Table 1: Personalization Framework

The first two options seek to offer a specific set of products that covers a wide variety of customer needs, available off the shelf or within a few days. When accessorizing, the offer presents a set of core products that can be accessorized and delivered quickly depending on the type of accessory. Parametering could involve longer delays since the customer is permitted to specify key parameters defining the essence of the product. Tailoring permits customers to design their own products within the capabilities of the firm. The last three options refer to customer offers breaking away from the single-sale-event mind frame, taking a lifecycle perspective. From adjusting to monitoring to collaborating, the firm is more and more involved with the customer to better adjust the product, replace the product and design products for optimal performance throughout the entire horizon during which the client uses the product.

Although the framework presents eight options, there is no emphasis on picking a single type of offer, on opposing extreme customization and standardization, on dictating a single pattern of customer involvement. Hybrids become the norm, the extremes become the exception. Offer richness and fitness are keys in the personalization concept. For instance, a firm could offer popularizing, accessorizing and collaborating in one market and only tailoring in another market.

3. Demand and Supply Network of Golf Club Industry

To illustrate the Personalization Framework and its implication on the demand and supply network framework, we apply in section four the framework to the iron golf club industry. In this section, we prepare the reader to comprehend the application of the framework to the industry. First we present a brief overview of the industry which supports the growing need for personalized golf clubs. Secondly, we present the basic components of an iron golf club and some parameters that can be offered through the personalization options. Lastly, we present the manufacturing process of an iron golf head.

3.1 Golf Club Industry

The sport of golf has gained significant popularity over the past fifteen years due to high-profile professional tour players, the increased accessibility of courses and equipment, and the increased demand from an aging population. An impact from this trend is the increased demand for personalized equipment. The types of golf clubs used to play golf are ‘woods’, ‘irons’, ‘wedges’ and ‘putters’. These can be sold separately or in sets by most golf club manufacturers. The fierce competition in this industry has caused many original equipment manufacturers (OEMs) to focus on

their leading product and form partnerships, or purchase other specialized companies, to complete their product portfolio. Some examples from 2000 to 2003 are: Titleist buying Cobra for their low and midline product, Spalding buying Ben Hogan for their top line irons and then Callaway buying Spalding to gain market shares. Manufacturers are investing enormously in R&D to capture the increased demand for personalized, value-added products, which is a growing portion of the 2.4 billion US\$ market for all golf equipment (SRI International, 2002).

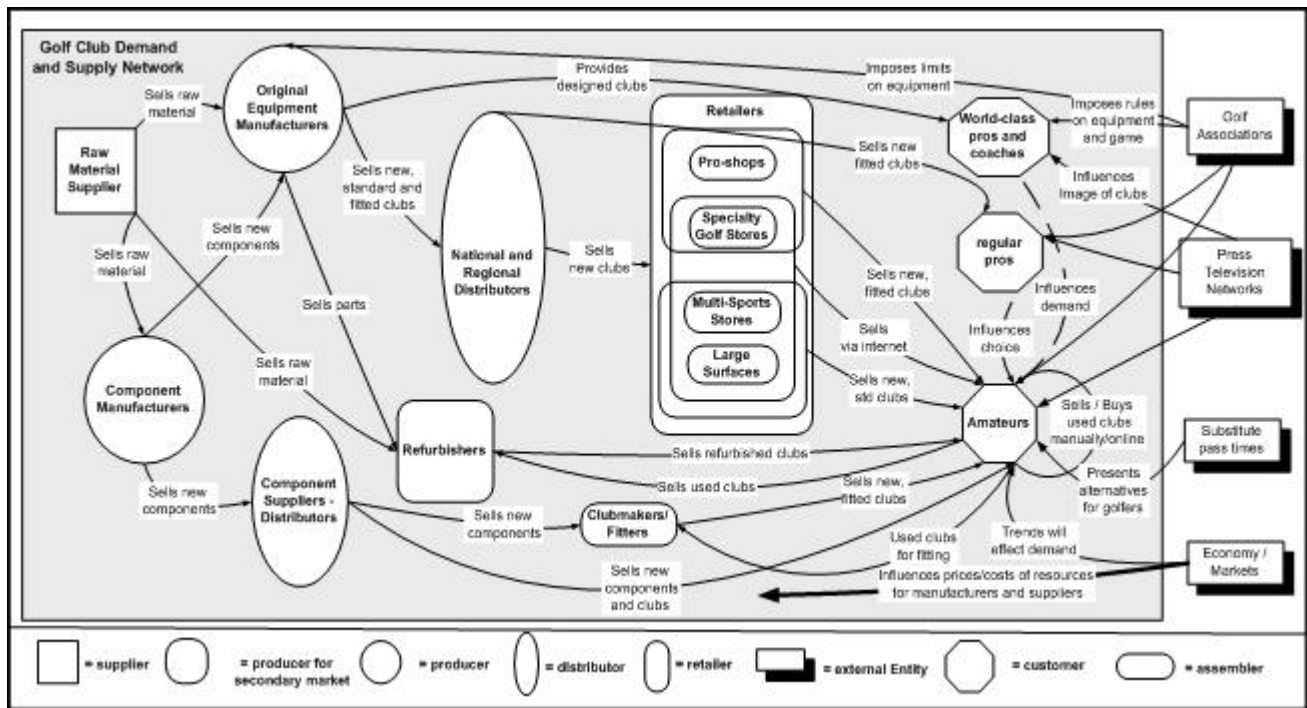


Figure 1: Demand and Supply Chain of Golf Club Manufacturing Industry

As illustrated in Figure 1, the demand for customized products comes from three groups of golfers: world class professionals, regular professionals and amateurs. Although the large majority of demand comes from amateurs, professionals have an impact on the product image and many world class pros participate in R&D activities for OEMs. Amateurs could be further subdivided into three groups: recreational players, friendly competitors, and serious amateur competitors. The majority of these amateurs value low to medium levels of personalized product but at an increasing rate, many value higher levels of personalization.

A key issue in satisfying demand is *fitting* the customer. Although manufacturers are improving rapidly, there is a lack of proper fitting tools and processes to find the appropriate product for a customer. Adding to this difficulty is the amateur’s inconsistent swing patterns and their lack of knowledge on what they really need to improve. Some manufacturers have developed solutions to address this problem such as online questionnaires, software and fitting equipment, yet there is much

to be done. What remains true in this industry is that customers demand various levels of personalized golf clubs.

Golfers can purchase golf clubs through retailers, clubmakers, component distributors, refurbishers or other golfers. Retailers can be classified in three categories. General sports stores (1) offer bottom line products at low prices. Although they differ in size and location, both, specialty golf stores (2) and pro-shops (3) offer mid to high end products. Delivery delay, price and personalization offers vary significantly within the last group. Clubmakers offer low to high end products, built to order at lower prices but with longer delivery delays. Customers can also build their own clubs by purchasing from component distributors. Refurbishers offer high end, refurbished products at reduced prices – but there are fewer choices and longer delays. Lastly, golfers can obtain low-priced used clubs from other golfers in their area, but the difficulty lies in matching a buyer and a seller. Intermediaries such as Ebay and Golfclubexchange.com have facilitated this process. Retailers are supplied from regional and national distributors, or directly from OEMs. Retailers offering mid to high end products usually buy a large quantity of products to be delivered at the beginning of the season and re-order a few times during the season. Highly personalized products are usually ordered as they are demanded and delivery time varies from 3 to 14 days, where some take several months for highly personalized clubs. Distributors usually hold inventory of popular products and components to increase service during season. Final products are assembled by clubmakers, component supplier distributors and brand named OEMs. Major brand name OEMs fabricate their major components and assemble the final products, but those that do outsource major components are usually supplied by the Orient. Due to the number of ways to satisfy customer needs for personalized products, firms will continue to be faced with complex design decisions for their demand and supply networks.

Firm must also pay key attention to external entities strongly influencing personalized offers such as the United States Golf Association (USGA) and the Royal & Ancient (R&A) that determine golf rules and limits on equipment specifications. Technology advancements have enabled firms to increase the performance of golf clubs but it has been constrained by the USGA, which modifies equipment rules in hope of retaining the integrity of the game. Finally, the media such as television, radio, and magazines highly influence demand by revealing the equipment used by leading tour professionals.

3.2 Description of Iron Golf Clubs

To convey the personalization concepts in this paper, the focus is put on the iron club market. As shown in part (a) of Figure 2 irons are constructed by assembling three main components: the shaft, the grip and the club head. The shaft is the long hollow component, usually made of steel or graphite, which fits the grip and the club head at opposite ends. The grip, made of rubber composites or leather, is a hollow tube that slides or is wrapped on the shaft and is held by a golfer in order to swing a golf club. The club head makes contact with the golf ball and is usually made of a metal alloy.

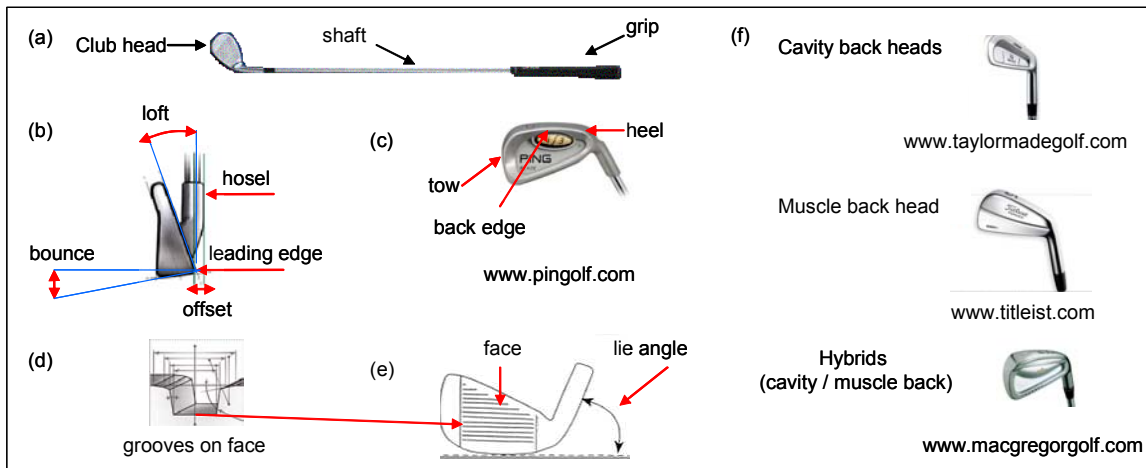


Figure 2: Description of iron golf clubs

Parts (b) to (f) in Figure 2 illustrate some parameters that can be personalized by golfers. Part (f) shows three common club head designs. Cavity back heads have weight concentrated on the perimeter of the club head providing more stability and forgiveness for golfers. Muscle back heads have weight concentrated evenly towards the bottom half of the back of the head which facilitates a golfer's potential to control the trajectory of the ball at the cost of losing consistency in distance and direction. Hybrids clubs have club head weight distributed between both of these extremes.

3.3 Manufacturing Process

The manufacturing process is comprised of making the three core components and assembling them together. This paper focuses on the construction of iron club heads, which is the most complex component of the club. Forging and casting are the two principal methods of constructing an iron head. Both methods have similar initial and final processes as seen in Figure 3. Both methods begin by *designing* a head, making samples and testing them. Once a design is selected, a *master head* is made to serve as the sample for further production of this type of head.

In forging, the master is used to create a die that is composed of two negatives of the master iron head, where each is an image of one side of the master. The dies are set in a press machine to stamp an ingot of iron into the rough shape of the master iron. The rough iron head is pressed again a few times by more precise presses until the head is quite close to its final shape. These secondary stamping operations are part of the raw forging process. The iron head then undergoes grinding and buffering to meet the desired specifications. Precise stamping then creates small engravings in the iron head that can not be done in the previous forging processes, such as stamping the club number, names and grooves. Throughout these final processes, there is intensive inspection and weighing done to guarantee specifications because once metal is removed, it cannot be added to a forged head. This makes the forging process quite labor intensive and more expensive than most casting methods.

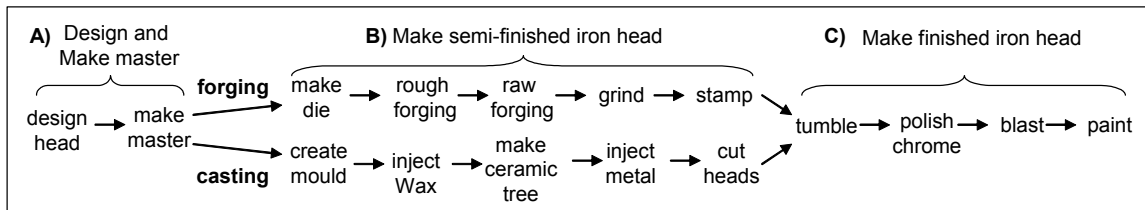


Figure 3: Manufacturing process for making iron club heads

As for casting, the master is used to build a mould which is also composed of two negative halves that form a tight block when joined together. Hot wax is then injected into this mould and when cooled, the wax takes the shape of the master. When several wax heads of the same mould are made, they are joined together with a metal frame to form a ‘tree-like’ structure, then dipped in ceramic slurry and left to dry. The wax ‘trees’, covered by a ceramic layer, are then heated to melt away the wax, hence leaving an empty ceramic tree. An extremely hot liquid metal alloy is then injected in the empty tree and it is left to cool slowly. The ceramic shell is then broken away and the metal heads are sawed from the tree to obtain semi-finished heads.

For both the forging and the casting processes, the semi-finished iron heads undergo a tumbling process to smooth out the surface. Depending on the type of iron, but especially with forged irons, they are then polished and chromed. The face is masked and sand blasted where the surface needs to remain non-polished and lastly, certain parts of the head are painted (www.swingweight.com).

Although the manufacturing process is relatively simple for the fabrication of a golf iron head, there can be many production options. Depending on the personalization demanded from a customer, it will be shown how many of the processes in Figure 3 could be influenced.

4. Personalization Framework Applied to the Iron Golf Club Industry

This section aims to allow the reader to grasp the essence and intricacies of the personalization framework through its application to the golf club industry. For each personalization option presented in Table 1, we describe its instantiation in the golf club industry. This is to prepare the reader to anchor the illustration of the impact of personalization on the demand and supply chain as described in section 5.

4.1. Option 1: Popularizing

With popular options, the firm offers a limited number of irons to match a wide range of customer needs directly off-the-shelf or with very fast delivery. For example, a firm could offer about three types of iron heads such as a muscle-back, cavity back and a hybrid model along with two popular shafts and two types of grips. This creates an offer of twelve iron types for each iron number in an iron set. Customers would expect to find all these irons in category killer retailers, selected combinations on the shelves of large retailers, and the most popular combinations in smaller stores or pro-shops. When not on the shelves of a specific retailer, customers would expect next day delivery or immediate availability in other nearby retailers.

4.2. Option 2: Varietizing

For this option, the firm proposes an extensive mix of irons to satisfy a wide spectrum of golfer needs. Golfers have the impression that there is an iron to satisfy every need even if it is not entirely the case. In the golf industry, this could mean offering about ten more types of iron heads, shafts and grips, bringing the number of final combinations in the thousands compared to a dozen in the popularizing example. With such an offer, golfers recognize that not all combinations can be stocked locally in a retail store, so they would tolerate a few days for delivery.

4.3. Option 3: Accessorizing

When selecting the accessorizing option, a firm offers a variety of core irons that may be accessorized. There is usually a wide variety of final products due to the potential combinations between core products and accessories. Simpler levels of this offer consist of supplementing a functional core product, such as engraving the customer's name on the club, adding a special head cover, changing the packaging or adding a vibration dampener in the shaft. In the case where the core product is not functional on its own, accessorizing could involve selecting a basic component such as a head, shaft or grip. For accessorized irons, golfers still expect relatively short delivery

times since they perceive that the required processes are simple and are done late in the manufacturing process.

4.4. Option 4: Parametering

This offer permits the customer to adjust design parameters of an iron, indeed setting its “genetic code”. Due to the extent to which some parameters can be changed, this option is subdivided into: *configuring*, *adapting*, and *transforming*. Customers are willing to tolerate longer lead times depending on their perceived complexity of personalization offered.

According to a *configuring* offer, a customer configures a club by selecting major components, such as the type of shaft and grip, amongst a large pre-determined set provided by the OEM. It could also include the setting of some parameters for these components such as their color. *Adapting* involves varying the dimensions of a component within certain bounds set by the firm. For instance, the loft and lie of an iron head could be modified within a certain range of degrees, or shafts could be cut to various lengths. Lastly, *transforming* allows a customer to change the design of key components upon technical and style approval. Although components can be redesigned slightly, they cannot be added or removed to fundamentally change the final product. Some examples include: selecting different metal alloys for the construction of the iron head, grinding the heel of the iron head, and selecting the shape of the grip. This offer resembles *tailoring* in option 5 but the distinction is that the customer is still selecting certain parameters, rather than freely designing the product in tailoring.

4.5. Option 5: Tailoring

Tailoring permits the customer to design an iron according to his specific needs. The firm must guide the customer to respect product integrity in terms of design, performance, quality and aesthetics. Customers are definitely willing to accept longer delays as long as they perceive development progress and delays restrained within a few months. Examples of tailoring would have a customer decide how to distribute the weight in the cavity of an iron head to correct specific, personal miss-hits. A second example would be to modify groove design to modify spin imparted on a golf ball at impact.

4.6. Option 6: Adjusting

Adjusting is the first personalizing option that involves a post-sale process. It focuses on a customer’s need to modify an iron after playing with it for some time. It does not refer to correcting

errors from the initial purchase but rather a continuous adjustment of the iron to improve playing performance. For example, a golfer taking golf lessons from a professional following his recent purchase of irons might improve his swing enough that his new irons are not the optimal set for his improved swing. This could be fixed by slight adjustments such as bending lie angles or more important changes such as changing the shafts for stiffer ones. The adjustments should not involve major design processes.

4.7. Option 7: Monitoring

A monitoring offer aims to monitor the playing performance of a customer with the intention of suggesting product alterations, complementary or new products that could better fit his needs. The firm needs to keep contact with the customer to monitor his progress such as by obtaining golf scores and by oral/written questionnaires via sales representatives and internet tools. The key lies in obtaining enough data to capture changing needs be it in performance or playing objectives. For instance, a firm could notice that a customer's accuracy with his new muscle back irons is decreasing and that he would benefit from new hybrid irons that would correct his most common miss-hits. Depending on the arrangement, the customer may pay a monthly fee allowing free-of-extra-charge for changing the iron, or rather have access to a pre-negotiated discount when he decides to actually make the proposed change.

4.8. Option 8: Collaborating

With a collaborating offer, the firm treats the customer as a long term client. Their aim is to optimize the performance of the customer over the long run. This objective translates to planning the equipment changes so as to maximize performance while respecting customer constraints, which are usually in terms of financial resources, time and the ability to change equipment. A close, trusting relationship needs to be developed with the customer to obtain feedback on performance and financial changes. The firm relies on high tech fitting equipment and trained professionals to analyze the customer's game at strategic intervals in time. This could even imply having the customer being fit at a factory, R&D center, or by field units. The firm seeks to make the processes as smooth as possible for the customer, for example taking responsibility for taking back used products with little or no hassle. This relationship between a firm and a golfer resembles the one between a touring professional player endorsing the products of the firm except that the pro has a much clearer picture of his needs than the typical golfer and he plays a larger role in product design with the R&D department.

Although these personalization options were presented separately, we maintain that firms should combine and adjust these complementary options in a holistic offer optimized for their specific context. Currently, most leading golf club manufacturers offer at the most, a few personalization options. The key to offering multiple options is to fit the price, delivery delay and personalization level with customer needs in each market segment. To attain this fit, a firm must first understand the offers' implications on several aspects within its demand and supply network.

5. Implication of Personalization Offers on the Demand and Supply Network Processes

There is hardly any doubt that a golf club manufacturer would become more competitive by offering and efficiently delivering a comprehensive personalization offer combining the various options presented in the previous section. In fact, the leading manufacturers who have expanded their offer for personalized golf clubs have gained market shares and popularity among professional players. However, offering personalized products implies major changes for the firm.

A manufacturer needs to determine what is valued by the market, whether it has the necessary capabilities to support its offer and whether its offer is profitable. This is common reasoning in the domain of strategic management but there are particular challenges in accomplishing this goal for personalized offers. At first glance, it might appear impossible to support all personalization options concurrently, and it might well not be the most profitable strategy. However, before knowing if it has the necessary capabilities to support an offer, it is critical that a firm realizes the implications of supporting specific combinations of different personalization offers. These implications will be discussed in this section.

Essentially, this section presents the key issues that should be addressed when designing the main demand and supply network processes for the iron club industry. First, it discusses the appropriate management policies and process characteristics for each main process in the network, with regards to each personalization option. Secondly, it presents how the personalization offers affect the resource requirements in the network.

5.1. Impact on Key Processes of the Demand and Supply Network

The recommendations for each key process in function of the personalization offers are summarized in Table 2, where each row refers to a personalization offer and the columns to a key process. To illustrate these recommendations, the iron golf club industry is adopted.

The first key process in Table 2 is the management of the supply network for material and components to make iron club heads. This process is critical to respect delays and reliability of deliveries since it can affect all processes down the supply chain. A common strategy for many U.S.A. based OEMs who outsource the production of their iron heads is to locate themselves on the southern coast of California simply to reduce transportation time and variability of deliveries from suppliers in Asia. The trade-off to consider with suppliers is either to order fewer but larger orders to benefit from economies of scale versus ordering more frequently but smaller orders, which lowers inventory costs and reduces dependency on forecasts that could lead to high stock levels at the end of a season. Ideally, supply should be synchronized with production but stock buffers may be needed for suppliers with longer and/or unreliable delays.

	Supply	Design, make master head	Make semi-finished head	Make finished head	Assemble club	Distribute club	Retail club
Popularizing	synchronize on forecast	rare, stable, strategic, forecasts	low mix, large vol, forecasts	low mix, large vol, forecasts	low mix, large vol, QR	stock rapid repl.	display/stock rapid repl.
Varietizing	synchronize on forecast	rare, stable strategic forecasts	large mix, average vol, forecasts	large mix, average vol, QR	large mix, average vol, QR	stock rapid repl.	display/stock rapid repl.
Accessorizing	synchronize on forecast of core & acc	rare, stable strategic forecasts	average mix, average vol, forecasts	average mix, average vol, QR	stock / synch repl. of acc & core compo.	stock core & acc, rapid repl.	acc. display limited stock core & acc club specs
Parametering	buffer for pop., QS2O	rare-unique, variable, forecasts/M2O	large mix, low vol, forecasts	large mix, low vol, QR	large mix, low vol, QR	no stock low vol QR	sample display no stock, ordering guide
Tailoring	QS2O, R&D cooperation	unique, unpredictable	infinite mix, unique	infinite mix, unique	infinite mix, unique, QR	no stock unique, QR	design guide, sales rep. R&D pers.
Adjusting	QS on customer feedback	rare, slightly predictable	low mix, very low vol QR	large mix, low vol QR	large mix, low vol QR	no stock low vol QR	ordering guide retailer sales rep.
Monitoring	forecast synch customer feedback	rare, predictable	average mix, low vol, QR	average mix, low vol, QR	average mix, low vol, QR	no stock low vol QR	adjust. guide, e-tools, sales rep.
Collaborating	R&D synch, customer collaboration	occasional, very predictable	large mix, low to unique QR	large mix, low to unique QR	large mix, low to unique QR	no stock unique, QR	inter. guides fitting equip. R&D pers.
<p>Key: acc: accessory, adjust: adjustment, inter: interactive, pers: personnel, pop: popular, rep: representative, repl: replenishment, specs: specifications, synch: synchronization, vol: volume</p>							

Table 2: Impact of personalization options on demand and supply network processes

When popularizing, varietizing and for some parametering, orders could be synchronized based on forecasts of iron demand since product variety is not too large and forecasts can be reliable enough to expect low levels of inventory at the end of a season. For accessorizing, orders should be

based on separate forecasts of core products and accessories since when taken separately, there is a relatively small number of each product type even if there is a large number of final products. Due to the wide variety of products when parametering and tailoring, manufacturers should carry almost no buffer stock, but rather seek suppliers supporting quick-supply-to-order (QS2O). Clearly, less frequent, small orders will tend to increase consumer prices but it is necessary to respect quoted service levels. Supply for adjusting and monitoring should be based on customer feedback and should also be supported with QS2O. When collaborating, since the final customer is involved in defining the components, the manufacturer should look for suppliers offering quick delivery times for newly designed components.

For all personalization options except for tailoring and collaborating, the design of the master iron head is done once per type of iron head. The fabrication of the master is done rarely since it is needed only for initial production and then for replacement due to deterioration from producing a certain amount of heads. It is only during some cases of transforming and tailoring that designs and master heads are produced once per client. For tailoring, these initial processes occur sporadically and are rather unpredictable. However, with the last two personalization options, the needs for these processes are more predictable due to the close and frequent customer interaction that exists, especially when collaborating.

For the processes involved in making semi-finished and finished iron heads there are significant differences in product mix and volume amongst the personalization options, as well as the ability to predict demand. Due to extensive seasonal effects and the probabilistic nature of demand, popularizing relies on forecasts to produce large volumes for a low mix of semi-finished and finished heads. Due to the larger product mix in varietizing and some parametering options, both make-to-stock (M2S) and make-to-order (M2O) policies may be adequate. Accessorizing is situated in between popularizing and varietizing in terms of product mix and volume depending on the number of accessories, hence their recommended policies could vary accordingly. Tailoring involves fabrication of unique iron heads for both processes and these should only be M2O. Since adjusting does not involve major equipment modifications, there is a low mix and volume of semi-finished iron heads for this level of personalization, but there is a greater mix and volume of iron heads for finishing processes. Monitoring has an average mix and low volume in both processes since personalization adjustments could equally affect both processes. Collaborating involves a large mix, but low to unique volume for each iron type. These three options must rely on M2O policies and

design-to-order (D2O) for collaborating offers. For personalization options having a large mix of finished iron heads, quick response (QR) policies (Suri, 1996) may be adopted to quickly send components to the place of final assembly and then directly to the customer.

The assembling process is influenced similarly as the previous two processes with regards to the product mix and volume. QR strategies are adequate for popularizing, varietizing and some parametering to satisfy response time requirements. When accessorizing, stock of iron heads, shafts and grips are kept for assemble-to-order (A2O) policies, which should be supported by synchronized replenishment of these accessories and core components. For the remaining personalization options, the product characteristics and management policies remain the same as for making finished products, except that M2O is not relevant in the assembly process.

The key issues for managing the distribution of iron clubs are the inventory and replenishment policies. Popularizing and varietizing require stock levels to support rapid delivery and replace iron clubs as they are removed 'off the shelf'. Both may gain from having locate-to-order capabilities. Accessorizing requires the same policies for both core products and accessories. The success of these offers relies heavily on rapid replenishment. The remaining personalization options do not stock irons since they all imply M2O. Consequently, they require QR techniques for quick delivery from the point where the iron is finalized.

For the retailing process, popularizing offers requiring zero delivery delay implies that irons should be available off-the-shelf or, displayed and stocked at the retailer. Since varietizing involves many more types of irons, only a small portion of final iron clubs will be displayed at each retail outlet. Irons displayed should reveal the largest number of components and options that can be ordered. For accessorizing, although there can be large number of final products, retailers stock a limited number of final products, core products and accessories to illustrate the potential combinations of final products. Similar to accessorizing, the remaining offers do not stock final products except for sample irons and components for demonstrating parameters which will facilitate the ordering process. From product guides to interactive fitting equipment, from sales representative to R&D personnel, tools must support the retailer in function of the level of personalization offered to the customer. Matching the appropriate personalized product with a customer's specific need is critical to the success of personalized manufacturers.

Figure 4 illustrates the impact of a personalizing option on the production and inventory strategies in the demand and supply network of a firm. The personalization options offered to customers are

located at the top of Figure 4. The dotted arrows below these options indicate which processes are affected by customer orders. For instance, with the varietizing option, two cases can occur. If the customer selects an iron club that is located at the retailer then his order affects the retailing process. However, if he selects a club from a varietized offer that is not located at the retailer, his order affects the distribution process. In other words, an iron club will be stored within the distribution network and it will be transported to the retailer only when the customer places an order for that iron club. As is illustrated, some options affect only one process while others can directly affect up to four processes with regards to customer involvement.

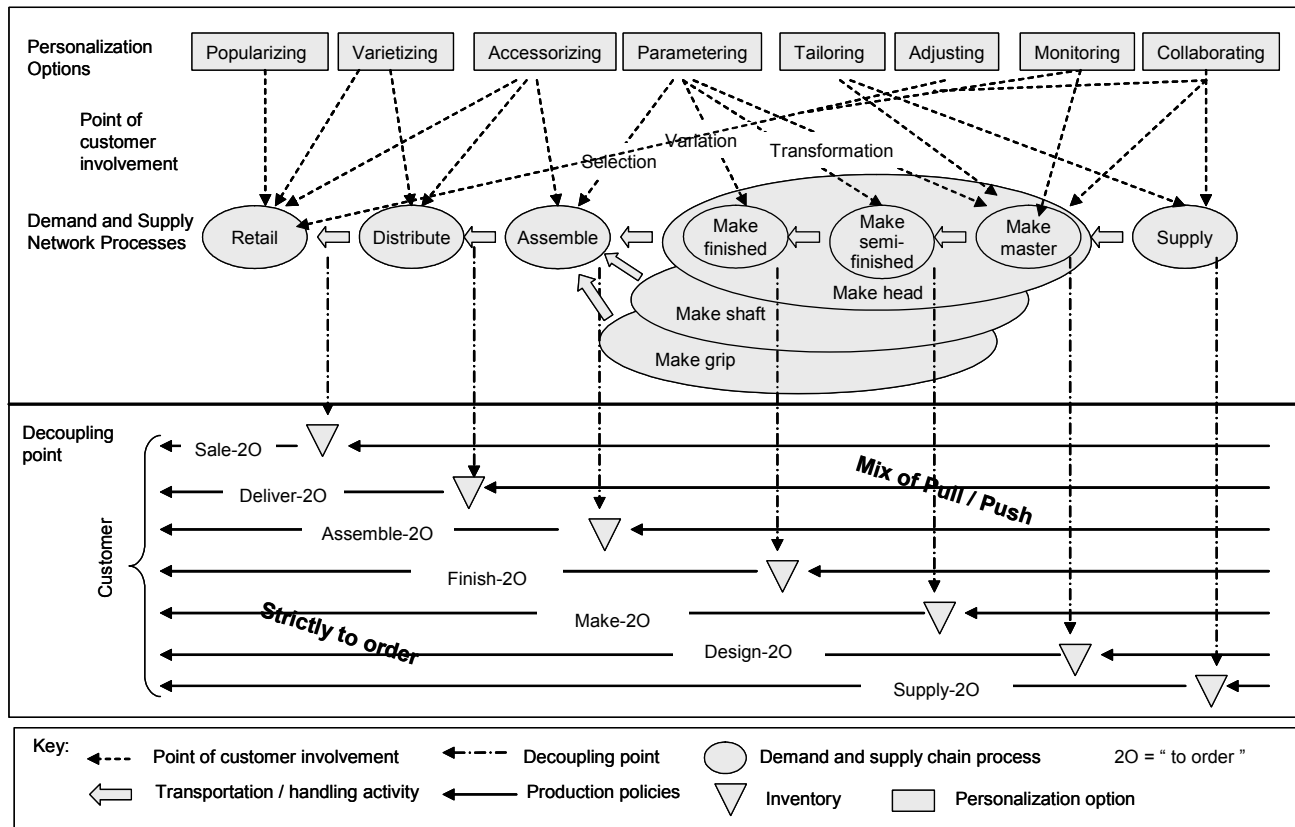


Figure 4: Point of customer involvement and decoupling point of personalized offers

The bottom part of Figure 4 illustrates the decoupling point (Alwis et al., (2001) in the demand and supply network. The decoupling point refers to the process that creates the personalization of the product. It can also be referred to as the postponement point or where the product is differentiated. Hence, the inventory at the decoupling point consists of standard products or components ready to be personalized by a customer order. The objective is to reduce total manufacturing costs, which mainly consists of inventory and physical resources while respecting delivery times. Due to the wide variety of final products after the process at the decoupling point, it would be much too costly to hold

inventory of all products. The strategy is to have minimal variety before the decoupling point through modularization strategies so as to minimize inventory variety and hence, inventory costs. However, this strategy implies resources at this process can provide throughput times quick enough to respect quoted customer service rates. For instance, at the assembly process, and for parametering offers, the strategy proposes there be an inventory of components (heads, grips and shafts) that the customer can parameterize within the limits of a firm's parametering offer. If the offer consists of selecting from a set of 10 heads, 8 grips and 30 shafts, then these components will be stored in inventory until there is a customer order rather than to store a few hundred different final products. For this process, it may be appropriate to adopt a production strategy of "Assemble-to-order". Note that for popular products, a different strategy is used at this process. Due to the limited variety of final products and high service rates offered by the firm in the popularizing option, the assemble process for popular products can follow either a push or pull strategy. A key element is that the products will be assembled prior to customer orders whereas it is not for parametering offers.

The figure also suggests that beyond all decoupling points, the strategy is to strictly adopt "to order" strategies. However, prior to the decoupling point, a pull or push strategy could be used to produce products for stock based on forecasts.

5.2. Impact on Resource Requirements

Once a firm investigates the impact of various personalization offers on its demand and supply network processes as demonstrated in the previous section, a secondary challenge is to determine optimal resource requirements to support process requirements. This investigation will directly influence the processes that will be adopted.

With regards to capital investment in equipment such as machinery, personalization offers influencing the early production processes tend to have the greatest financial impact. The assumption made is that depending on the personalized offer, the point of customer involvement will vary in the manufacturing process, and this point will directly influence the production strategies. Often, the point of customer involvement will be the point where product variety increases significantly in the manufacturing process and consequently, it is often financially advantageous to hold lower levels of inventory for final products at this point. In other words, manufacturers will tend to finish the product only when there is a customer order, which implies either D2O, M2O, A2O, or F2O policies. Furthermore, these policies usually require more resources since throughput can only be satisfied by production resources and not inventory of final goods. Since there will more product variety over

shorter periods, requested with short delivery times, changeovers increase and production batches decrease.

Consider the personalization offer where the customer can modify the design of the club head. Modifying the design of a club head requires specialized human resources for designing and testing heads, and raw material to make a distinct master head for each design. These processes can only be done once a customer orders a product. However, it does not always imply that as the point of customer involvement occurs earlier in the fabrication process it will lead to higher resource costs. The fabrication of semi-finished iron heads, which occur midway in the fabrication of iron heads is an example of a process requiring costly resources such as industrial-sized ovens, molding systems and large floor space. Nonetheless, it is often the case that final processes do require lower resource costs such as the process of creating finished iron heads.

Determining optimal resource needs implies that a firm must also investigate other interrelated issues such as the orientation of a production center, the resource layout and the production policies. Suppose a firm wants to offer all personalization options in a specific market and it seeks to determine resource requirements for a center producing the iron heads. The center could be organized in various ways from offer to process oriented. For instance, a center could have all resources required to fulfill a specific personalized offer or to conduct a process for one or more processes. It could also opt for one, flexible production line or many distributed production centers. Simultaneously, it needs to address inventory, scheduling and handling strategies. One can clearly see there are endless possibilities in configuring resources to support a personalized offer. The challenge of a firm is to minimize resources costs while satisfying all personalized offers with regards to throughput, and quoted service levels.

6. Conclusion

Our work was motivated by the fact that there is a growing demand for personalized products and that for certain firms, fulfilling this need is becoming a matter of survival and prosperity. The paper has attempted to convey the different personalization options that can be offered and combined for the iron golf club industry. The first few options are offered to the mass accompanied with high service rates and short delivery delays. For highly personalized options, customers are involved earlier in the manufacturing process and they expect higher prices and longer delivery times. The key for manufacturers lies in the ability to offer the appropriate blend of personalization options and to

support it through a well designed demand and supply network, so as to concurrently deliver excellent value to shareholders, partners and customers. In the short term, the model will be validated with a key OEM in the golf club industry.

This paper sets the stage for quantitative analytical methodologies to (1) evaluate the impact of proposed personalization offers on the demand and supply network, (2) design (transform) demand and supply networks given strategic intent in terms of personalizing, and (3) develop sets of personalized offers given the demand from the market and the capabilities of the firm in terms of adapting its demand and supply network.

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References

- Alwis, A., C. Mchunu, and J. Efstathiou (2001), Methodology for Testing Mass Customization Strategies by Simulations, *Working Paper*, Manufacturing Systems Research Group, University of Oxford.
- Davis, S. (1987), *Future Perfect*, Addison-Wesley Publishing, Massachusetts
- Duray, R. (2002), Mass customization origins: mass or custom manufacturing? *International Journal of Operations Management*, 22, 3, 314-328
- Duray, R., P. Ward, G. Milligan, and W. Berry, (2000), Approaches to mass customization: configurations and empirical validation. *Journal of Operations Management*, 18, 6, 605-625.
- Kotha, S. (1995), Mass Customization: implementing the emerging paradigm for competitive advantage”, *Strategic Management Journal*, 16, 21-42
- Mallonée, M. SRI international, (2002), <http://www.sri.com/news/releases/11-14-02.html>
- May, M. (2002), Golf: Play Is Steady While Sales Struggle, *SMGA International*, www.sgma.com
- Montreuil, B. and M. Poulin (2002). Demand and supply network design scope for personalized manufacturing, submitted to IJPPC
- Pine, B.J. II (1993), *Mass Customization: The New Frontier in Business Competition*, HBS Press, Massachusetts
- Poulin M., Montreuil B (2003), *Implications of Personalization Offers on Demand and Supply Network Design : A Case from the Golf Club Industry*, IEPM2003, Porto, Portugal
- Suri, R. (1998) *Quick Response Manufacturing: A Company Approach to Reducing Lead Times*, Productivity Press, Oregon
- Swingweight.com, www.swingweight.com