



**SAVONIA**

# **ON DEMAND PRODUCT DEVELOPMENT CUSTOMIZED FOR PRODUCTION**

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<p><b>Abstract</b></p> <p>The ultimate intention of this thesis was to analyze the present product development and production process at the client organization and to develop methods to improve the agility of the product development and production process. Thus the organization can be ready for on demand product development and corresponding customization in production by maintaining enough agility. The overall study will help the organization to comprehend the present process improvement potentials and guideline to improve those drawbacks.</p> <p>The research work concentrated on two major issues, e.g. product development and production. Preliminarily basic product development process is studied and later on it has moved to more specific area, the apparel product development. "No Interval Coherently Phased Product Development" model was adapted as the basic framework. Some other methods like concurrent product development, agile production method, relationship in supply chain management etc. were also studied in parallel. Later on, collected data based on interview questions and sales data of the client organization is analyzed and connected to the theoretical framework. The data lead to some findings that are presented as recommendation.</p> <p>This work emphasizes on time management in the processes and perceived that, it is the key towards "On Demand" service stance. The achievement of required agility in the product development and production process are connected to proper time management, a few changes in the working methods, a few improvements within the supply chain partners, reduction in quality faults etc. Implementation of these small improvements will lead to an efficient apparel processing that could also help other firms to apply the improved methodologies. It is to be believed that the study work and recommendations will be also useful to similar kind of organizations.</p>			
Keywords On demand product development, agile production, customized production, concurrent product development			
Public			

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## ABBREVIATIONS

AM	Agile Manufacturing
CIC	Core information compilation
CP	Centralized purchase
CPD	Concurrent product development
CM	Cellular Manufacturing
GT	Group Technology
JIT	Just-in-time
NICPPD	No-interval coherently phased product development
NOS	Never out of stock
PD	Product Development
PM	Product Manager
SCM	Supply Chain Management
SS	Salesman sample
WIP	Work in progress

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## 1 INTRODUCTION

The ever changing nature of fashion world and versatility of consumer preference intensifies the competition in clothing business. The easiness of producing the products in terms of know-how and widespread facilities throughout the globe has intensified the competition even more. Moreover, prediction and trend analysis cannot serve as the dominating tool for forecasting the upcoming business situation, but anticipating the needs of the consumers. Thus there is no more alternative than putting the organization towards specialization and concentrate on core competence. Particularly, the firms those are lying in expensive labor arena, they have to do something exclusive in order to confront the tough pressure from the less expensive resources. Developing joint collaboration with the customers as well as with the suppliers in product development phase and “On Demand” development of product with enough agility could be the success factor in today’s world. The key is to react fast and efficiently with the market demand. This study puts significant effort towards potential of process improvement in PD and production.

“On Demand” efficient product development circumstance allows firms to confront the challenging situation exerted by the business environment with intensive competition. Of the many profound changes to which businesses must respond to succeed in today’s turbulent climate, none is more difficult, more perilous, or more vital than being customer-focused (Pine, 1997, p. 3). More specifically, the fashion business is more intensely customer dependent. A continuous product development effort throughout the year is desired to satisfy the consumers’ need that varies from season to season, as well as it will satisfy regular needs.

However, it is not enough to perceive solely the consequence of product development, but a comprehensive understanding of promptitude production and synchronization with product development is also significant. Traditionally, the attitude of designers has been “We design it, you build it” (Boothroyd, Dewhurst & Knight, 2010, p. 8). But this approach is not any more favorable in context to the present business world. By aligning product development and production, agility can be achieved which is the precondition for effective service. By agile we mean that the company can quickly respond to market change by quickly reengineering its business process, reconfiguring its manufacturing systems, and innovating its products (Salvendy, 2001, p.527). By adapting coordinated agile product development and production systems firms can organize and prepare for fast reaction.

The intensity and pattern of the global business competition has altered remarkably. Especially it is more appropriate for the products that bear a short life cycle. Fashion products fall under such category. As prediction plays a less important role in the volatile business environment, firms can be prepared with on demand agile systems to respond to the situation.

### 1.1 Statement of the problem

Most industries today operate in a turbulent business environment and an increasingly turbulent global marketplace impacts on organizations more and more (Male, 2003, p.129). Clothing industries are particularly vulnerable to volatile environment. As these kind of firms deal with the products of relatively short life cycle, high volatility in such market is generally exists and this volatility ultimately results lower predictability on market condition. Hence forecasting often fails to provide a secure direction. Indeed, firms have to be flexible by considering the functions accountable for turbulence. Generally it has been found that the simplicity of the organization's strategic orientation and its ability to innovate, improvise, change, adapt and experiment has a direct impact on how well it will function in a turbulent business environment (Male, 2003, p.130).

Nevertheless, to settle upon an appropriate method is not that naïve. There are many methods, that have emerged in terms of managing production techniques in the last few decades like Just in Time, Lean, Agile etc. These many options have exerted more challenges while choosing the applicable method in clothing industries with particular properties. This study is limited to JIT and Agile to set latitude in research work. It had a wide influence to the entrepreneurs when "Just in time" and "Lean" ideas were initiated. Lean could be characterized in short as "doing more with less" (Putnik, 2012). On the contrary, Agile Manufacturing is a relatively new concept while compared with Lean. AM is characterized as being able to meet volatile business requirements with adaptability (Flumerfelt, Siriban-Manalang, & Kahlen, 2012). However, the foremost thing is to maximize the gains by satisfying the customer which will help the enterprise to grow more. When the day is done, manufacturing professionals all seek the same thing – gaining a larger share of our market using manufacturing as a market differential (Hobbs, 2004).

The concept of agility (flexible and quick responsive manufacturing) will reduce time to reach market with appropriate products / services (Gunasekaran, 2001, p.V). This

is the approach that particularly demands by the clothing manufacturing business. Responsiveness is the key thing and therefore entire supply chain's participation and preparation is critical. The firm cannot act individually in reaction to the demand without the assistance of the supply chain partners. With a proper integration of the components of the supply chain all parties will be benefited, which will result in lower product price. Ultimately that will make the product more competitive. However, product price is not the only winning criteria while competing in a volatile market. Competition basis, which used to be the product's price, has moved to quality, delivery time, and finally customer choice or in a more exact way, customer satisfaction (Sharifi & Zhang, 1999). Although customer satisfaction is probably one of the most important factors, it is itself quite vague to distinguish the satisfaction of the customer. Customer satisfaction is the ultimate result of the effort from PD which is ready for "On Demand" approach and an agile production system with the assistance of an effective production planning and scheduling system. This study particularly inquires the method of entire process from product development to production and finds out the points of interest where necessary upgrades should be made to meet the changes in the business environment.

## 1.2 Purpose of the study

The research work is aim to analyze "On Demand" product development customized for production, implies that an apparel company prepares for immediate response from the customer or market and is able to process it from preparation of PD until release from production through proper organization and planning. A successful study will be able to evaluate the current situation about the agility in PD process and rapidity in reproducibility during production of apparel products. The fundamental research questions that the study is based on:

1. What is the present method of PD and reproduction method of developed apparel products in production?
2. What impedes the smoothness of the entire process?
3. How to smooth out the flow of the process to react agilely to the "On Demand" PD and production of apparel products.

More precisely the study diagnoses how the factors influence the AM or suppress the quick reaction of the process. Exclusively, the research work tends to support the

improvement of the present product development and production process of the case company where this study has been centered.

### 1.3 Assumptions

The study conducted to the case company based on the researcher's experience and familiarity about the plant, process and participants in research. Besides this, it has been assumed that:

1. Professionals taking part in the research work through interviews possess adequate knowledge on PD, production and the overall process from PD to production.
2. Participants provide professional opinions and information and they have enough experience on their area of expertise whether it is in PD or production or some other departments.
3. It is assumed that the outcome of the research will be able to assist the firm in updating the present method and also will be applicable to some other firms that consist of similar processes, structures and products.

### 1.4 Limitations

Product development process and nature of development of apparel products largely depend on the type of the products, whether it is a fashion product, basic product or falls under some other category. So, a particular method for developing a product cannot be followed by many firms. The study was conducted by knowing this fact as well as the following:

1. The study is conducted only in one site and thus investigation is done on limited PD and production process. It could be useful if the research work could include some more processes or firms. But it was not possible due to the non-availability of similar kind organizations nearby.
2. All the data through interviews is also collected from a single site. So the suspicion of narrowness of data and information is not baseless. For the same reason the number of participants was also quite limited, a better number could make the information collection more affluent.

3. The overall views of the organization of the processes are centered to a specific geographical area. Information on studying on rest of the part of the world could make the study more versatile in approach towards findings.

The single location, limited participants and process left the study towards possible biased outcome. The possibility will remain, although precautionary actions are taken.

### 1.5 Entire study at a glance

On Demand Product Development and thus production is an aligned approach of integral product processing with agility in each step. To analyze the potential of the topic, the research work has followed a sequential organized way throughout. To understand precisely the PD method, existing literatures was reviewed. Stage gate process and Next Gen Stage gate were reviewed first to comprehend the general PD process. Thereafter, “No-Interval Coherently Phased Product Development” model for apparel was examined to get a profound knowledge on PD for apparel products. Once, a clear understanding on PD was accomplished, observation on reproducibility in production and agility during production was studied. The overall agility of PD and production greatly depends on the participation of other associates. The connection of the fact was reviewed too. The following chapter discusses the methodology of the research work. Detailed description of the data collection and analysis process is presented. After that research data and analysis are presented and discussed. In the end, conclusions are drawn of the research work including the guideline and possibilities for future study.

## 2 LITERATURE OVERVIEW

Product development is an endless run which helps an organization to move forward. PD demand in apparel industries is even more expeditious. It guides the firm to develop new apparel product range followed by a season. Also private labels urge to act in PD and production swiftly which is even more challenging. Following an effective product development method is the key. The process of developing products is complex and is influenced by many factors, including customer needs, market trends, cost, technology, timing of product introduction, and good old-fashioned human creativity and innovation among others (Fiore, 2005, p. 4).

Typically trend forecasting is the base for apparel firms to extract the demand of the consumers. But the rapid change in consumer desire and demand in today's world made it difficult to identify the right trend. So apparel companies must remain responsive with the market demand to be successful and this responsiveness allows an organization to fulfill the immediate demand. On Demand Product Development ability with agility is the key to success and it could be the core competence of an apparel firm. The main PD phases are illustrated in FIGURE 1.

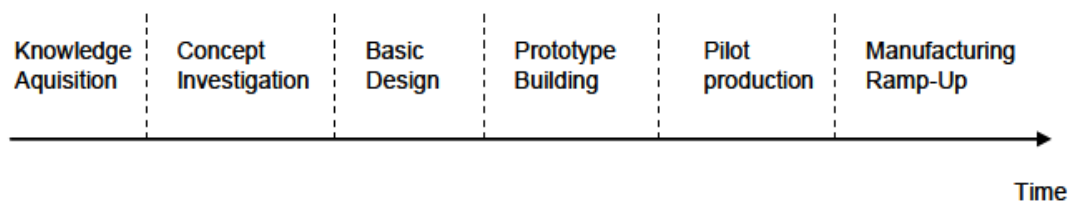


FIGURE 1. The main product development phases by Hayes, Wheelwright and Clark (adapted from Paulin, 2006).

### 2.1 Product innovation models

A manufacturing company often needs to develop new products or improve the existing products. Rapid changes in economy and consumer behavior demand an even more frequent and efficient PD. Usually the PD process consists of a series of steps. The new product development process is a series of interdependent and often overlapping stages during which a new product (or process or service) is brought from the idea stage to readiness for full-scale production or operation (Monckza et al., 2000, p. 4-5). It is important to align those processes for agile product development and successful transfer towards production.

In terms of apparel product development for apparel firms, PD is an almost continuous process. Typically, there are two different types of product development procedures are common for the apparel firms. Apparel products are developed as a part of a product range for a specific season to present to the customers and direct product development request from the customers, commonly by private label customers. The main objective of this chapter is to present elaborately the methods of product development and to attain an understanding of the agile and optimized product development of the apparel firms. Though the emphasis is mostly on analyzing and optimizing the apparel product development based on the available PD models, the general product development methods were studied too.

### 2.1.1 Stage gate<sup>®</sup> process

The main reason to pick up the stage gate<sup>®</sup> process for reviewing the product development models is due to its clarity and simplicity of presenting the PD process. The Stage gate<sup>®</sup> process is a series of steps followed in an innovation process designed by Cooper (2001) as illustrated in figure below (FIGURE 2). This is a widely accepted process followed by many organizations around the world.

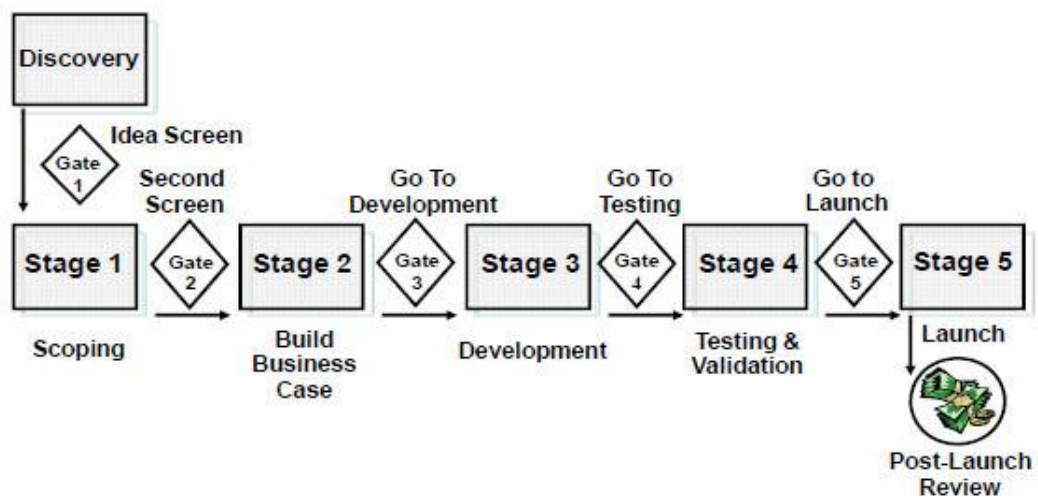


FIGURE 2. An overview of a Typical Stage gate<sup>®</sup> system for major new product development processes (Cooper, 2001).

A Stage-Gate<sup>®</sup> process is a conceptual and operational map for moving new product projects from idea to launch and beyond – a blueprint for managing the new product development (NPD) process to improve effectiveness and efficiency (Cooper, 2008). The aim is to help companies to develop products in a simplified way by dividing the

activities in distinct steps. Each step consists of structured actions. In the Stage-Gate process, each phase (called a stage) is separated by a decision point (called a gate) (Levine, 2005). Individual steps pass through the gate with an evaluation process. If it passes through a gate after evaluation, it will move to the following step. The gates work as a checkpoint for “go” or “kill” decision. The evaluation process in each gate usually follows some pre-determined criteria.

Stage gate<sup>®</sup> process basically assists the PD activities to align in a constructive way. The product development process of a specific company might not need to change much for adapting the Stage gate<sup>®</sup> model, but with a few adjustments. Typically PD activities are divided to some stages. A Stage gate<sup>®</sup> process will align those activities with transparency. Thus it will be able to improve the process agility and reduce the expenses.

### 2.1.2 Next Gen Stage gate<sup>®</sup>

It was already discussed that the Stage gate<sup>®</sup> process divides the innovation process into series of stages from idea to launch. Perhaps the greatest change in Stage-Gate over the last few years is that it has become a scalable process, scaled to suit very different types and risk-levels of projects – from very risky and complex platform developments through to lower risk extensions and modifications, and even to handle rather simple sales force requests (Cooper et al., 2005).

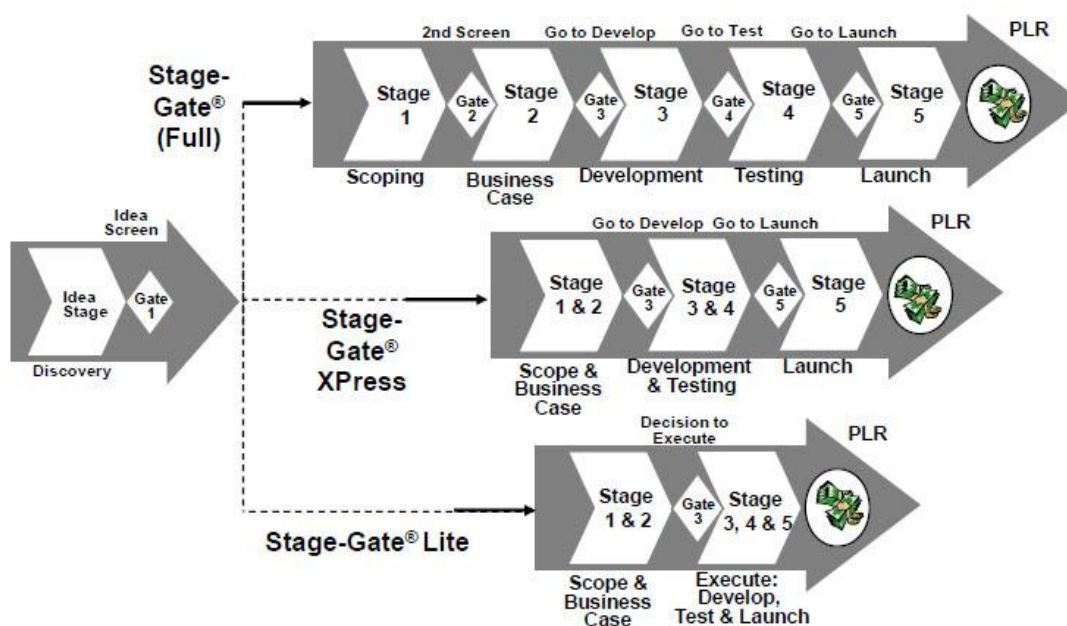


FIGURE 3. Next Generation scalable Stage gate<sup>®</sup> system (Cooper, 2008).



The first Stage gate<sup>®</sup> model has a rule that “one size fits all”. But practically in some cases, the model doesn’t fit to pass through all the stages and also in each case it is not necessary to go through the full five-stage process. The process has thus morphed into multiple versions to fit business needs and to accelerate projects (Cooper, 2008). A demonstration of such idea has been presented in FIGURE 3. The Next Generation Stage gate<sup>®</sup> system were developed by recognizing that, there are risks and activities consume resources that have to be managed.

The new system has three forms based on the risks involved in the process. Stage gate<sup>®</sup> (Full) follows the normal five stage method as followed in its basic version. According to Cooper (2008) Stage-Gate<sup>®</sup> XPress is for projects of moderate risk, such as improvements, modifications and extensions; and Stage-Gate<sup>®</sup> Lite for very small projects, such as simple customer requests. If one process involves a higher amount of risks, it is likely to screen through more phases to get the answer. On the other hand, if activities are limited and risks are almost known, it is not feasible to pass the process through long five stages. The development in Stage gate<sup>®</sup> model provides more flexibility which allows to pick the right process as per the nature of the requirement.

## 2.2 Apparel product development models

Apparel product development is followed by a season rather than developing individual products as in other industries. At the same time apparel product development also consists of different groups of products which should be developed simultaneously. There are not quite many literatures and models available concerning the apparel product development process. However, it was Gaskill (1992) who suggested a widely accepted apparel retail product development model, which is related to our research study to some extent. Wickett et al. (1999) has reworked on Gaskill’s model to develop it further. FIGURE 4 below represents a comparative picture of the apparel product development models of Gaskill (1992), Wickett et al. (1999) and Glock & Kunz (2005).

“No-Interval Coherently Phased Product Development” model for apparel was developed by integrating the models and literature of the predecessors. The model integrates information from the literature, professional presentations, documentary videos and discussions with industry professionals (Burns and Bryant, 1997; Glock and Kunz 1995; Kunz, 1993; Littrell, 1997; Magg, 1997) (May-Plumlee & Little, 1998).

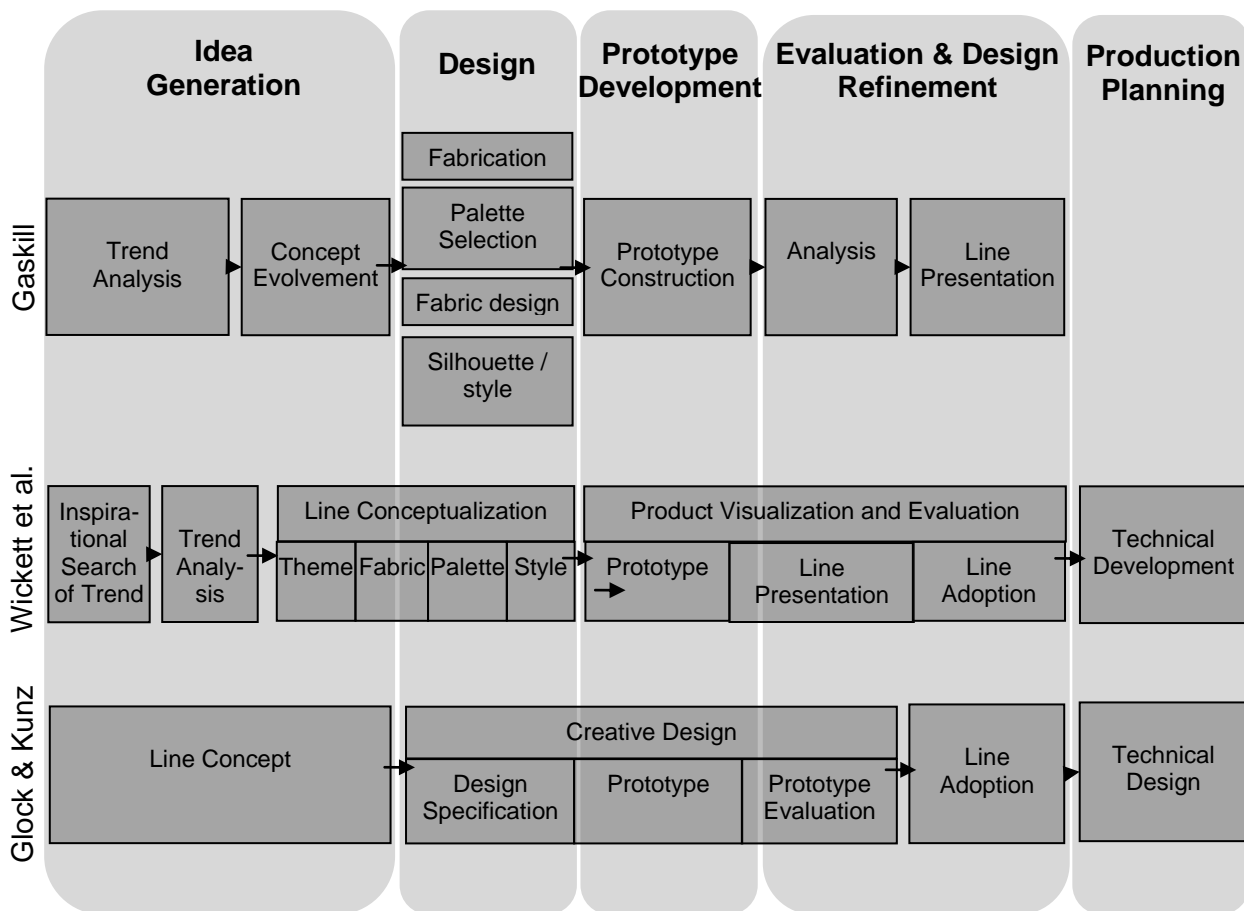


FIGURE 4. Apparel product development models in comparison (adapted from Suh et al., 2010).

### 2.2.1 No-interval coherently phased product development model for apparel

NICPPD has been developed by May-Plumlee & Little by coordinating four functional areas of an apparel firm. These four functional departments as suggested by them are marketing, merchandising, design and development and production. Among other available apparel product development models, NICPPD has been found most suitable for this particular research work because of the nature of the model. The model is closely aligned with the research objective and method which has influenced to study and compare the actual work with this model.

“No-Interval Coherently Phased Product Development” model for apparel is presented through figures 5 to 11. NICPPD model legend is presented in Appendix 4. The process overview is presented on FIGURE 5. It starts with Line planning and research which is generally one year prior to consumer purchase. A similar concept is

found to be followed by the case organization. The planning phase guides towards phase 2, where the concepts are actualized. This phase involves mostly creative activities. In phase 3 designs are developed and styles are selected. The collection is ready for the marketing or sales people for further activities. Phase 4 describes about marketing the product line, once the entire product collection is ready.

The PD activities carry through pre-production stage at phase 5 for necessary execution and projection by marketing. This is also known as modified line, because prototypes that have been made before are made again after necessary corrections. The phase 6 is line optimization that is known as final line. Some corrective actions or modifications are even found during this phase as per requirement emerged from the market. Of course the marketing people or responsible personnel who are connected more closely to the final consumers' play the role here.

The six phases of "No-Interval Coherently Phased Product Development" model for apparel are discussed in details with process flow chart on the following pages. FIGURE 5 that represents the NICPPD process overview, shows the four functional groups, e.g. marketing, product development, merchandising, and production planning and control. It describes the overall process from the beginning until the end in its simplest form. The process is depicted in the form of time-line and each phase is constrained by a specific time period.

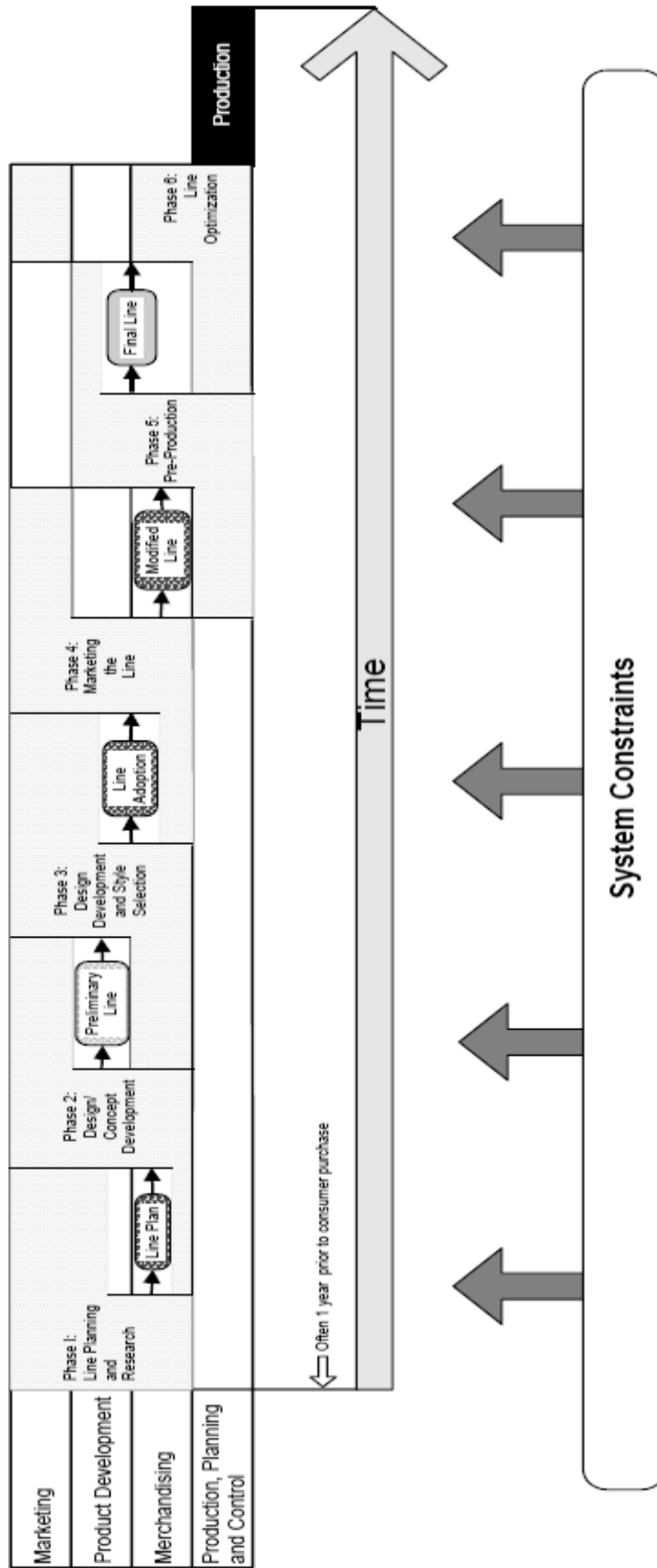


FIGURE 5. NICPPD process overview (May-Plumlee & Little, 1998).

Phase 1 of the model represents the ground work of the overall product development process that is represented in FIGURE 6. The process starts based on a season for which the entire process will continue. This phase integrates the trend research (Market research, color research) and planning the line. The base of the phase is created through input from marketing by providing general parameters for the process. Therefore sales forecasts develop and sales goal is set. It guides the development of the product line. Merchandising uses this information for line planning.

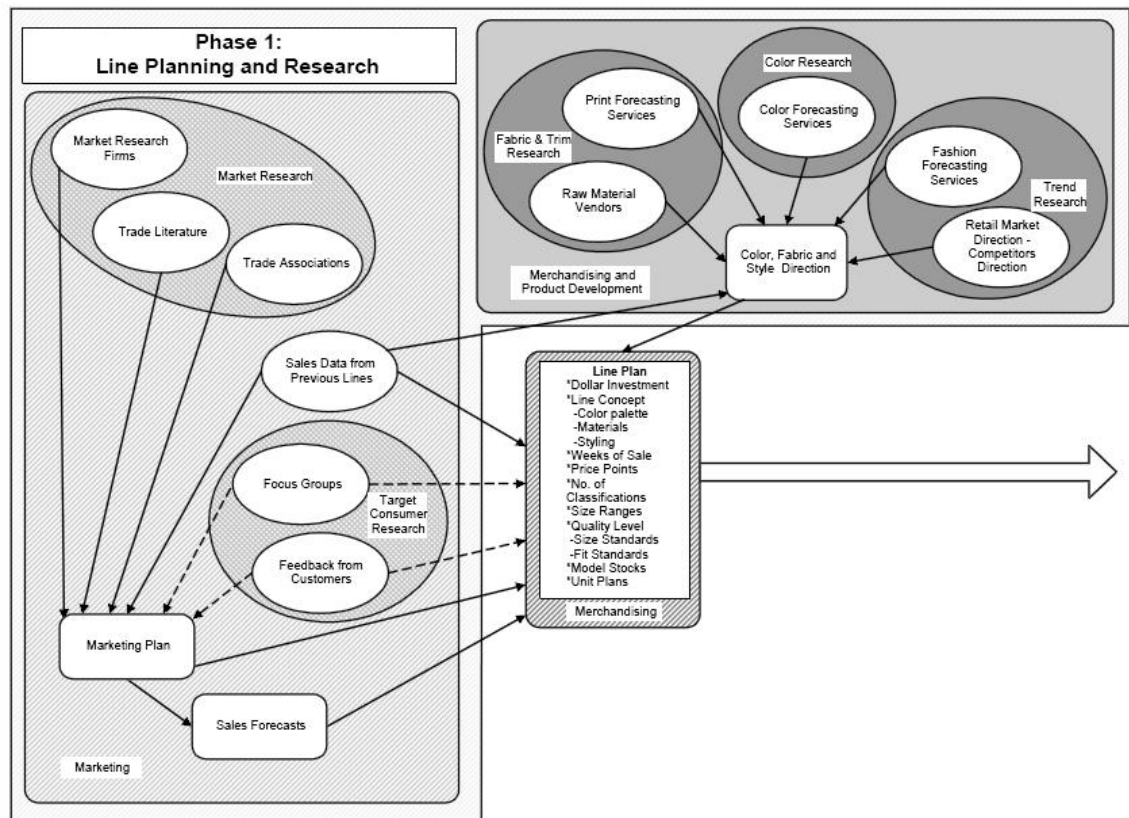


FIGURE 6. NICPPD model, phase 1: Line Planning and Research (May-Plumlee & Little, 1998).

In phase 2, development work proceeds by developing specific products (FIGURE 7). The line concept that was developed in phase 1, guides this phase to accomplish the color range and product group. The proto type is developed with preliminary creative ideas and research work. The range of collection is generally bigger in this stage than the real collection to be ready for final range. It is basically provide a selection potential for finalizing the collection by a color and concept meeting. Some companies also arrange consumer reviews followed by concept meetings.

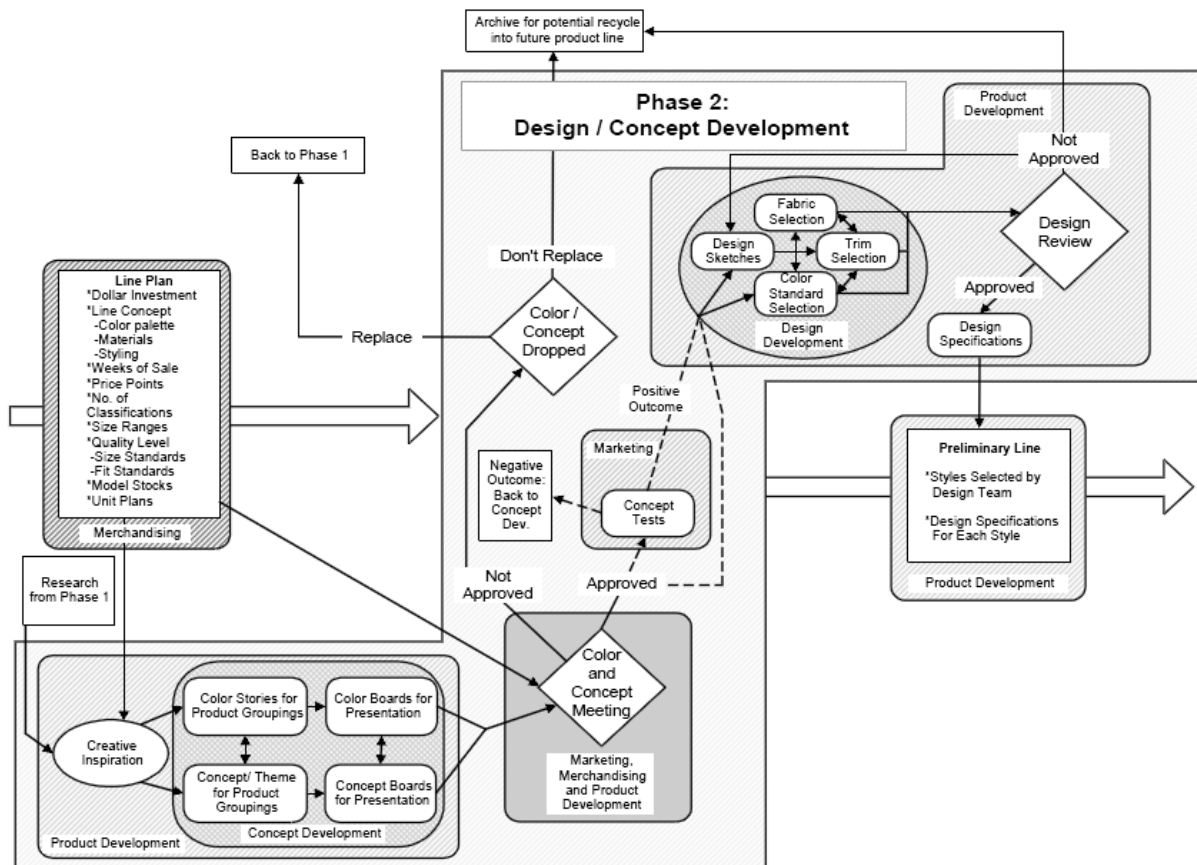


FIGURE 7. NICPPD model, phase 2: Design/Concept Development (May-Plumlee & Little, 1998).

In Phase 3, final samples are produced based on the drawings and the prototype that is created in previous phase (FIGURE 8). The necessary materials required for preparing the final samples are also ordered. Patterns are finalized with necessary corrections from the first prototype and product fitting is finalized by testing through fit models. This phase ends by reviewing the range through merchandising, marketing and product development.

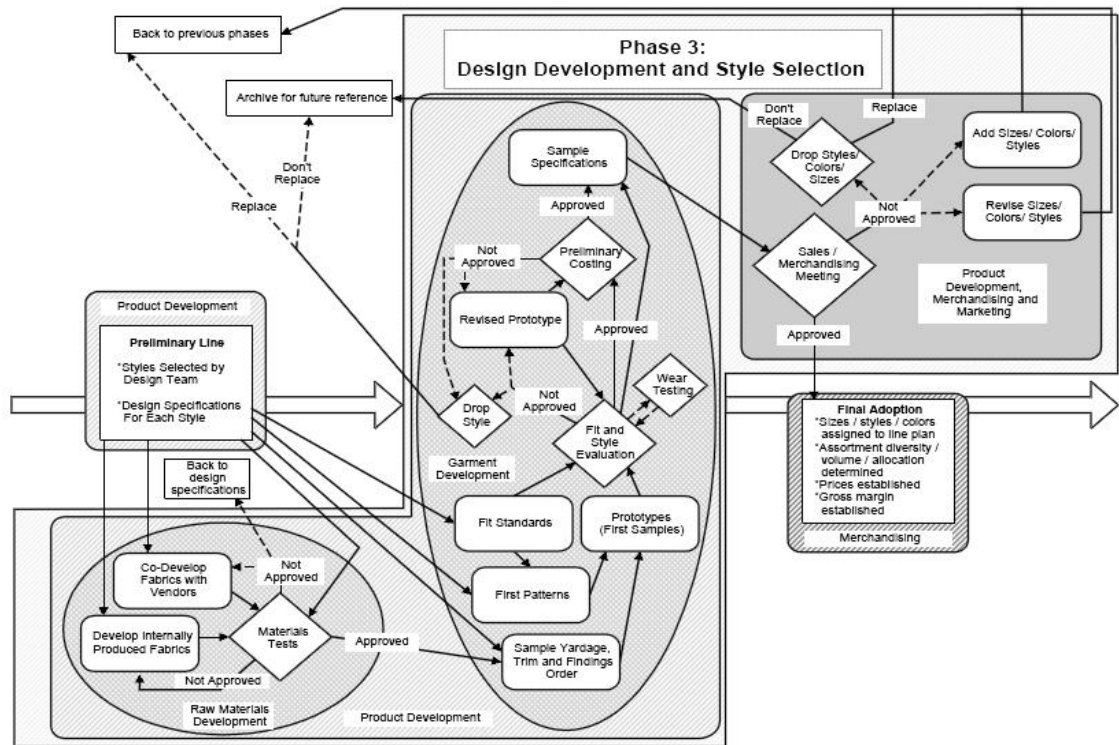


FIGURE 8. NICPPD model, phase 3: Design Development and Style Selection (May-Plumlee & Little, 1998).

Finalized products are marketed through a proper channel or retail channel in Phase 4 (FIGURE 9). Salesman samples are produced for the sales people. Product cost estimation is cross checked once again as the product is final by now, though there might be some possibilities of modification based on customers observations and requests.

Phase 5 is pre-production step where the final product range size specifications are made ready (FIGURE 10). The cross check of technical parameters are done and production schedule according to sales forecasts are accomplished.

Phase 6 is the line optimization, which is presented in FIGURE 11. Order continues in this phase and modification and updates are often necessary. Sales forecasts are also modified as a clearer picture about the sales can be obtained.

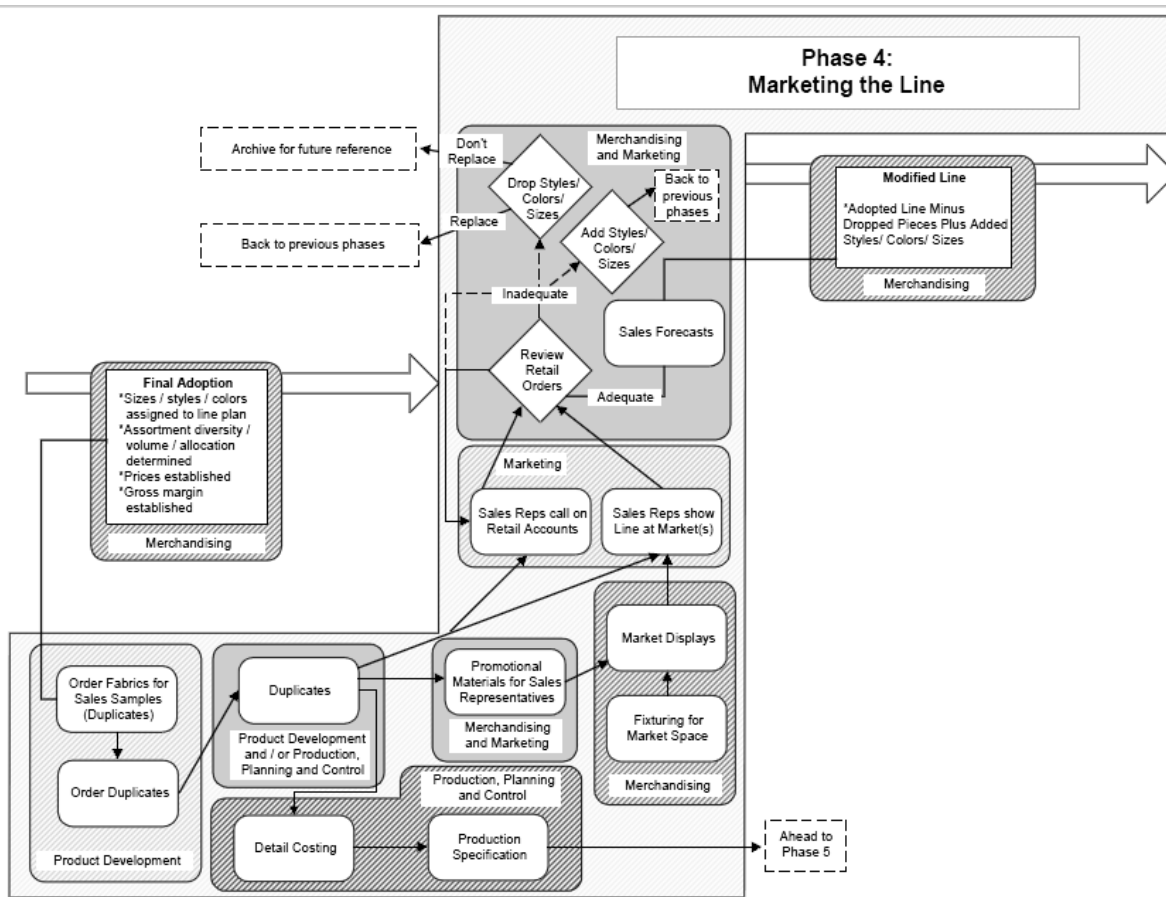


FIGURE 9. NICPPD model, phase 4: Marketing the Line (May-Plumlee & Little, 1998).

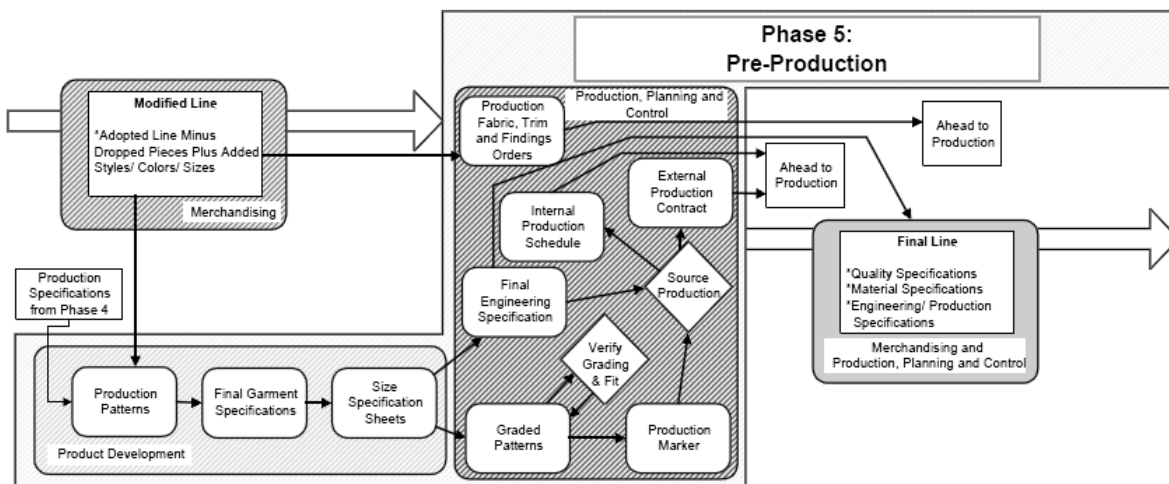


FIGURE 10. NICPPD model, phase 5: Pre-Production (May-Plumlee & Little, 1998).



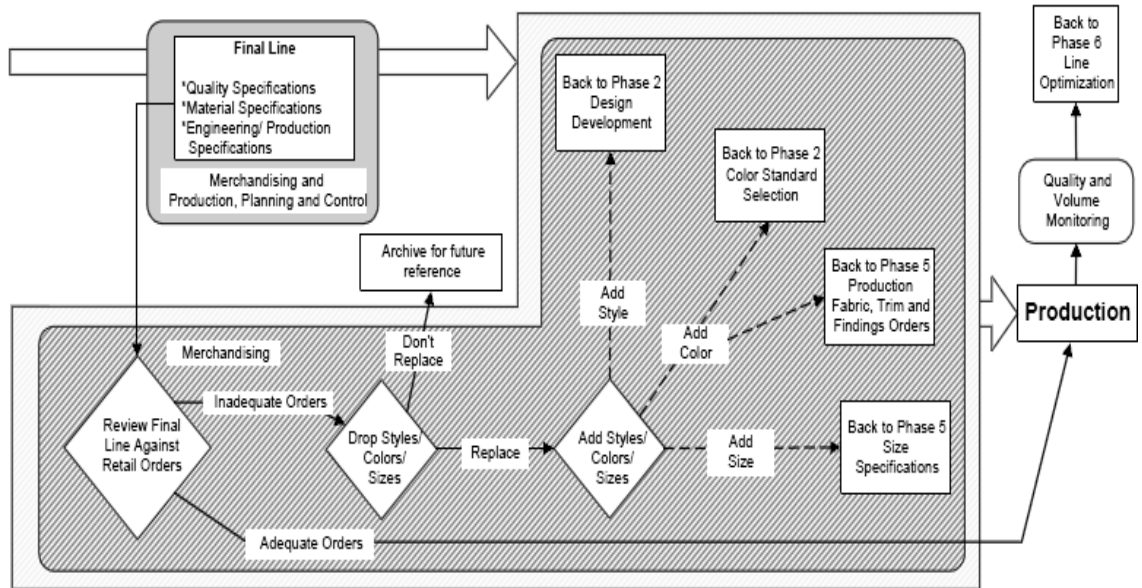


FIGURE 11. NICPPD model, phase 6: Line Optimization (May-Plumlee & Little, 1998).

The overall presentation of NICPPD model for apparel justifies the general stage gate process of product development. The model is not limited to innovation that typically stands for product development but carries through the end of the process. This model serves as a framework for research work. The visual process detail provides a better understanding about the long story of the apparel product development that flows from trend research to production.

### 2.2.2 Concurrent product development model

The study focuses on the agility in product development process. The traditional sequential PD usually is less efficient in context of agility. Also cooperation between PD and production is not remarkable in sequential process which is imperative for agile PD and transformation. On the other hand, concurrent product development also follows a sequential way but it is done parallel in different departments. Operating under a concurrent model, communication is enhanced and the expertise of all departments is employed throughout the process (May-Plumlee & Little, 1998, p.346). This is the concept used in concurrent engineering. To achieve a smoother transition from product design to production, and to decrease product development time, many companies are using simultaneous development or concurrent engineering (Stevenson, 1996, p.148). A pictorial presentation of over-the-wall approach that is traditionally practiced in PD is depicted in FIGURE 12.

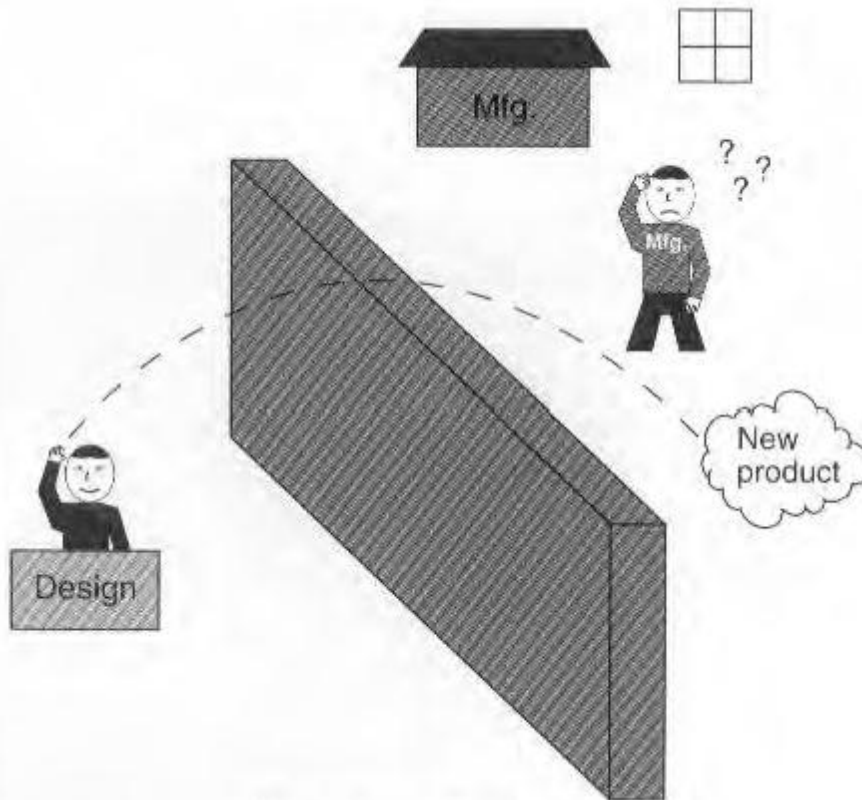


FIGURE 12. Over-the-wall approach (Stevenson, 1996).

The picture above is a good example or view of how product designs emerged as new product is transferred to manufacturing or production. PD and production act as two separate departments and work independently. May-Plumlee & Little (1998) has presented an Erhorn and Stark's (1994) integrated process model presented in FIGURE 13. The model demonstrates that product development occurs in an aligned way throughout in various departments and the act of PD goes on laterally and smoothly with production. According to the authors (Erhorn & Stark), use of this model facilitates product innovation, cost management, meeting quality requirements and a shortened product development cycle (May-Plumlee & Little, 1998, p.346). These advantages facilitate agility in the product development process.

Parallel and concurrent product development model emphasizes the communication between departments. This communication is not only related to operational departments but the other organ of the organization, e.g. marketing. Enhanced communication improves coordination, which ultimately leads to agility in the process and helps to improve the quality.

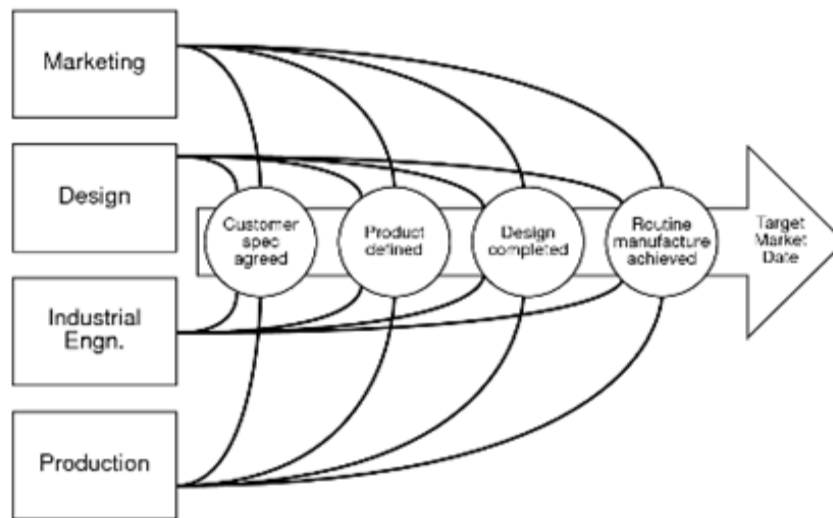


FIGURE 13. Erhorn and Stark's (1994) integrated process model (May-Plumlee & Little, 1998).

### 2.3 Customization for production

Design for manufacturability (DFM) is the practice of designing products for ease of manufacture (Anderson, 1997, p. 234). In any production process reproducibility is one of the most important factors. It is extremely important to design and develop the apparel products which are easy to reproduce during production. This is also a key factor of agility in apparel production. The apparel production involves many manual and semi-automatic steps. Therefore setting the simple process steps for producing an apparel product during PD stage helps in achieving agility during production. However, easiness of reproducibility is not limited to product design only, but some other factors like: availability of raw materials and accessories, procurement lead time, product quality, process safety, regulatory compliance, logistics etc. are also need to be considered.

Product cost in association with efficiency to reproduce the designed product is also quite significant in apparel product development. As it is mentioned, that apparel manufacturing process consists of manual steps. Much of the focus of DFM is to design cost out of the products from the beginning (Anderson, 1997, p. 235). It is often said that 80 percent of costs are committed as soon as the product has been designed. This means that when a product has been developed, the design of the prod-

uct defines most of the product costs have been “locked in” (Lyly-Yrjänäinen, Velasquez, Suomala & Uusitalo, 2010, p. 283-284).

With the intensified market competition of apparel business, the traditional robust garment production mode can no longer meet the market demand. Therefore, in order to meet the development requirements of social economy, garment enterprise shall adopt the production mode in compliance with quick response system (Song, 2008). Apparel production facility should be flexible enough to respond with the customization demand from the market through product development. The production lines of apparel companies are now a day no more narrowly specialized for certain types of products. Rather companies are more and more focusing on the flexibility of the lines that are able to produce diversified products.

#### 2.4 Integration of product development parties and SCM

On demand product development and its agility is very much dependent on the common understanding, trust and co-operation between parties of a supply chain. The prompt product development activities of an apparel firm are not enough without involving other members of the chain and proper SCM. There are three common understandings summarized by Lee & Kincade (2003) about SCM. The first one is about involvement of participants. All channel members within a company or between companies, including supplier, manufacturer, distributor, and customer, should be involved in the chain activities and collaboration between members (Lee & Kincade, 2003). The participation improves the quality of work and deepens the co-operation. The second component is the flow of both materials and information (Lee & Kincade, 2003). It is about the flow of physical goods like raw materials or final product and flow of information throughout the chain. Shared information between supply chain partners is necessary to sustain the extended enterprise where collaborative alliances support the exchange of information to enable such activities as joint product development and common systems (Bruce, Daly & Towers, 2004). Thirdly, integrated and coordinated value-added activities are required (i.e. cross-functional approach, joint planning and forecasting, flexible operations), in order to manage the flow of materials and information and to provide high customer value (Lee & Kincade, 2003).

Apparel firms are obliged to develop and keep relationship efficiently both with suppliers and customers for their efficiency. There are external and internal players involved in supply chain activities, whose involvement and activities influence supply

chain performance (See FIGURE 14). Among the external parties fabric suppliers and the customers are crucial for the success of apparel firms. The different players and their role in supply chain are presented below:

- **Fabric suppliers:** Fabric suppliers play an important role in the production scheduling of the apparel manufacturer. Soon after product development, apparel manufacturers almost instantly like to start processing of the procurement of the fabrics. The apparel production largely depends on the on-time supply of fabrics. To react fast to the demand from the customers, it is very important to develop a partnership with fabric suppliers which will ensure the reliability of promise given by the apparel manufacturer to their customers.

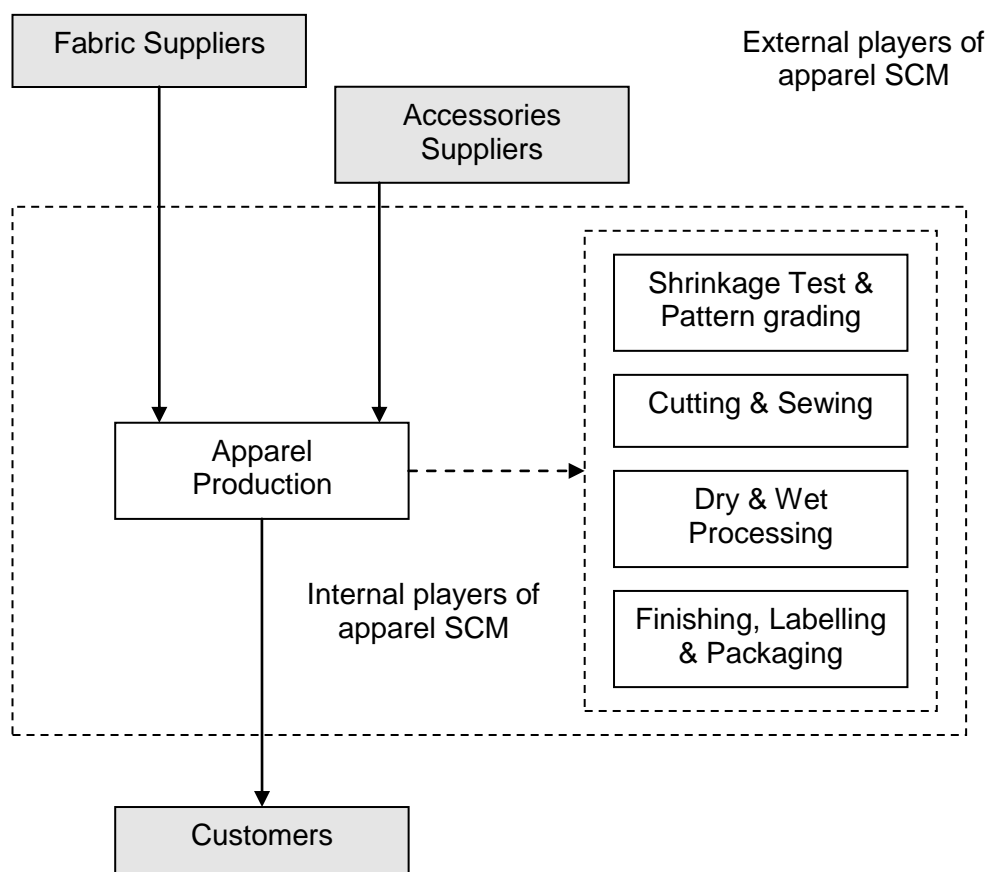


FIGURE 14. Effect of internal and external parties in an apparel supply chain.

- **Customers:** Apparel manufacturers' business performance is highly dependent on the customers approach. The nature of the relationship between a supplier and a customer (e.g. manufacturer and retailer) can be described along a continuum from adversarial to partnership and from short term to long term (Lee & Kincade, 2003).

For the sake of the satisfying performance of the total supply chain, it is imperative to establish a quality relationship between apparel manufacturer and customer. In a proper supply chain, information flows from the customer to manufacturer as the product flows from manufacturer to customer.

However, it is also very important to establish extensive co-operation between the internal parties of the apparel manufacturing supply chain.

- Apparel manufacturer: Apparel manufacturing process consists of some distinct considerable steps. A close co-ordination between these steps is crucial in terms of success and agility. The process starts with pattern grading which depends greatly on shrinkage testing. Pattern grading is the process whereby patterns of different sizes are produced from the original master pattern (Cooklin et al., 2006). It is an important step for production scheduling and preparation for production.

With a speedy scheduling process, the production flow can move forward by cutting fabrics into parts and sewing those together. The apparel manufacturing lines should be versatile to act fast with the demand. Once the products are ready from sewing, these pass through dry & wet processing department where the apparel products get the look. These steps include mechanical and chemical actions. Finishing process of apparel also includes some manual activities. Nevertheless this is also an important step, as it is necessary to present the garment nicely to the final consumers. All those generalized steps of apparel production demand co-ordination for success of the internal supply chain.

## 2.5 Agility of product development for private label

When the retailer decide to sell products or a line of merchandise which is owned, controlled, merchandised and sold by the retailer in his own store/ chain of stores, he is said to be selling Own label/ brand or Private Label merchandise (Pradhan, 2006, p. 214-215). Private labels, especially apparel private labels are responsive and have to be responsive to consumer needs. Apparel manufacturers are expected to meet the rapid demand from the private label customers. As the Private Label concept is growing in apparel business, it is also capturing a large portion of production for the apparel producers. While Private Label is important to the retailer, it's worth nothing that retailers are becoming very important to the manufacturers (Lincoln & Thomas-

sen, 2008, p.20). Apparel private labels are also agile to bring the fast fashion to the consumers. So, the ultimate pressure of the swiftness shifts to the manufacturer.

As private labels are getting extremely important for the manufacturers, they have to obey the customer needs. It is very demanding for the private labels to achieve higher quality with lower price. Undoubtedly, faster service at minimum cost can only be possible with highly efficient product development and production process. Responsive apparel manufacturers are ready with supply chain co-ordination and formation to co-operate with customer for the sake of their own success. There is also a balance need to be set between seasonal product production and private labels production. A flexible production planning system is important for proper co-ordination. Private-label production typically results from a direct relationship between retailers and manufacturers (and sometimes even contractors) (Bonacich & Appelbaum, 2000). A close co-ordination helps both parties to reduce some important expenditure. Forecasting gets better, as customers are directly involved in the process. So that right and fewer amounts of materials are needed to be stored. At the same time, finished product inventory should get less or even to zero. By increased communication, and proper organization, the overall process is quicker and more cost effective. So, getting price of the final product price is lower, it will not lower the profitability of supply chain participants.

## 2.6 Agile or Lean

The terms 'Agile' and 'Lean' are often confusing when they are compared. As Christopher and Towill (2001) presented at its simplest, the lean paradigm is most powerful when the winning criteria is cost; however, when service and customer value enhancement are prime requirements for market winning, then the likelihood is that agility will become the critical dimension. Despite of the difference in nature between Lean and agile method, both focus on agility. To provide a better service level to the customer, undoubtedly it has to be agile in its reaction towards customer. Whereas to be cost effective it also has to be agile in the production process and should minimize the total lead time.

<b>Agile Supply</b>	<ol style="list-style-type: none"> <li>1. <u>Quality</u></li> <li>2. <u>Cost</u></li> <li>3. <u>Lead Time</u></li> </ol>	<ol style="list-style-type: none"> <li>1. <u>Service Level</u></li> </ol>
<b>Lean Supply</b>	<ol style="list-style-type: none"> <li>1. <u>Quality</u></li> <li>2. <u>Lead Time</u></li> <li>3. <u>Service Level</u></li> </ol>	<ol style="list-style-type: none"> <li>1. <u>Cost</u></li> </ol>
	<b>Market Qualifiers</b>	<b>Market Winners</b>

FIGURE 15. Agile versus Lean supply (Source: Mason-Jones, Naylor, and Towill, 2000).

Firms often can have different product types. In case of an apparel firm, it may contain seasonal product collection that serves a particular season. On the other hand, apparel company oftentimes also has “Never out of stock” products. So that agile or lean cannot be applicable in both the cases. When the market is highly volatile, it is not wise always to follow lean process. Rather a firm should adapt agile process to be competitive. For example, fashion market is quite unpredictable and firms often focus on agility. Product life cycle is often quite short, so that following cycle arrives quite fast after finishing of the immediate cycle. In case of Lean supply product life cycle is quite long and market is predictable. So, firms often get enough time and flexibility to improve the process by elimination of excess time in the process.

## 2.7 Methodology to achieve agility

The unpredictability and volatility of business environment demands firms to be agile and firms are increasingly emphasizing to be agile to react as per requirement. However, the ultimate strategy is to satisfy customer. Dahmardeh & Banihashemi (2010) stated that the purpose of agile enterprise is to enrich / satisfy customers and employees. They have developed a conceptual model of agile enterprise, which is presented in FIGURE 16. An enterprise is ready with agility, when it is able to absorb changes. In order to respond sharp changes, firms should achieve certain competences. As presented in Dahmardeh & Banihashemi model, they emphasize on four specific capabilities:



- In order to acknowledge and react to the changes, responsiveness is considered as key attribute. Responsiveness imparts the ability to deal with the circumstances with essential calibre as demanded.
- Competent firms are able to confront tough situations efficiently and effectively, thus making the organization agile.
- To react agilely with the need, firms must prepare itself to be flexible in response and ready for alteration in processes and methods on demand.
- All of these three properties will be effectual if the organization is indeed able to carry out the activities with sufficient agility in the shortest possible time.

These capabilities require a coordinated integration to perform and provide desired agility output. Achieving agile enterprise requires responsiveness in strategies, technologies, people, business processes and facilities (Dahmardeh & Banhashemi, 2010). The combined effort of different segments can ultimately make the firm agile. FIGURE 16 represents Conceptual model of agile enterprise as proposed by Dhamardeh & Banhashemi.

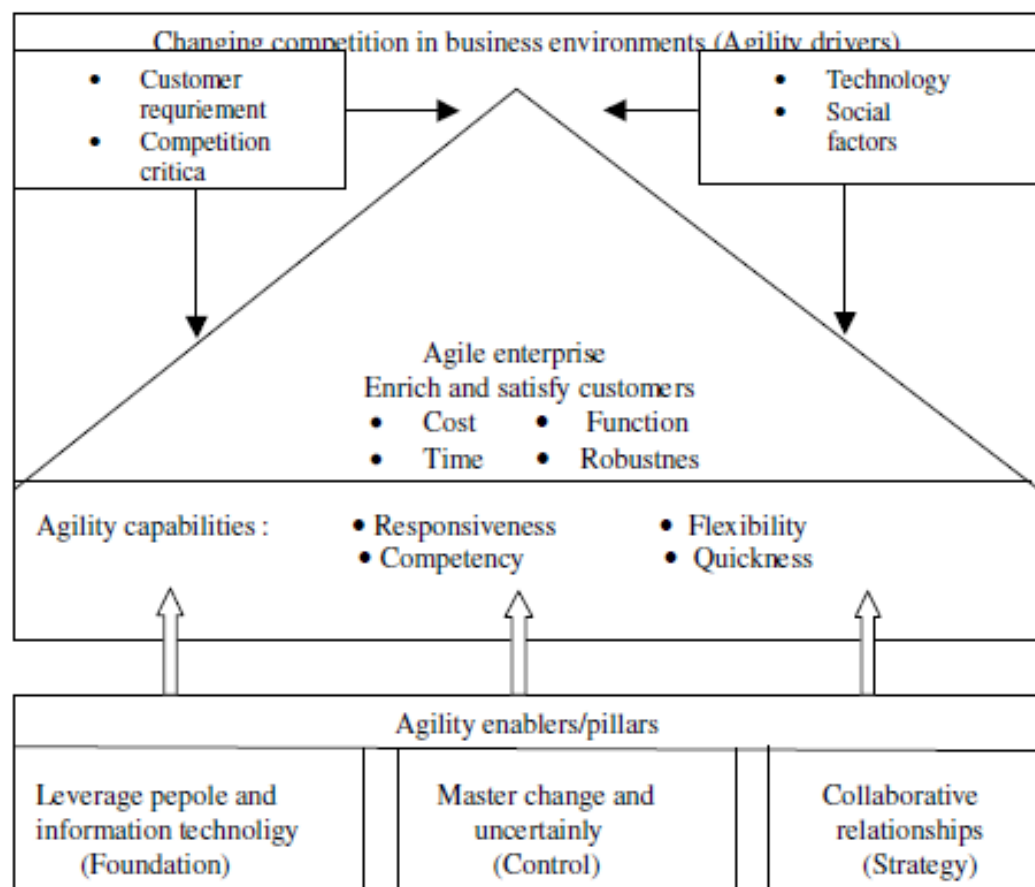


FIGURE 16. Conceptual model of agile enterprises (Dhamardeh & Banhashemi, 2010).

## 2.8 Transition towards agile process

It is not complex theoretically to implement agile manufacturing methodology. Firms have to analyze the present situation in terms of agility, possibilities and the way of implementation. It is to be mentioned here that, successful implementation depends on identifying difficulties and considering them during implementation. By considering these facts, a conceptual framework is developed, based on the methodology explained earlier. Sharifi & Zhang (1999) proposed a conceptual model for implementing agility presented below. It consists of three major stages:

- Commitment of the company towards Agile Manufacturing and determination of its position within the process in terms of agility.
- Agility Capabilities of the company, strong enough to respond to the changes.
- Major areas of the organization sought as agility providers by which capabilities of the firm could be achieved.

In addition, firms should also have an organized IT platform that supports implementation of the AM process. Coordinating and linking together different capabilities and supportive instruments can really improve firm's processes towards agile manufacturing. Ultimate implementation of AM can lead a firm to a stable condition, albeit turbulence business environment.

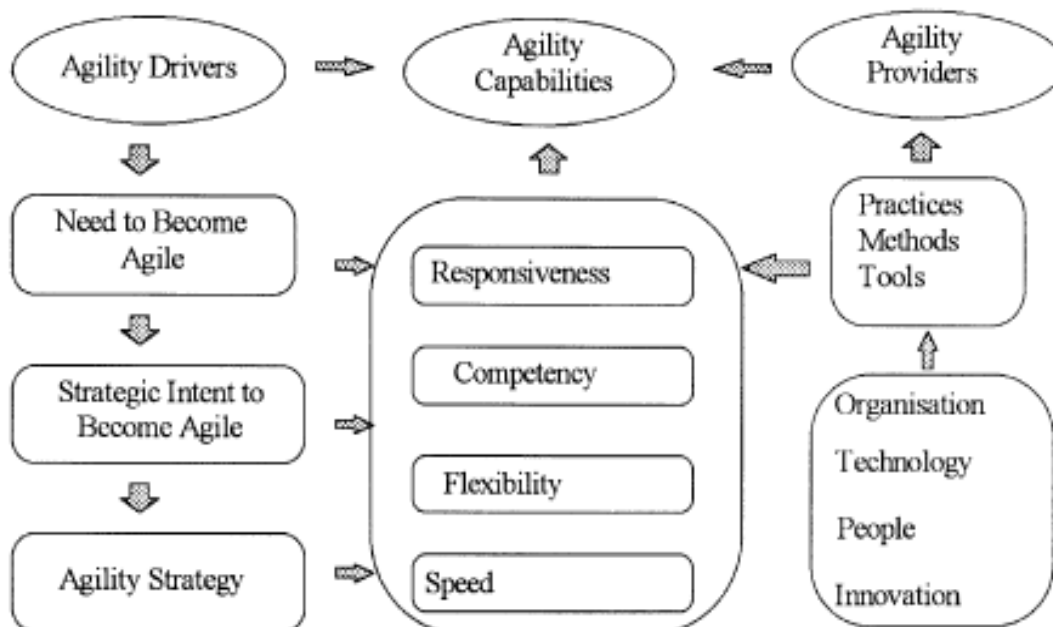


FIGURE 17. Conceptual model of agility implementation (Sharifi and Zhang, 2000).

From the discussion above, it is quite clear that agile process is a combined effort of a few strategic criteria. It is critical to assess the organization's present capabilities and thus changes can be made as per requirement. As explained earlier, the responsiveness, competency, flexibility and speed determines the position of organization capabilities towards agile process. In case of apparel firms, it is important to achieve and hold those capabilities because of the nature of the fashion market and stress and demand from the customer.

### 3 RESEARCH DESIGN & METHODOLOGY

This part of the report focuses on the methodology that will carry through the research project. It is important for the researcher to adjudge about the scientific approach to be followed. The overall research methodology will follow an integrated quantitative and qualitative way. The process can be defined as mixed methodology research as stated in the work of Bryman (2006), where he states “Indeed, for some writers it has come to be seen as a distinctive research approach in its own right that warrants comparison with each of quantitative and qualitative research”. In this research project, qualitative and quantitative data will be obtained that will complement each other, therefore it will find a balanced way of analysis.

The background theoretical study supports the structure of the research process and interview questionnaire formation. The stage gate model for Product Development, Wickett, Gaskill’s Revised Apparel Retail Product Development Model (1999) and NICPPD provides the basic framework for the product development process study. These are examined through on site study about the process, methods and interviewing personnel who are involved directly and indirectly in PD and production process. In addition, data collected on sales and costs involved in PD and production supports evaluation through quantitative analysis.

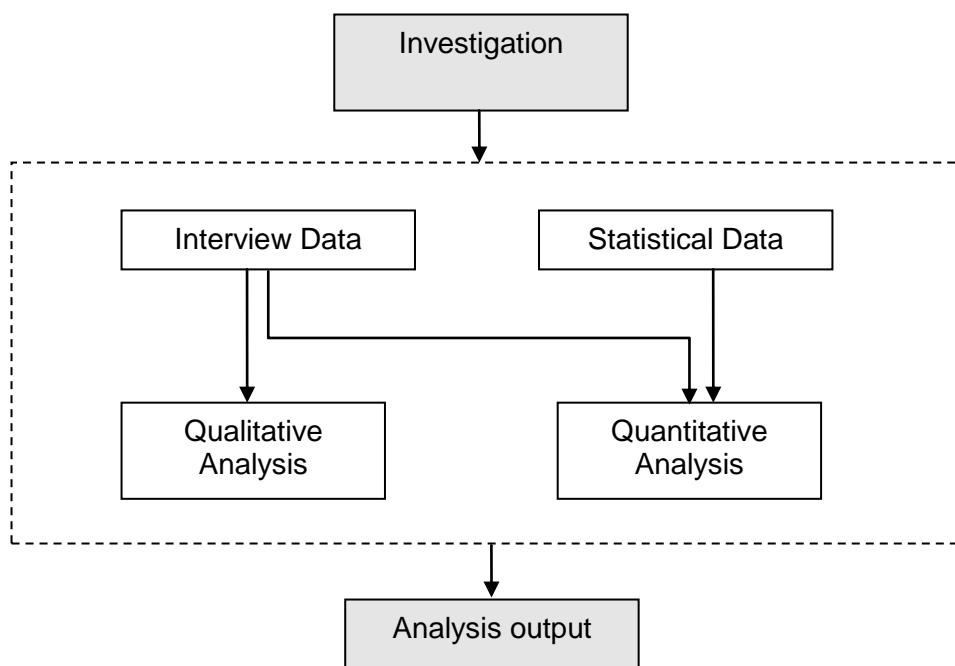


FIGURE 18. An illustration of study data analysis.

### 3.1 Research objectives

The research work aimed to study the contemporary methods for apparel product development and the reproducibility during production. The main target was to acquire a deep understanding on the process and procedure of work. In order to do this, a generalized understanding was achieved from the Stage gate process to find out the similarity for the case study. Furthermore, additional understanding particularly on apparel product development was achieved based on “No-Interval Coherently Phased Product Development” model for apparel by May-Plumlee and Little (1998). The research approaches toward deeper aspect by Erhorn and Stark’s (1994) “Integrated process model for concurrent product development”. However, the literature review and competitive analyses are not limited to PD only, but the research work tries to get a clear picture on customization for production too. The entire work concentrates on agility of the processes and procedures in all the steps. The following research objectives were set based on the theoretical studies:

1. Defining the initiators of the On Demand Product Development process that guides the complete process through production. The process initiates with trend research and data collection for a particular brand and also for all the brands as a whole.
2. Synchronization of trend research information to the PD and the steps and process of PD for a specific brand.
3. PD process for the continuous models or make-to-stock products.
4. Finalizing procedure for a product range for a specific season.
5. Identifying the drivers that drive the product development process and customize it for proper reproducibility. Customization for production of different products from different brand range.
6. Production planning and scheduling for different products as per promise to the customers.
7. Technology and methods available for the PD and production.
8. Determining the obstacles in the PD process and organization which often disturbs the process.
9. Finding out the importance of “On Demand” function or agility in apparel product development process and thus in production.

### 3.2 Research design

The research focuses on combined method of qualitative and quantitative analyses to utilize the foremost parts of both, that best match the requirements of this study. There can be little doubt that research that involves the integration of quantitative and qualitative research has become increasingly common in recent years (Bryman, 2006). The design of this mixed research is aimed to avoid overlapping and both methods should be used in a way that they supplement the entire work.

The main and initial emphasis has asserted to qualitative analysis. Qualitative data analysis follows the process of data collection, reduction, display and drawing and verifying as stated by Miles & Huberman (1994). Qualitative approach was preferred because of the explorative nature of the research work. Since the nature is explorative, interview method is found suitable to find out the answers for research questions. For data analysis, the data should be collected based on the research question, so that the collected data and its analysis will tend to answer those questions. The general research questions focus on the method and practices of PD and production that is presently executed and constraints realized by following them; the scope and practicability of introducing new approach that supports "On Demand" requirements; effect and amplitude possibility of the findings. This process will work as a fundamental approach towards data handling, specifically in qualitative analysis. A semi-structured questionnaire will support the research work in collecting data. Thus it is indeed crucial to set up proper questionnaire that can dig out the gist necessary for the final analysis. A good questionnaire design ensures reliability and validity of data which will ultimately ensure the acceptance of the result of the study.

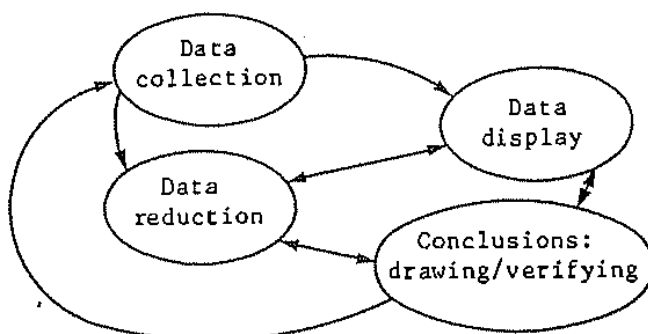


FIGURE 19. Components of Data Analysis: Interactive model (adapted from Miles & Huberman, 1994).

On the contrary, quantitative analysis and data collection for analysis are based on statistical data and figures. Data necessary for quantitative research is collected from the experiment site. It is important to select the proper source of data for analysis. Careful sampling strategies and experimental designs are aspects of quantitative methods aimed at produce generalizable results (Thomas, 2003). The overall quantitative analysis will follow a deductive research approach based on conceptual model. Though generally quantitative approach involved experiments which are often quite complex, in this particular research it is unlikely to involve critical experiments.



FIGURE 20. Knowledge Claims, Strategies of Inquiry, and Methods Leading to Approaches and Design process (Creswell, 2003).

Research framework by Creswell (2003) presented above in Figure 20. This displays how three elements of inquiry (i.e. knowledge claims, strategies, and methods) combine to form different approaches to research. This is the process of research work for this particular study.

### 3.3 Study site and interviews

The foremost reason of selecting the particular study site is exclusively based on researcher's easiness, existing knowledge and deeper accessibility as required to the particular study. In addition, deliberation towards advancement of PD and process by the research work participants' was the chief motivation and willingness to participate to the interview process which was also critical. There are also few more potentials involve in selecting the site. As an apparel product producer in Europe, the organization is in tremendous pressure always from the low-cost sources that have a serious impact on reducing cost and taking competitive advantage, e.g. logistical advantage. It is worth mentioning that this is not easy for an apparel company to continue its PD

and production activities in this high cost arena. For this reason the PD and production process and the total supply chain should be able to deliver something special and intently efficient that keeps them competitive in such volatile environment and corresponding contests. It is important for the firm to align their product development activities organized and efficient as of its existence in an exorbitant zone, especially for the textile related industries. Nevertheless, it is also fascinating to work on such organization that is rare in this region, deals with divers' brands, several product types, various methods etc. The full-time presence at the site also has been acknowledged as an added opportunity.

The entire research and fieldwork for the study was lasted a six months period from the end of January to end of July 2012. Extensive study was carried out about the processes, products and modes during this period. These includes product types, product categories, process types, PD processes for different brands, production processes for various product ranges, supply chains etc. Experts and professionals from various departments were interviewed to collect all the required information. Besides, sales records and expenses related to PD and operational activities were collected for analytical purpose. Researcher's presence in different meetings, discussions, presentations also provided a lot of information that helped in the study work. The last, but not the least, the long experience of the researcher in this particular field assisted the study work.

### 3.4 Formation of the questionnaire

The qualitative research design part of the research work prepared to reveal and examine the facts and processes behind the "On Demand Product Development" and reproducibility during production with sufficient agility. This design has employed questionnaire survey as a major source of data collection. As the questionnaire is the principle data source, it is important to collect quality data for qualitative analysis. Therefore, the data collection method should be organized for proper execution. Procedure for developing questionnaire consists of nine steps as per Churchill & Iacobucci (2009). These steps are illustrated in Figure 21. The functional aspect of design is critical: whether it really works or whether it goes wrong (Gillham, 2000). Indeed, the total research process was a blending of the theoretical aspects and practical engagement of it.



Professionals from different parts of the product development processes, production processes and supporting departments were taken into consideration as an information resource for data collection. The selected professionals of different activities of different brands or product lines or departments were asked to share their knowledge in product development and production processes. A total of sixteen professionals were interviewed, who work in marketing, designing, pattern making, technical, logistic or production activities. A track record of the interviews was maintained as presented in the Appendix 3.

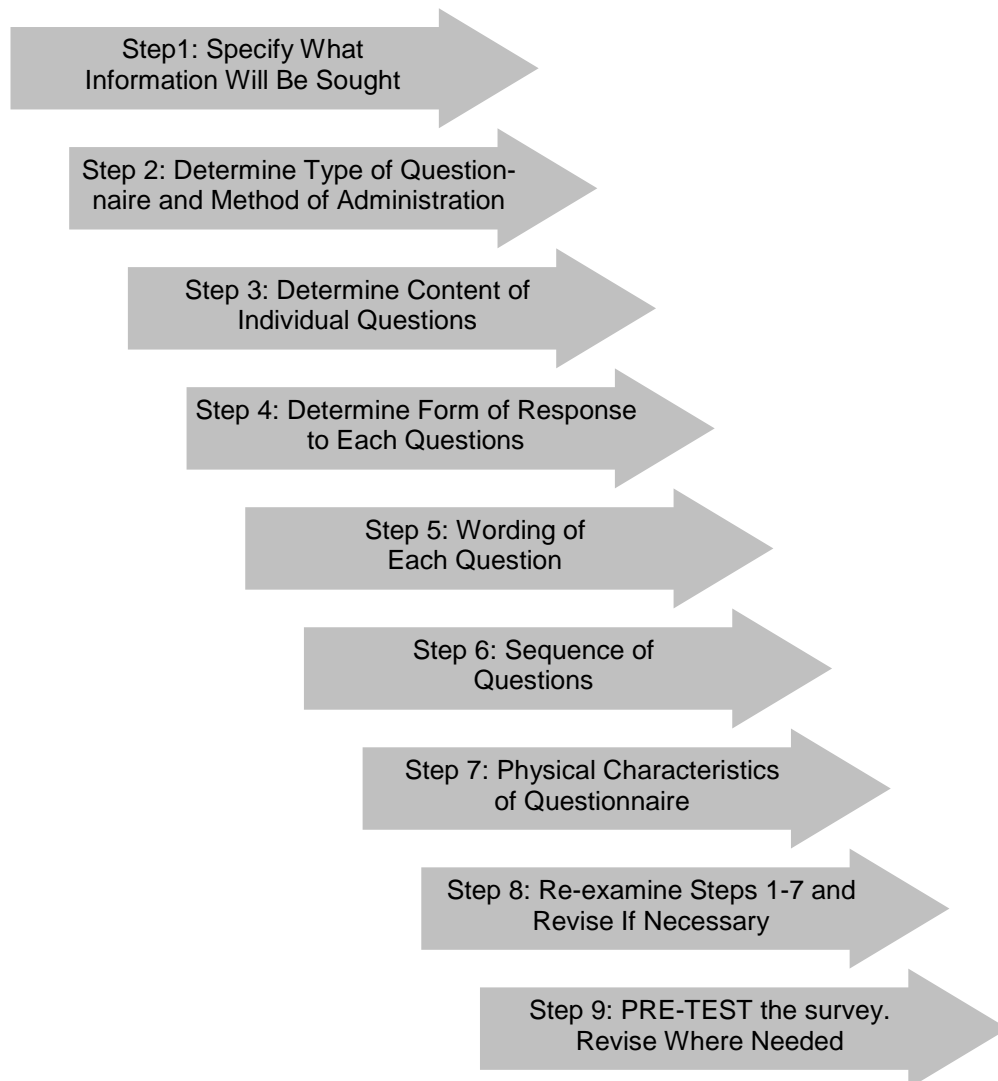


FIGURE 21. Procedure for Developing a Questionnaire (Churchill & Iacobucci, 2002).

The interview consists of well formatted series of questions based on the procedure for developing questionnaire which is split to four specific parts. This is considered as a research instrument which guides the overall interview task and data collection work for qualitative analysis.

### 3.5 Data Collection

The main source of data collection was the semi-structured interview based on the questions mentioned on Appendix 2. The questions were conceptually designed to allow those to be semi-structured as suggested by Wengraf (2001). “Common-sense Hypothetico-inductivist Model” suggested by him was the construction basis of the interview project. In a fairly common-sensical model, the researcher collects ‘all the relevant facts’ and then examines them to see what theory is suggested by this set of ‘all the relevant facts’ (Wengraff, 2001).

Besides interview data, supportive data like: sales reports, reports related to product development, technical specifications and many other documents were collected from different data sources of the organization. Researcher’s participation in fabric trend fairs, product development meetings and production meetings also has provided a lot of information. The overall approach of the interview process was not to disclose much information that is treated as a personal or organizational. It was mentioned to the interviewees prior to each interview session. Each participant was asked to sign and accept the interview terms as presented in Appendix 1. Each interview took 20 – 120 minutes depending on the participants’ importance and knowledge on the matters required for analysis and around four months were spent periodically for the interviews. For further analysis purpose, interviews were audio recorded. The interviews took place on factory site and in corporate head office. As planned, the interview process extracted information from the personnel of different levels starting from top management to professionals from execution level. All the departments and sections directly or even indirectly involved related to PD and production were covered within the interview process to collect as much deep information as possible.

A pilot interview was conducted to examine each objective and the questions belong to the specific research topic. The pilot interview assisted to reform the questions and reorganize the topics. A key person intimately involved in the core product development and production process was interviewed during the pilot interview process. That was the base of the long interview work for collecting data.

While collecting data, it was kept in mind that the data is going to be examined through qualitative analyses and statistical analyses too. Qualitative analysis and quantitative analysis demands certain criteria for analyzing the data. In general, preliminarily it was considered that interview data will be used for qualitative analysis.

The information can also be used in analytical processing. The answers of the questions by the interviewees will be counted by a number in the scale of ten. Those numbers will be presented in a table. The point tables could be analyzed in statistical way. Besides these, the other data related to sales and expense will also be analyzed and checked for correlation. In this way the research work will try to find out the relationship among different important determinants of PD and production process.

### 3.6 Method of Analysis

The purpose of the analysis of collected data was to find out a way to summarize and categorize information. The data analyzing approach was somewhat equivalent to grounded theory. By adopting grounded theory methods you can direct, manage, and streamline your data collection and, moreover, construct an original analysis of your data (Charmaz, 2006). The table (presented in Appendix 3) that has been maintained to keep the track record of the interviews helped to organize the preliminary records. Additionally, each question sheet consists of further information on interviewee and content of the interview. Audio recorded data were summarized to collect the gist out of each interview. It is to be mentioned here that the descriptive data from the interviews were the source of qualitative analysis. In addition, important topics from the interview question were extracted by giving points in the scale of ten for quantitative analysis. The main purpose was to check whether the quantitative analysis provides some correlated information that assists the research work.

The explorative nature of the research work demands qualitative analysis, therefore qualitative analysis was the major analyses method. Barratt, Choi & Li (2010) has presented in their research work that the biggest challenge behind data analysis is to demonstrate the objectivity of the process through which the data and field notes are developed into conclusions (Eisenhardt, 1989; Miles and Huberman, 1984; Van Maanen, 1988). Qualitative data analysis can be done in many different ways. To analyze the collected data, especially through interview process, conceptually clustered matrix was found suitable in this particular study. This matrix was generated by extracting data from the interviews and by putting those in a table. A conceptually clustered matrix delivers output in two ways: conceptual (the analyst may have some a priori ideas about items that derive from the same theory or relate to the same overarching theme) or empirical (During early analysis you may find that informants answering different questions are trying them together or are giving similar responses) (Miles & Huberman, 1994).

While made the interview structure for this specific research, the conceptual and empirical association has adopted as one of the major considerations. The main emphases were given on quality data collection to make the research work fruitful, so that the study work could move towards intended findings. Again, Barratt, Choi & Li (2010) have stated that when attempting to build theory from case studies, researchers should have a clear focus to collect specific data in a systematic manner (Mintzberg, 1979). In addition to the qualitative analysis, a descriptive analysis also has performed and correlation values are achieved that could help in analyzing the relationship among variables. These studies will help the research to find out the dependence of the specific factors in the process of PD and production. The collected data from the interviews and also the data received from the reports, e.g. sales reports were passed through descriptive analysis processes and correlated values were analyzed.

### 3.7 Validity and reliability of data

Validity is an important key to effective research (Cohen et al., 2007). The long and hard work could go in vain, if information collected through different activities and sources could not prove its validity. Data validity is required for both the qualitative and quantitative research work. It is more critical in this specific case as this research involves qualitative data analysis as well as analytical presentation of collected data. It is required to collect data cautiously, so that the collected data could represent the motive of the study. The data that were selected for analyses must be representative of the samples.

In this particular research, all documentation for data collection was organized in an acceptable manner. The way of data collection and documentation has mentioned on proper places as per necessity. All the interview track records were kept in a table with date mentioned as presented in Appendix 3. Each of the interviews was audio recorded and kept as an audio file, so those can be presented as demanded. Each interview participants signed on the interview consent paper and those papers were kept as document. The interview consent was signed at the beginning of the interview process and both the researcher and participant were signed at the same time. All other data collected from the site, was also kept as document. Nevertheless, the main intention was to collect clean and unbiased data, so that a true consensus can be achieved.

Besides validity of collected data, reliability of the data was also considered. Reliability stands for trustworthiness, which ensures the significance of the gathered information. The study has considered that, interviewee's delivery of information might depend on situation and condition of the interview and even the mood of the participant. Additionally a clear understanding of the interview questions is very important to deliver right information. It is also necessary to find out the right questions to ask which will help to collect intended information. All of these points were seriously considered during collection and organization of data for analysis. All of the answers of the interview questions of each participant are rated in the scale of ten. In order to rate the answers, audio records and interview notes are analyzed to ensure correctness. During questionnaire formation, importance was given to make unbiased questions. It was ensured by following scientific method of questionnaire formation. The interview appointments were organized by ensuring that the participant is not in a hurry, which will ensure the normal discussion condition. To avoid the vagueness of a question, examples were presented to the interviewee. The recorded audio data of such examples and conversation are kept for reliability purpose. Even in worst cases, the question is withdrawn from a particular participant, if the meaning is not clear at the end. As this research work very much dependent on interview data, serious importance was given to collect reliable data.

## 4 RESULTS & DISCUSSION

The unpredictability and volatility of business environment demands firms to be agile and organizations are increasingly emphasizing to be agile to confront those challenges. This study focuses on the apparel product development and production process and inquires about the “On Demand” PD of the apparel firms to meet these unpredictable challenges. Forecasting often fails to give a direction in a volatile environment and thus it requires anticipation to meet the expectations. Fashion business deals with the products with short life cycle, but demands agility. It is the fact that, companies need to be ready for on demand product development in response to the market needs and simultaneously emphasize concurrent engineering to reproduce it with agility. The two well established concepts agile and lean could be the answer for the situation. But it is critical to choose and implement the right method to the right situation or right type.

This study examines the PD and production process for different product types of the particular firm. This section discusses the results and findings from the interview work and presents the process and procedure followed by different product lines. The results are discussed, which is based on analysis of interview content and collected data through qualitative analysis along with descriptive analysis.

### 4.1 Participants profile

The study encompasses an extensive area from product development to production. Accordingly, it is crucial to gather information from the associates of different units from the beginning until the end of the process. Interviewees from different parts of the product development processes, production processes and supporting departments are taken into consideration as an information resource for the data collection work. The selected professionals of different activities of different brands or departments have shared their knowledge about product development and overall process.

All the participants in data collection worked in the same company that has helped intense concentrated research work. The interview participants were from marketing, designing, pattern making, logistics or production activities. On demand product development and production work requires coordinated effort from all the exclusive

parts of the company, hence all the departments were considered for the study. The table below (TABLE 1) presents brief information about the participants.

*TABLE 1. Profile of participants.*

<b>No</b>	<b>Department / Brand</b>	<b>Position</b>	<b>Role in Product Development &amp; Production</b>
1	General Administration	Managing Director	Supportive role in product development & production
2	Logistics	Logistics Manager	Supportive role in product development & production
3	Outdoor clothing brand	Product Manager	Direct involvement in product development & supportive role in production
4	Outdoor clothing brand	Designer	Direct involvement in product development & supportive role in production
5	Outdoor clothing brand	Pattern maker	Direct involvement in product development & supportive role in production
6	Licensed International brand	Product Manager	Direct involvement in product development & supportive role in production
7	Licensed International brand	Designer	Direct involvement in product development & supportive role in production
8	Licensed International brand	Pattern maker	Direct involvement in product development & quite important role in production
9	Private Labels	Designer	Direct involvement in product development & supportive role in production
10	Prominent Ladies brand	Product Manager	Direct involvement in product development & quite important role in production
11	Prominent Ladies brand	Designer	Direct involvement in product development & supportive role in production
12	Famous Hat brand	Product Manager	Direct involvement in product development & supportive role in production
13	Production	Production Manager	Direct involvement in production & supportive role in product development
14	Production	Quality / Pattern	Direct involvement in production.
15	Production	Wet pro-	Supportive role in product develop-

		cessing technician	ment & directly in production.
16	Administration	Administrative Manager	Supportive role in product development & production

A graphical presentation about the participants is represented in FIGURE 22.

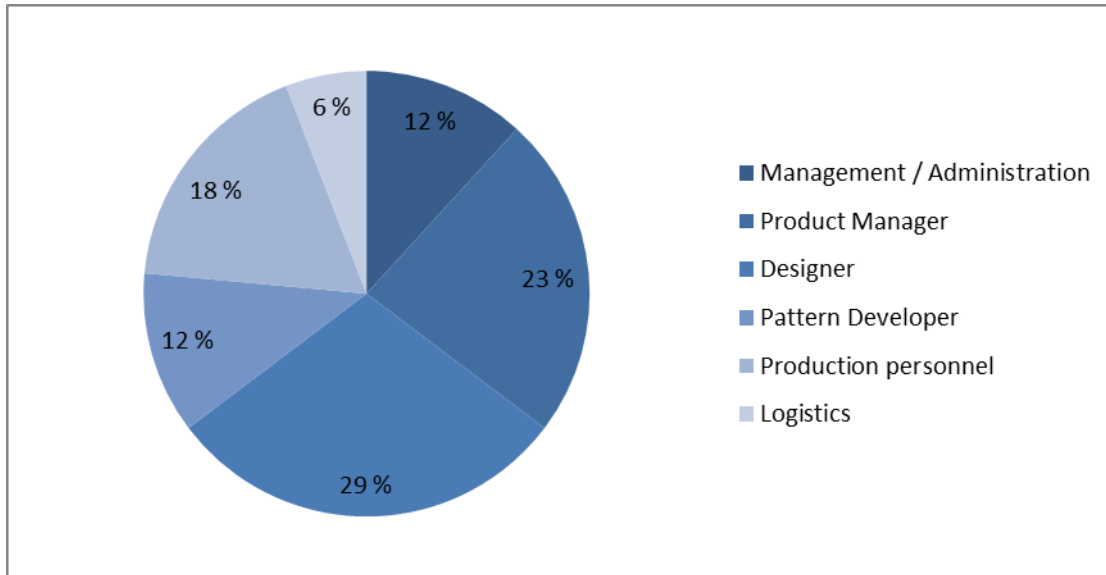


FIGURE 22. Interview participants by different functions.

From the graphical presentation in FIGURE 22, it is evident that the interview work has concentrated to collect information from the Product Managers and Designers. They play the most important role in product development and almost always involve in PD activities, thus they could provide very practical and intense information on product development and further processes. The next significant presence was from the personnel related to production activities. The research work demands some work on production activities also besides PD. So that production personnel would be the important source of information from production point of view.

#### 4.2 Outline of the consecution of PD to Production

The research work has put substantial effort on studying the processes comprehensively from PD to production. Undoubtedly, the conversations with the professionals from various departments have contributed a lot to information collection. The study has perceived that it is critical to determine the working methods of different blocks, which will reveal the essence of aligning the total process. An aligned process with



rational production planning is the key to on demand product development and corresponding customization for production.

It is recognizable that most of the activities during product development stage are based on the seasonal products which start with trend research. For the seasonal fashionable products, a lot of involvement was observed during the PD stages. However, a bit vague picture was seen during the transition period from PD to production. All the activities from the beginning up to the end were studied cautiously to attain the present picture and potentials for further analysis. Clustered content table (Table 2) was built based on the interview results and collected information on-site.

*TABLE 2. Clustered content of consecution of entire apparel PD to production process Profile of participants.*

<b>Event</b>	<b>clustered acts / chief actors</b>	<b>Brief illustration of acts</b>
Trend Re-search	Setting the base for PD process through trend research.	<ul style="list-style-type: none"> <li>- Collection of trend information through idea trip and shopping from international market, shopping from local market, fashion publication, websites, and fabric fairs.</li> <li>- Analysis of collected trend forecasts.</li> <li>- setting seasonal theme and preliminary planning for product range.</li> </ul>
	Trend researcher	Product Manager, Designer and occasionally Technical Personnel.
Product development	Anticipation through testing ideas and developing prototypes.	<ul style="list-style-type: none"> <li>- Anticipation of product range and setting the base range.</li> <li>- Fabric selection based on the idea collected from fabric fairs and assortment of newly developed fabrics from the suppliers.</li> <li>- Pattern selection from the pattern bank and development of new pattern. Test for fabric shrinkage and effect on the product.</li> <li>- Select product colour, shade, detailing like embroidery, labels, stitching and other details.</li> <li>- Development 1<sup>st</sup> proto and corrective 2<sup>nd</sup> or 3<sup>rd</sup> proto as per necessity. Salesman samples.</li> </ul>

		Several proto meetings.
	Product developers	Designer, Product Manager, Pattern Maker, Finishing Expert.
Actualize product range	Setting the product range	<ul style="list-style-type: none"> <li>- Confirm the final product range and development of salesman samples.</li> <li>- Sales meeting along with the product range catalogue and product price.</li> <li>- Sales forecasting and potentiality of sales.</li> <li>- Transfer product development knowledge to the production team and check for manufacturability.</li> </ul>
	Sales team	Product Manager, Sales Representative.
Customization for production	Agile Production	<ul style="list-style-type: none"> <li>- Technical specification of products.</li> <li>- Product size assortment.</li> <li>- Production planning.</li> <li>- Ordering raw materials and Scheduling.</li> </ul>
	Planning, Sourcing & Production team	Production Manager, Logistics Manager, Production Planner, Technical Personnel and purchase department.

From TABLE 2 it is apparent that the entire activities from the beginning until the end were divided into four crucial parts. In general, good association between the parts was observed. More specifically, coordination among the different tasks in PD stages, e.g. trend research, product development and finalizing the product range was dealt professionally. However, there are some external factors that have intense influence on the organization and schedule of the PD activities. Those are mostly out of the control from the organization, but possibilities have observed to minimize those inconveniences.

All the first three blocks are functional quite evenly, however the fourth phase and the transition towards this phase requires more attention. Apparently the introduction of new players into the scene and depart of most of the earlier performers from the action affects a lot. The situation creates a transition phase and many things are performed and intended to perform automatically. Software and databases assists those tasks to be performed in automatic manner, nevertheless the importance of human interaction was also perceived as an important factor.

### 4.3 PD & production process comprehended from interviews

The interview questions were formed in way to cover up the acts from the beginning up to the end. All of the interviewees have presented their knowledge on trend research, product development, product range finalization, customization and organization of production. It is to be mentioned here that all of the participants did not possess a deep understanding on all the parts of the entire process. It is researcher's knowledge and caliber to extract the right information from the appropriate person from the vast information collected. However, participants who were involved in similar tasks have identified the corresponding processes in quite similar fashion. A complete picture is sketched of the entire process as acquired through the information collection, presented in FIGURE 23.

The process begins with the trend research by the core personnel involved in the product development process. Product managers and designers collect information from various sources like fabric fairs, idea trips and shopping, internet sites, magazines, trend books etc. Based on this information designers develop the styles and models and creates product card to proceed for prototype. It includes product model, designing details, color, trimmings etc. Pattern makers develop patterns as required by the designers. Prototypes are made after pattern picture is sent to the sampling department with the product card. Once products are ready from sampling department, the prototypes pass through dry and wet processing as per requirement. Products usually get the final look here. After necessary treatment products are controlled through quality control department and finishing process is done as required. Each prototype model passes through this routing during first prototype development. All the first prototypes for a brand or line are made in this way.

Proto meetings are held by the product manager, designer, pattern maker and technical personnel and after that corrective actions take place. If corrective actions are necessary a second proto is made, otherwise salesman samples are made for the sales people. Sales meeting takes place after all the salesman samples for the entire collection is ready. Product managers and designers provide the information and idea behind the products to the sales people. In this step, a product range is finalized.

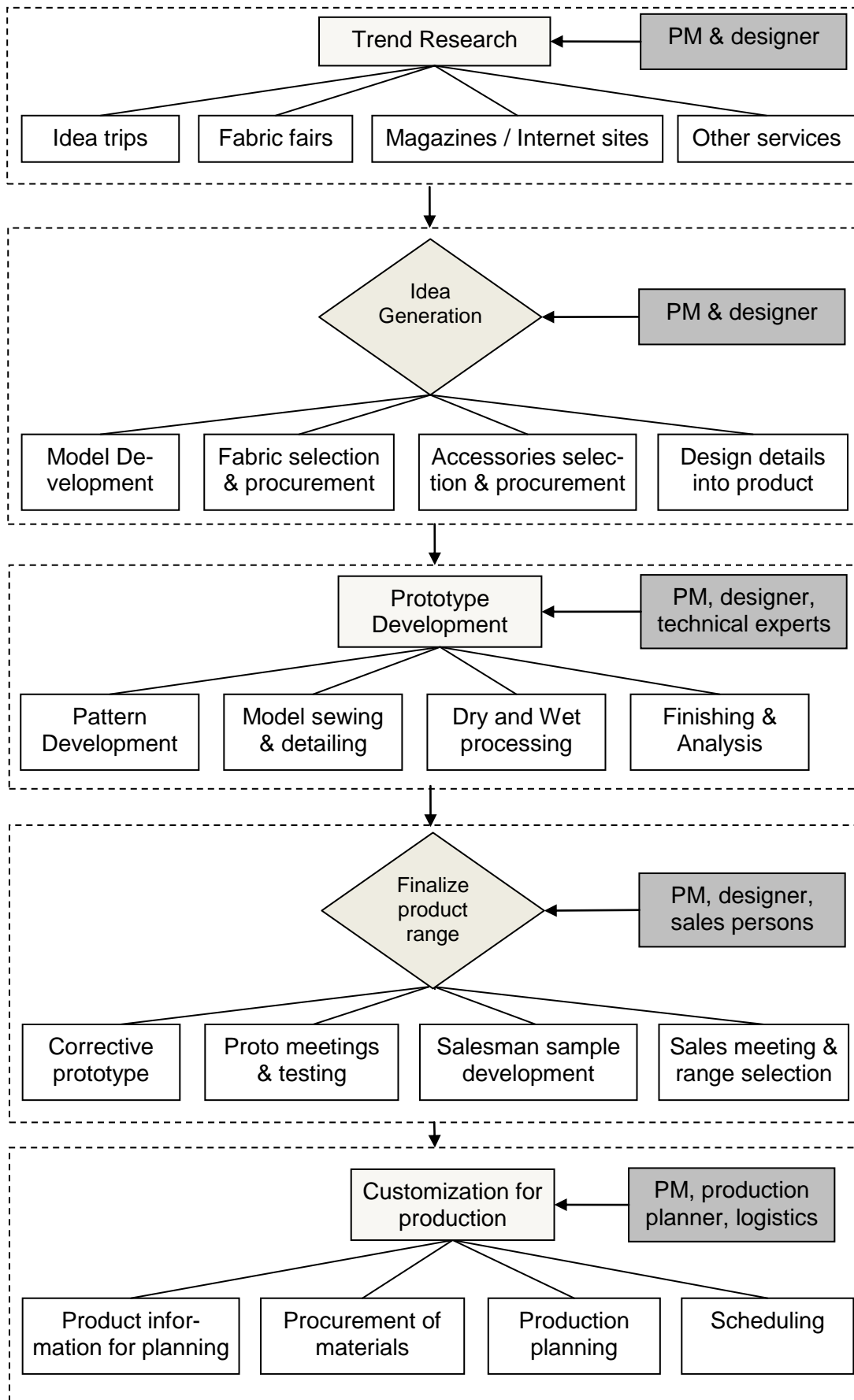


FIGURE 23. PD and production process comprehended from interviews.

Product managers provide necessary information and quantity to the purchaser and production planner. So that purchaser could procure necessary materials and accessories and production planner prepare the plan. The production planning is generally quite flexible to meet the changes in demand. Scheduling is done as per the job requirement in the production plants and promise to customer.

FIGURE 23 depicts the product development process and customization for production. It is to be mentioned here that presented figure is quite similar to the PD process for seasonal models. The seasonal continuous models are also come out as byproduct from this development process. However, there is a big portion of sales are committed by “Never Out of Stock” products. There are not that much activities and effort observed for those NOS products. These products are produced just at the time when it is required, but no intense work compared to the seasonal models.

The overall PD process seems to be quite long and a considerable amount of effort was noticed by the product development team. Once the product range is finalized, no proper method for transferring the PD knowledge to the production was seen. There is a high possibility that misunderstanding and misleading information might pass through because of the missing interaction between PD and production personnel. As it is mentioned that, there are different product groups and the activities related to those groups are different. So, it is also to be considered whether the plant should follow agile concept or lean method. Private labels and a portion of the seasonal products from different line could demand agile process. However, NOS models could be processed by following the lean methodology, because it requires quick processing with minimum resources.

#### 4.4 Analysis of contribution by different product types

The overall study came up with three key business types. It was observed that each type has a particular mode of accomplishing the task specially while initiating the process. The collected sales analysis from the earlier years provides a view of the portion shared by different segments. The leading type represents seasonal products and consisting of two major seasons followed by supplementary seasons. Product development for seasonal products outlast round the year albeit two principal seasons. Consequently product development and production has learned and prepared for instant response to the necessity over the years.

Constant product development practice facilitates on demand product development for other types too. Because a wide range of tests of fabric and their finishing is done, the platform gets ready to carry on PD for other lines, e.g. continuous models. Each particular brand and also other types follow the seasonal development approach. There is not any noticeable separate effort recorded for seasonal continuous models. The work on seasonal models seems to be aligned with the seasonal continuous models. However, effort on continuous models during PD stage is quite ignorable though this type contributes a major portion in sales and profit. Graphical representation of the portion shared by these three major product lines is presented below in context to sales, profit and quantity.

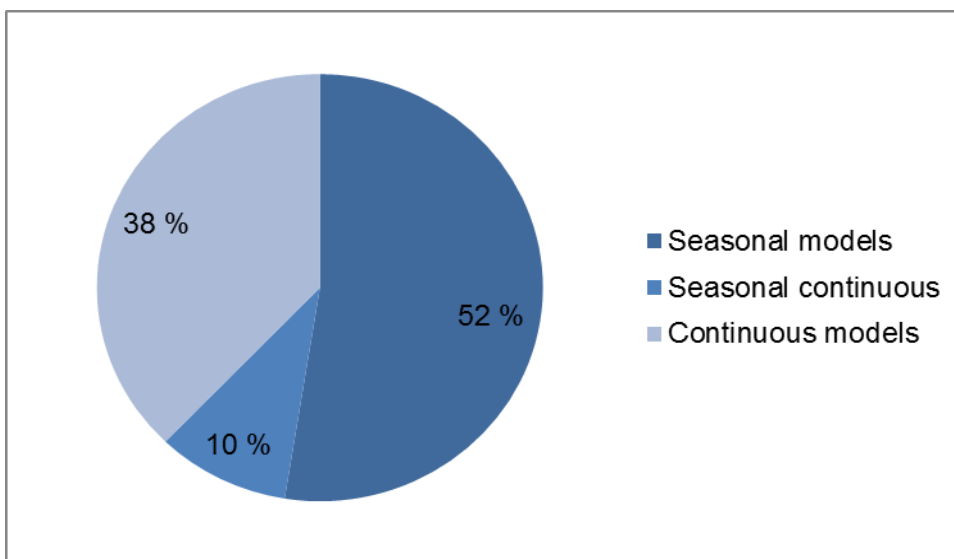


FIGURE 24. Contribution on sales by three different product lines.

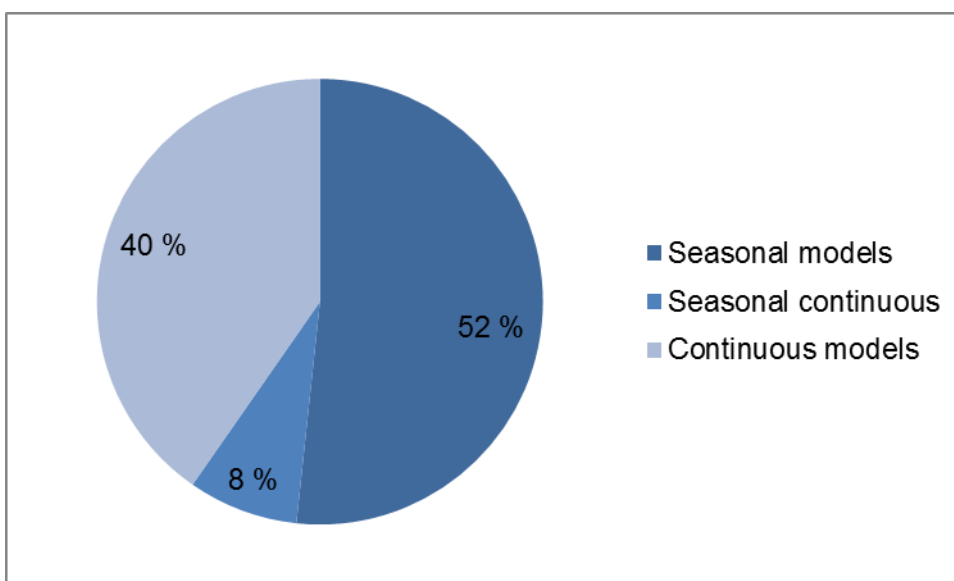


FIGURE 25. Contribution on profit by three different product lines.

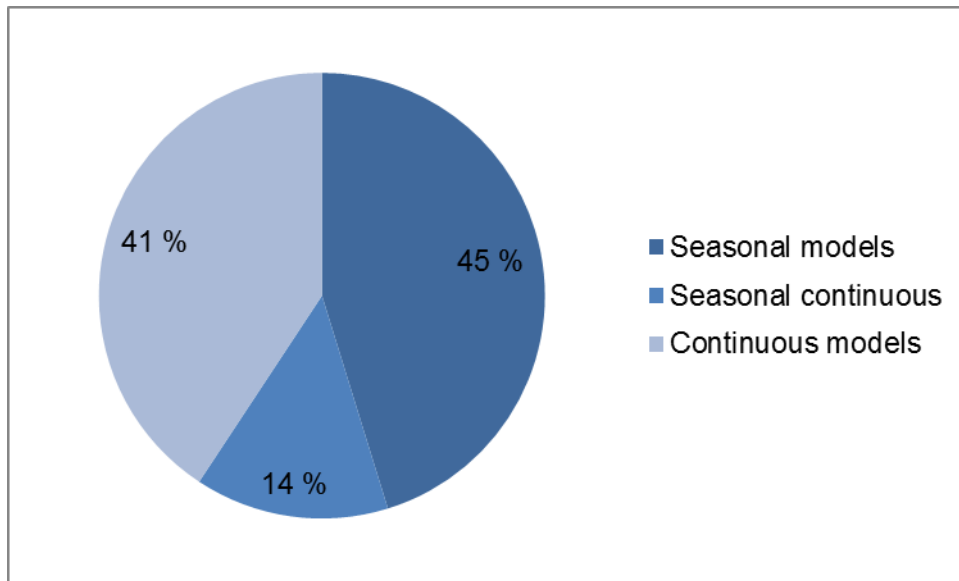


FIGURE 26. Contribution on sales quantity by three different product lines.

#### 4.5 Consideration of "On demand" PD and customization for production

The term "On Demand" PD and customization for production was described to the interviewee during the interview process. Some of them apprehended the term and acknowledged the importance. Though, it was quite unclear to a considerable number of the participants. Most of the participants mentioned the necessity of agility in PD process and they are aware of the slowness of the process. Nevertheless they didn't know, how and what could improve it. Almost all of them mentioned about long procurement time of the materials, but they added that it cannot be solved by them. But "On Demand" PD cannot allow such long procurement times, if it is supposed to be agile enough. A few of them also added the location of the sampling department, as a cause of the longer process time.

Customization for production with ample agility depends greatly on the flexibility in production planning and proper organization of the production process. Of the participants, many of them don't have a clear picture on production planning. However, some of them think that the production planning works quite well. Those who have a good understanding on production planning admitted, that it is not sufficient and production planning should be improved to offer more flexibility. Customization possibility makes the systems flexible and thus agile. Production planning and proper execution during production with perfect scheduling goes hand in hand. Many of the interview-

ees believe that the production process is agile enough to execute the plans on demand. Some of them feel that the company is not up to the mark with the technology and some improvements are necessary. Those improvements are mostly concerned to elimination or substitution of manual tasks to semi-automatic or automatic work phases.

The changes in the layout, as required for different models were also seen as a concern while considering the setup time and corresponding costs. Setup cost involves the time involved in downtime in operation and the cost necessary for the rearrangements of the layout. This is the cost of setting up the production equipment to produce a different item than the one previously produced on that equipment (Summers, 1998). To be agile these setup times and downtimes should be reduced or excluded. As the firm deals with small lot sizes and different styles, it may require time to time interchange the layout. It is found that participants, especially who are related to production activities are not enthusiastic about changes in layout. Involvement of production personnel in PD can play a great role in development of products that requires less layout alteration and if necessary, arrangements can be done beforehand. Production personnel are able to provide guideline to produce a particular product in more practical way. If consider their opinion, product could be produced during PD process with minimum changes that could make also the production process easier.

#### 4.6 Critical steps in PD process

The study attempted to find out the most critical steps in PD process. In fact, a clear question was in the list of questionnaire. After analyzing the interviews, it has not been attained any concrete decision about the critical steps. However, during the discussions many of the participants mentioned about the timetable during the PD. Besides, the availability of the materials, accessories have also found critical for PD process.

To maintain the timetable in PD, two major points were emerged during discussions.

- **Suppliers and their commitment play the most important role.** Product managers and designers select necessary materials for the upcoming seasons from the fabric fairs or meeting with the supplier with their collection. Because of tight schedule, it is crucial to get the fabrics quickly. Fabric sourcing is the fundamental action of the PD process. Once fabric is in house, several tests are done to get the right look and shrinkage ideas are taken out of those tests. Once the right look



is achieved, prototype is made and processed. If the PD team experiences any discrepancy, they would like to go for other prototypes, otherwise salesman samples are ordered. The total process is quite long and occurs in two different places. So, if there is a delay in fabric sourcing the total process will be delayed and in the worst case the product could not be produced because of the delay in getting the right materials.

- **The second crucial matter upraised is the location of the units.** The total PD process cycle time for making a single product is quite long. In many cases, a corrective proto has to be made which has to pass through another long cycle. Ultimately the PD cycle for a specific model gets delayed. These discussions confirm that, if the timetable problem could be solved and product could get finished quicker, PD activities could be more efficient. That could reflect positively on demand and volume.

#### 4.7 Summary of analytical presentation of questionnaire data

The research work method of data analysis is mostly based on qualitative analysis. However, the importance of determination of relationship among the determinant factors is also critical. Data analysis by descriptive statistics intended to examine those potential connections. It is to be noted that a simple statistical method is chosen for the simplicity of the understanding of the results.

For this analysis, important issues were selected from the interview questionnaire. These specific topics or issues from the interview of each participant were rated on a scale of 10. TABLE 3 presents the calculated values of mean, standard deviation, minimum value and maximum value of the rated values of interview data. The following discussion tries to represent the significance of the values presented in TABLE 3.

The descriptive analysis represents that a considerable amount of the participants do not know or they are not clear about the PD strategy for a specific brand or organization. It was not traced a very strong position about the role of customer or supplier in PD activities. But it is not also negligible as many of them recognized the role of customers or suppliers in PD. A very strong stance can be seen in favor of the importance of receiving fabric or accessories on time. Importance of timetable mostly depends on the on time receipt of the fabric and accessories, therefore it is a crucial factor. The values on product pricing represent that it is also quite important consideration in PD. Influence of customer involvement in PD activities did not show a very

strong position compared to other topics. To some brands it is really critical, on the other hand for some brands it is not so important.

The values show that the company is missing some technological competences that could support the PD activities as well as the production more efficient. Majority of the participants agrees that it is necessary to have an organized way to transfer PD knowledge to production. Results show that the production planning capability is not up to the mark and it needs some improvement. Most of the interviewees have agreed the influence of the suppliers in production planning. Results represent that the PD activities are somewhat smooth. Mean value of importance of involving production personnel in PD activities represents that, it is very important as almost all of the participants quite strongly agree on it. Many of the professionals do not know or they are not aware about the delay in PD activities. Result value expresses that the company is not quite agile in PD and production activities. The value justifies this particular research, where the firm particularly needs improvement. A bit vague result was found about the necessity of coordination among the brands.

*TABLE 3. Descriptive statistics of questionnaire data.*

<b>Topics</b>	<b>Minimum value</b>	<b>Maximum value</b>	<b>Mean value</b>	<b>Standard deviation</b>
PD strategy for brands	0	9	5.42	2.91
Role of customer/supplier in PD	6	10	7.75	1.42
Importance of receiving on time fabric/accessories in PD	8	10	8.71	0.73
Importance of timetable in PD	7	10	8.62	0.77
Influence of product pricing	5	10	8.21	1.25
Influence of Customer involvement in PD	7	10	8.00	1.08
Presence of ample technological competence	6	9	7.27	1.03
Necessity of organized process to transfer PD knowledge to production	7	10	8.67	0.98
Production planning capability	5	8	6.57	1.02
Suppliers influence in production planning	7	10	8.86	0.86
Smoothness of PD activities	7	9	8.07	0.83
Importance of involving production per-	7	10	9.00	0.93

sonnel in PD activities				
Effect of delay in PD activities	5	9	7.80	1.48
Agility of PD and production	5	8	6.58	0.90
Necessity of coordination between brands	6	10	7.91	1.30

#### 4.8 Summary of analytical presentation of collected data

During the field study some data were collected on sales and investments of previous years. Those data were analyzed through correlation measurement. Correlation measures the strength and direction of relationship between two variables (Stevenson, 1996). The correlation between variables is calculated by using the following equation (Adapted from Stevenson, 1996).

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{(n(\sum x^2) - (\sum x)^2)} \cdot \sqrt{(n(\sum y^2) - (\sum y)^2)}}$$

Where,

r = correlation value

x = variable 1

y = variable 2

n = number of data

TABLE 4 represents the data of the sales and investments of the previous years, where sales and investments are two different variables. Correlation value is to be calculated by following the above equation.

*TABLE 4: Sales vs. investment data.*

Year	Sales	Investments
2012	15009	162
2011	15024	932
2010	14566	971
2009	16039	971
2008	15007	971
2007	13782	202

In light of the data from the above table, correlation value 'r' was found +0.52. A correlation of +1.00 indicates that changes in one variable are always matched by

changes in the other; a correlation of -1.00 indicates that increases in one variable are matched by decreases in the other; and a correlation close to zero indicates little linear relationship between two variables (Stevenson, 1996). As the correlation value between variables sales and investments was found +0.52, it can be said that there is a possibility of increase in sales if investments are done accordingly.

However, practically it is not possible that, all of the investments will be reflected in sales. Many investments are done, as upgrade is necessary to keep continue certain operation, e.g. upgrade equipment. On the other hand, some investments are done to increase sales. The correlation value found from the calculation is a general value to achieve an understanding between sales and investments. To get a practical relationship between sales and investments, the investment data should be categorized. The investments that are intended to improve sales can be analyzed with the following year sales data. Because, it takes time to get sales result from a particular investments. In this way, a practical relationship between investments and sales could be achieved. This particular study was not able to do it, because lack of investment data which is used for improve sales.

*TABLE 5: Sales vs. PD expense data of 2011-12.*

<b>Line</b>	<b>Sales</b>	<b>PD expense</b>
Brand 1	4252	112.2
Brand 2	2618	122.5
Private Labels	2202	73.5
Brand 3	2314	102.5
Brand 4	2936	125.9

TABLE 5 represents sales vs. PD expense data for the year 2011-12. These data were analyzed to find out the correlation value between the variables. The main reason was to examine whether there is any strong relationship exist between sales and PD expenses. The correlation value has been found +0.90, which is almost closer to +1.00. The value denotes a strong relationship. So that if there is an increase in PD expenses it will directly reflected in sales. However, this correlation value also should be achieved with categorized PD expense data to get a practical relationship. PD expenses that are done to improve sales should be categorized and checked with corresponding sales data.

## 5 RECOMMENDATIONS

The purpose of the study was to understand and analyze the “On Demand Agile PD Process” and an organized way to reproduce customization flexibility possibility in production. The research has put comprehensive effort to study the theories related to general product development, PD process for apparel products that is suitable to specific condition and location. Also the theories related to concurrent PD and earlier works on customization for production were studied. This summary statement tries to state briefly this total effort.

### 5.1 Summary of the study

Throughout the research work it was always mentioned “Product Development” instead of “New Product Development”, because of the continual activities in PD. For apparel companies PD is a continuous process and extent of the PD activities are large compared to most other industries. Because apparel industries deal with many different brands and PD is required throughout the year. These extensive activities are never easy to control which was found during this study. Moreover, additional pressures from volatile and competitive market ask for even more profound and prompt action. These labile activities can be properly compared with the “No-interval Coherently Phased Product Development” model by May-Plumlee & Little (1998). Furthermore, NICPPD model has considered production besides PD, which is another reason to select this model. Production is an important component in this particular study.

The study has revealed that there are three major product types from all of the brands. All of those types do not really follow the same procedure learned from NICPPD. Especially, the seasonal continuous models and NOS models are produced in different way. From operational point of view the studied PD process, more specifically PD for seasonal models is quite analogous. But some questions were raised that should be taken into consideration for solution. Some recommendations for accomplishment are discussed in this chapter later. The recommendations emerged from the comparative study of the theories and the practical study and data analysis.

The entire study traced out some disarrays in execution of PD activities, which also reflects in production planning and production. Because of the size of the project, it was not possible to go through all of those disarrays. However, a lot of works were

done on the critical issues and recommendations on those issues are compiled in this literature. It is believed that many complications will be eased once those recommendations are executed. It is also not necessary to work with every single disorder, if the critical issues are solved.

For “On Demand” product development, the PD process should be agile enough. Agility demands quick action in every stage of PD. Agile Product Development largely depends on the quick receipt of fabrics. The late receipt of the fabric often disturbs the timetable in PD and production process. Better practice of supply chain management might be able to improve this situation. Product development and finishing departments are located in two different locations. Generally products are delivered from sample sewing department to the finishing department twice a week. It is to be mentioned that the schedule is being maintained quite nicely. But in any kind of rush situation or disorder, the process demands quicker action. Because of the distinct location, personnel involved in sample sewing and organization of initial product making activities are not able to analyze the final product. This is found as a significant gap in PD process. On the other hand, products made and finalized are passed to production department without any proper method. This research work recognizes this matter as a serious gap in transition phase from PD to production. This is not directly related to PD, but very important for the agility of the entire process.

The overall production planning was not found quite ready for the Agile Production through customization. Flexibility in production planning and also scheduling is the key for fast reaction to the demand from the customer. A proper coordination between production planning and scheduling is critical. The entire production process and each department is just managed rather than scheduled by a proper method. Although existing production planning, provides the guideline but it does not plan for each single step of the entire process. All the steps throughout the process could be reorganized by checking the bottlenecks and over capacities. However, the extra capacities can be supportive for agile processing. The company already deals with small production batches. From that viewpoint it is already practicing the agile process which is an important advantage.

While considering the big picture of the organization, it is in a good shape towards “On Demand” processing from PD to production. It has an excellent positional advantage that can be converted to logistical advantage and in fact the advantage has committed already. The production capacity is suitable for agile manufacturing if it synchronize with proper production planning. The organization is also seriously com-

mitted towards green processes that help them to save energy and utilities, thus able to reduce production cost. If all of those competitive advantages are combined and executed properly, it could be a perfect example of the existence of an apparel company especially in Europe. Because it is dealing with the manual or semi-automatic batch operations, that is indeed quite difficult in this part of the world to continue operation. This research tries to exhibit those gaps with the outline towards advancement.

## 5.2 Concurrent PD in association with production

There is a separate sampling department which executes the tasks required by PD. The sampling department receives the order from the product development team or more precisely from the designers. All the required information in the form of a product card is passed to the administration of the sampling department. The information is then passed for execution through cutting, detailing, and sewing steps. The ready product after sewing is then sent to another location for dry processing, washing or dyeing. Some more detailing might be necessary after that. Finally product passes through finishing step. Entire process is handled by personnel responsible for PD.

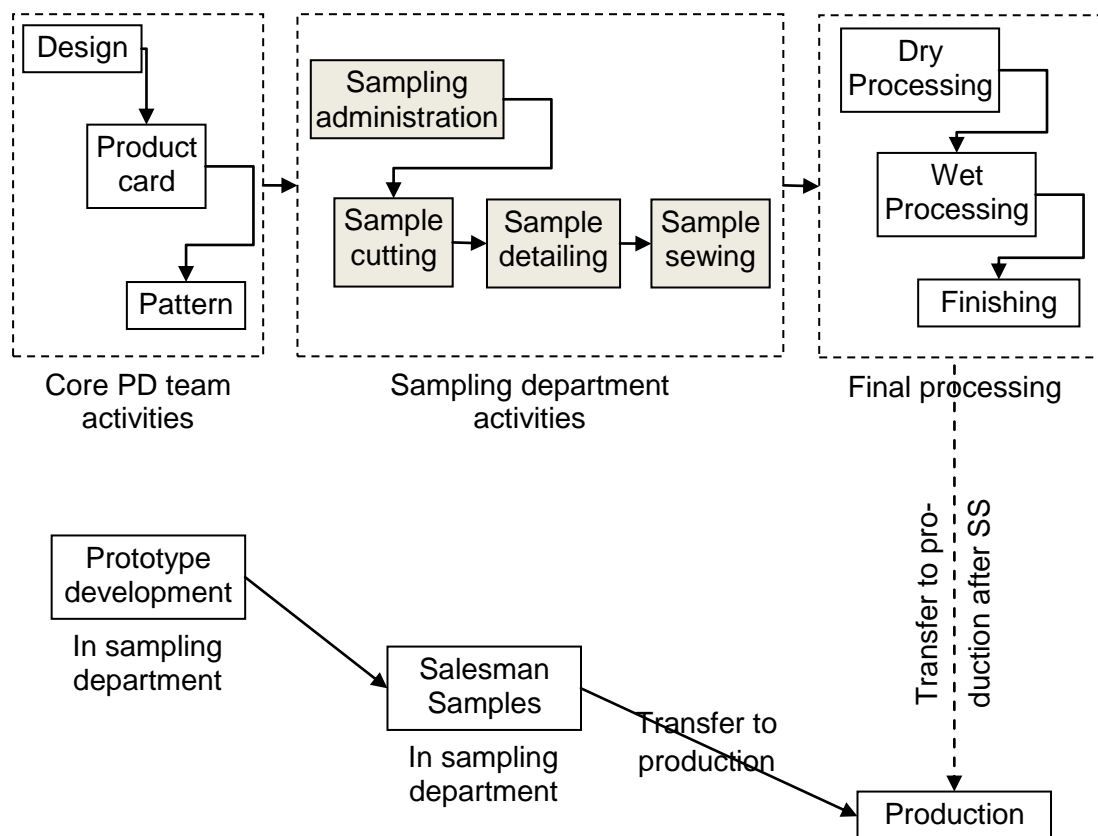


FIGURE 27. Present product development steps.

The normal PD process carries through different steps are shown in the FIGURE 27. The entire sampling process is presented into three groups. When all tasks of those three steps are fulfilled, the product is transferred to production once order is committed. The transfer of information from PD to production is mostly passed electronically. The concurrent product development attempts to minimize this gap. Concurrent PD suggests that PD process will be performed within production, so that production is in touch with PD. FIGURE 28 illustrates the suggested product development process based on concurrent PD concept.

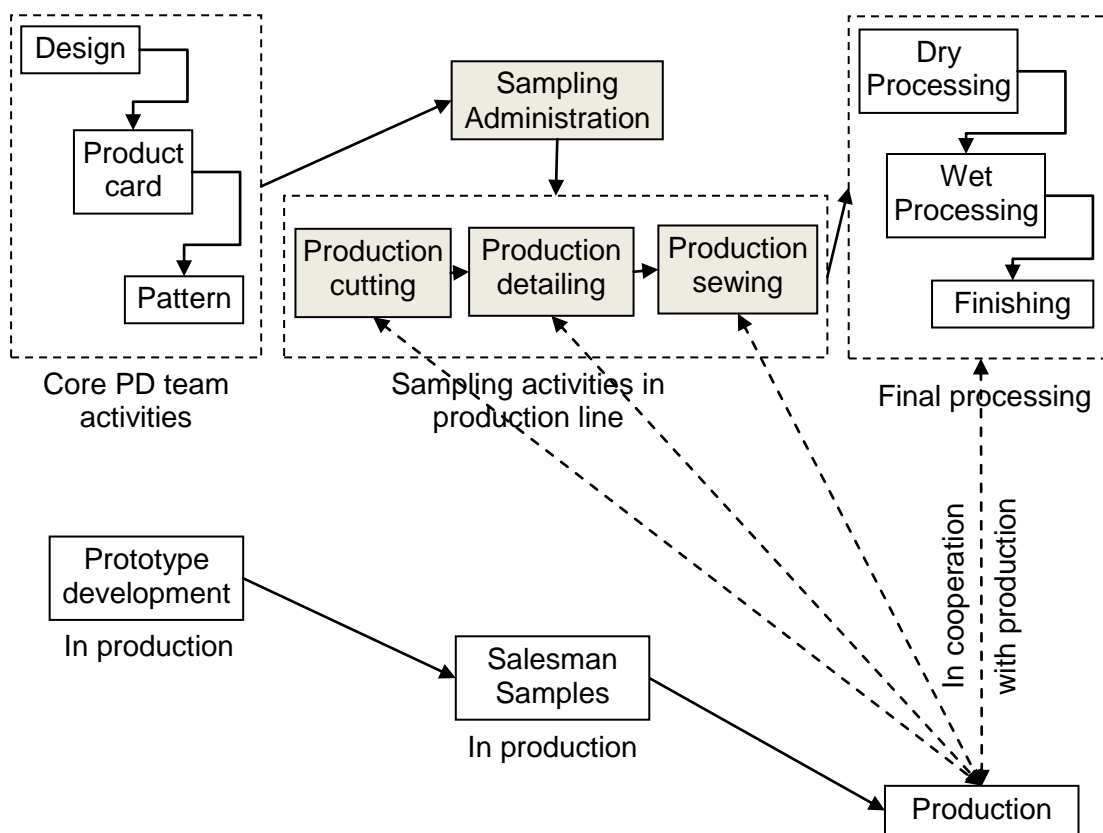


FIGURE 28. Concurrent product developments in association with production.

Parallel PD process within the production is a concept of taking the product development together with production. The benefits thought of this parallel approach are as follows:

- Production personnel get to know about the products that are expected to come in production.
- Tasks on ground level are performed jointly, thus communication between PD and production is enhanced.



- During execution, expertise of different departments can be utilized that might not be available to the PD and related departments.
- Usually the production activities are agile. The agility of the production can be employed to the PD activities, thus the overall PD cycle time can be reduced. This ultimately makes the PD process agile.
- While the prototypes are produced within production and production professionals are involved, they can easily identify manufacturing capabilities. So, more realistic products are achievable that can be really reproduced. It will ensure that the promise that is given to the customer and the product that is submitted as sample is going to be reproduced in large volume too.
- If it is necessary to procure new processing equipment for a new task, it would happen realistically much before as professionals in production are concerned about the right machine for reproducibility.
- Professionals can examine the technical feasibility of the entire process to produce a particular product. If any special expertise is required that can be procured and practiced early on.
- During the simultaneous PD with production, a picture can be achieved about the utilization of the equipment. If some equipment has possibilities of less utilization, the concern can be raised and it might be possible to change the process layout to include less utilized machineries.
- There is possibility of overall improvement of the product quality. Many quality problems usually arise because of the less understanding about a particular product that has just come to production without proper method. So, many problems are revealed during production process only.
- Products could be developed on any of the production lines (if multiple production lines exist) once it is practiced throughout.

If properly implemented, concurrent PD could help exceptionally the firm in organizing the PD activities. This approach will bring agility in PD process and also it will be able to reduce time and costs in manufacturing products because of the reduced quality problems. When a firm deals with small batch sizes, many varieties of products are naturally in process. Thus many different types of quality problems are assumable. It has found that quality faults emerge almost proportionally to the product types. A lot of effort is noticed for the solution of the emerged quality problems. But if precautionary steps are taken beforehand, a lot of time could be saved. Concurrent PD helps to reduce the extent of quality problems and therefore improves the agility of the manufacturing process. All of these activities and advantages could significantly reduce the process cost in PD and production. However, it is also to be concerned that the in-

involvement of the production professionals in PD could impede towards new development. It is not uncommon that if the professionals in production realize during PD stage that certain process or product could create problem during the production process, they might be able to avoid or change the process prior to finalize it.

### 5.3 Rearranged group layout for process smoothness

This study revealed that most labor intensive and time consuming activities are related to sewing operation. All other activities prior to sewing are organized and automated. Especially the cutting is done in an automated way, controlled by software operated controller, which facilitates flexibility in size variations. The post processes following sewing are also quite technical and well organized in terms of technology, flexibility, process, capacity etc. There are also certain possibilities to include improved automatize process in garment finishing, which could reduce processing time and improve quality of products. The focus towards agile processing is therefore on the sewing process, which is the central point of consideration.

The sewing process is consists of several sequential steps in a linear processing unit. All steps are executed in different kind of machines. Generally, most of the models follow certain steps or groups of steps. Single processing for a similar task can be done differently by different machines. In other way, there are some specific process steps that may contain a group of machines, by which particular operation can be done. For example, detailing or ornamenting a back pocket of a trouser can be done by a simple ornament machine or by complex and modern embroidery machine. However, generally it is not necessary to use both machines for a product or it is normally avoided. These similar types of machines can be grouped for a particular unit operation. One of the machines from this group is used for a specific model. These machines can form a production cell.

Cellular manufacturing is a type of layout in which machines are grouped into what is referred to as a cell (Stevenson, 1996). In these kind cells, group of machines performing similar tasks are arranged as a group. The grouping process is known as group technology and involves identifying items with similarities in either design characteristics or manufacturing characteristics, and grouping them into part families (Stevenson, 1996). In case of sewing activities, it is possible to group the operations because there are many processing steps involved in the production line and there are many similar unit operations requirements. The main reason to bring CM in this

particular processing and case is, that it will support the process to be agile. The cellular manufacturing aspect of GT was also recognized as a core element of Just-in-time (JIT) production systems (Suresh & Kay, 1998).

The case study plant deals mostly with trousers and therefore the layout planning is based on the trouser assembly. This study has not gone deep into the processing steps, but focused mostly on the basic major processes. A trouser assembly line consists of the following major processes:

- Preassembly
- Front part arrangement
- Back part preparation
- Main assembly
- Edges preparation
- Finalizing

FIGURE 29 depicts the idea of grouping tasks for a work phase (for example, main assembly of a trouser). A work phase may contain several unit operations. Some of those operations may contain a task that is mandatory and have to be executed. In this case this step is fixed. GT is not required for this phase. On the other hand, when a specific task can be done with different possibilities, then GT can be applied. "Cell 1" in FIGURE 29 represents a cell where three different operation possibilities are grouped together. Any of the option from the cell can be chosen to execute a certain task. Principally all of the machines are able to do the required operation, but a particular machine in that cell is employed as per the specialty requirement of a particular product. The idea depicted in FIGURE 29 is concerned with the layout of the machines or equipment, but not manpower. The corresponding operator together with machine might be shifted with the equipment but that is a different consideration.

The ultimate goal of the CM is process smoothness. By combining different machines, equipment and personnel into a group or cell, total responsibility for making a set of parts can be delegated to the group (Suresh & Kay, 1998).

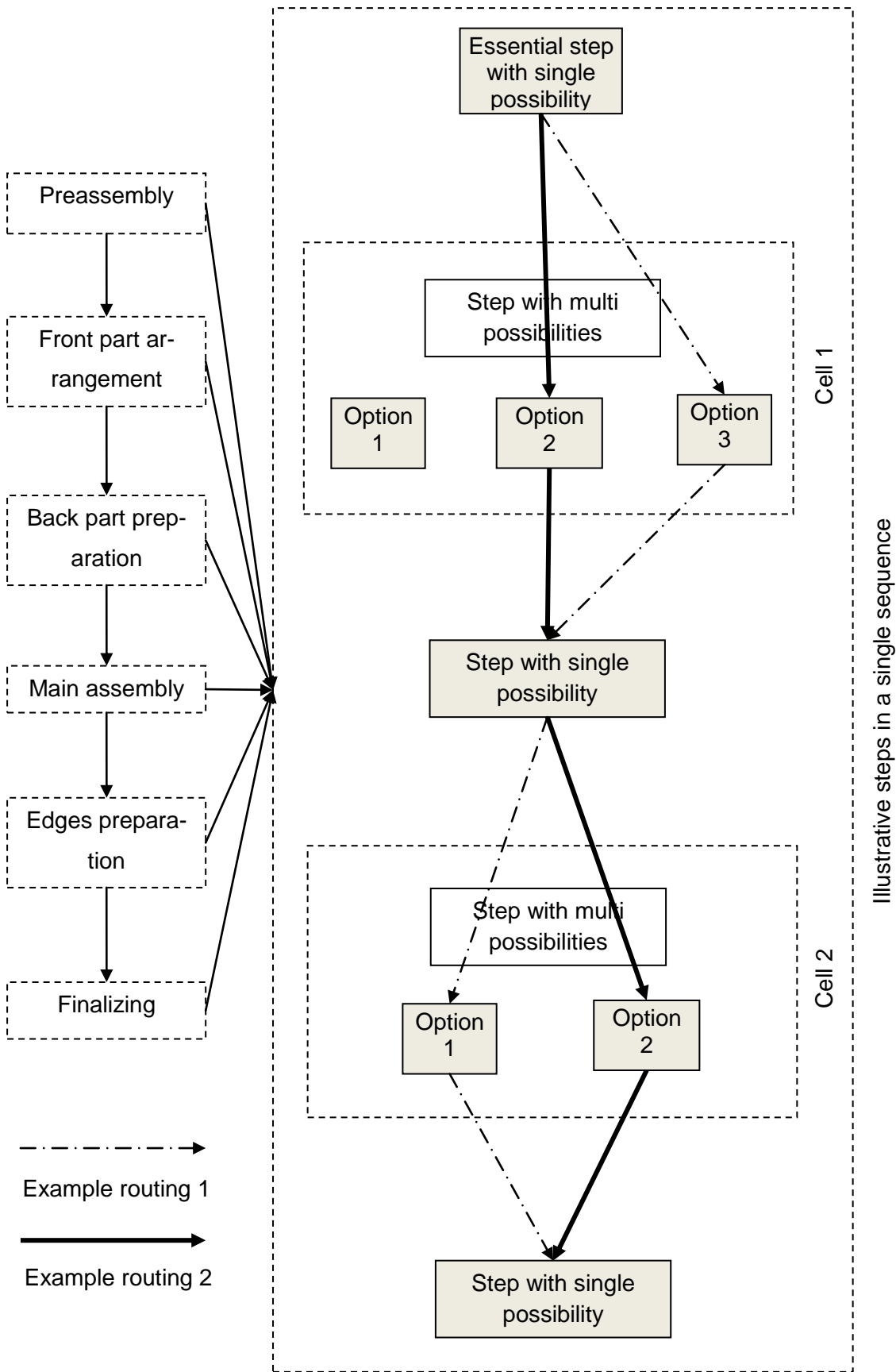
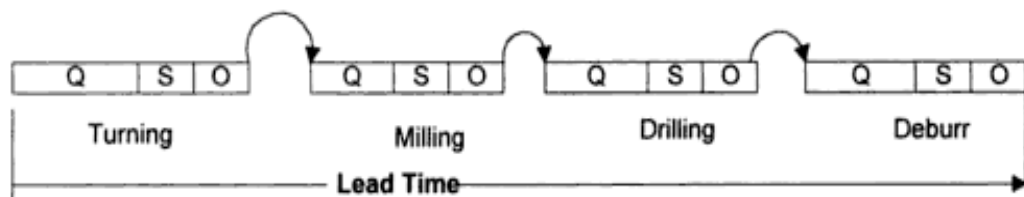


FIGURE 29. Illustrative steps with grouping tasks for a sequence.

The clear job routing in CM reduces the need of process control and that is why less supervision is required. In this particular case, reduced supervision is even more meaningful and necessary, because of cost sensibility. Agility and cost effective production is the key for the existence of such business in this part of the world and CM helps to achieve that by bringing the flexibility in the most important production process. FIGURE 30 shows the difference between functional layout and cellular layout as presented by Suresh & Kay (1998). It illustrates clearly, how the lead time is reduced by cell production.

### Operations In Functional Layout



### Operations In Cells

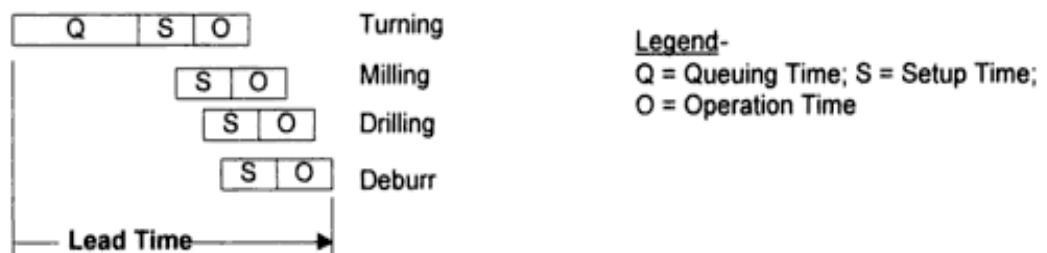


FIGURE 30. Operations in functional and cellular layouts (Suresh & Kay, 1998).

There are quite a many theoretical benefits known from GT. Essentially it helps in better routing and easiness in scheduling thus reduces lead time and WIP. When a plant deals with small batch sizes and many different kinds of products, it is quite helpful if there is less WIP inventory in between the work phases. It also helps to utilize the space in the production floor better. As the responsibility is delegated to every cell or unit, liability increases which helps in better distribution of load.

Once the grouping idea is implemented in a sewing unit, there might not be any loss of time due to setup or rearrange the line for a new product. This is a huge lack in the sewing lines as rearranging takes long time and resources. Especially, when the plant deals with small batches and great variety of products, they really cannot afford to allow such setup or change over time. Also maintenance of equipment could be bet-

ter scheduled with CM organization. Ultimately there will be a clear and common understanding the routing on the entire line, and the production planner could be able to see the utilization rate of the process and work phases. Finally, but not the least, the CM implementation would simplify the work flow in sewing line.

#### 5.4 Centralized pattern and fabric compilation

With the effort of PD activities in a specific season, a lot of fabrics, accessories, patterns are produced which are not used into the main collection of the particular season. It is also noticeable that the PD activities in every season start almost from the beginning and lasts until the end of the season. Therefore, it consumes a lot of time and effort. As there are many different brands and product lines are working under the same roof, knowhow can be diffuse from one brand another brand. If leftover fabric tests, patterns are collected and reused, that could help the firm in saving time and better utilization of resources. Because leftover resources could be useful for another brands.

In the questionnaire for data collection, one of the questions was related to coordination between brands. The result of this particular question was not quite impressive. The results indicate that action is necessary in order to improve the coordination between brands and segments. A centralized information resource could work as a virtual coordination place among the brands. Centralized pattern & fabric compilation is a concept on better utilization of resources and activities. Generally Major brands in the organization follow almost similar PD activities, though some dissimilarity has been noticed between the brands. Nevertheless, each brand deals with a lot of different kind of fabrics. The main sources of collecting new fabrics are fabric fairs and the in-house meeting with the fabric manufacturer or agents. In each season, a handsome amount of fabrics are chosen for trial. Those fabrics are then tested. Some of them are kept for that particular season, whereas most of them are leftover. It is to be noted that an extensive work is involved in trial and test and selection of fabrics.

Different lines attempt to try new patterns occasionally. It proceeds the same way as fabric tests. Some of those tests are included in the collection and some of them are leftover. A similar continuous effort is also imparted by the dry and wet processing department. Very little information from those efforts is really spread over and reached to different product lines. Even if information is available, it needs a com-

bined effort to really use those ideas in right cases. Thus compilation of those ideas could be used as a source of possibilities and tools for the designers.

This concept attempts to collect those unused tests and resources in association with the used one and convert to usable resources. The compilation would be formed through virtual collection as well as a real stockpile of the resources, e.g. patterns, fabric shades, color shades, different kinds of effect on the fabrics, used look effects etc. The new information that will come from the fabric suppliers, accessories suppliers and other sources will be straightway added to database and thus to stockpile. The entire collection of information will be remained in the form of a database through well-organized and user friendly software. This database should be connected to the organization's database and software platform. FIGURE 31 illustrates the idea of the information compilation concept.

The platform will facilitate the PD personnel to get previously unknown information about the PD activities spontaneously. The information will be ready-for-service and practical, because these were produced inside the company. The most significant advantage, that will be achieved through implementation of this concept, is reduction of time in activities. Task repetitions will be reduced significantly because of the visibility of activities by other brands or lines. It will also help to save cost in PD process. Ultimately resources will be used more professionally and comprehensively.

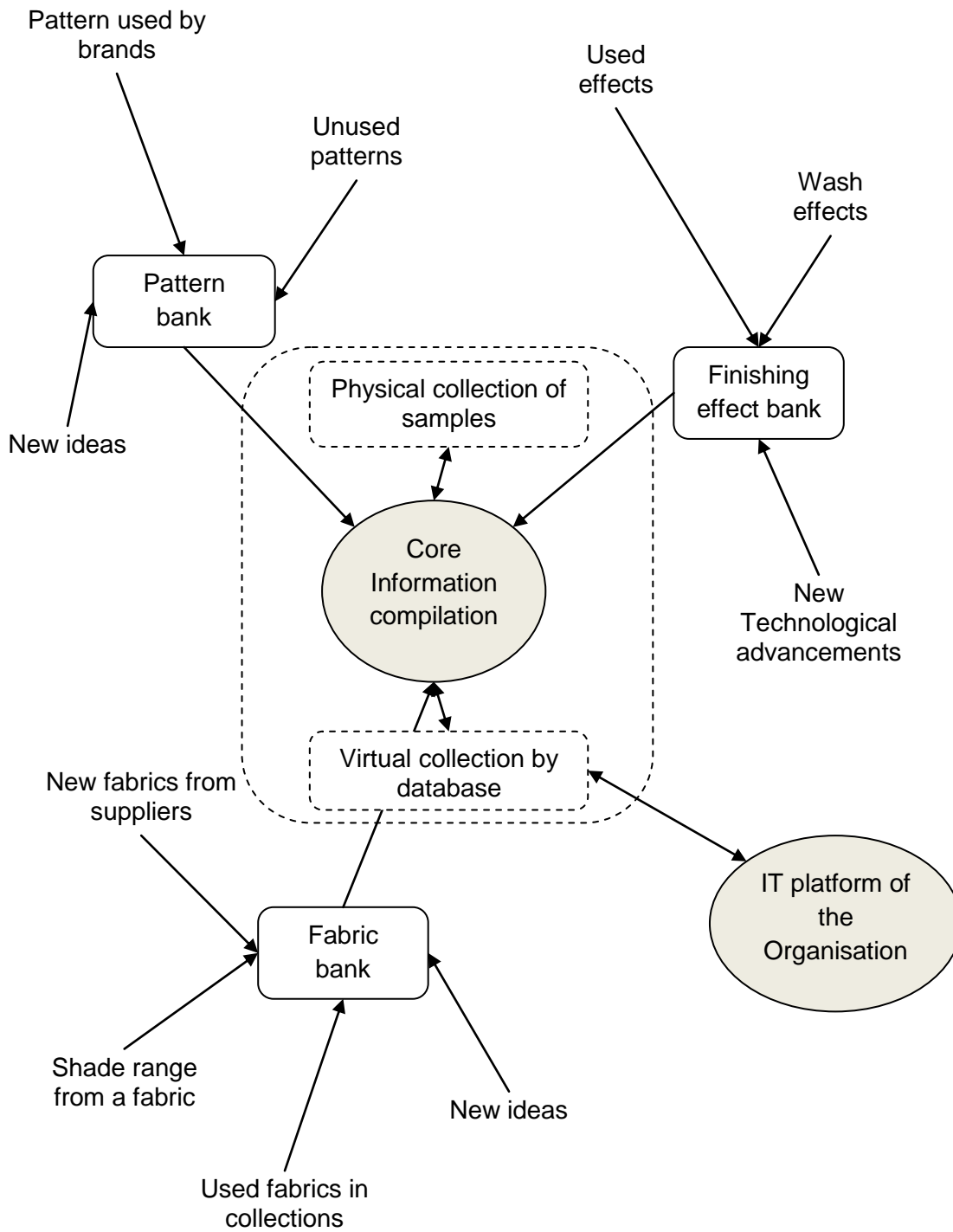


FIGURE 31. Illustration of information compilation concept.



## 5.5 Centralized procurement

The research has revealed that most of delays in PD activities are due to the lateness of the arrival of fabric. It has also noticed that same or similar kind of materials or fabrics from the same supplier are used for different brands in the company. The procurement of the materials is mostly handled by the brand itself. Even though the same fabrics or accessories are being used by different brands, this information is unknown to other parties. This is due to the system fault and lack of coordination. These issues can be minimized by bringing the material and accessories sourcing together in a centralized format.

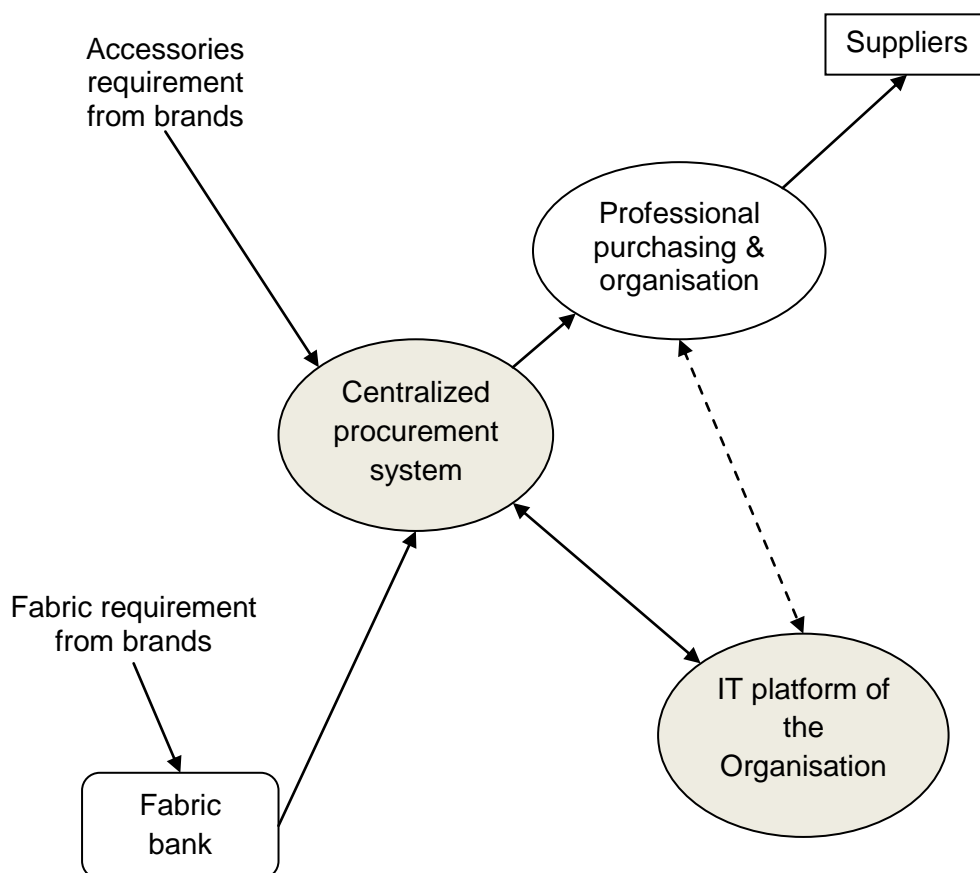


FIGURE 32. Central procurement layout to support PD.

Centralized purchasing means that purchasing is handled by one special department (Stevenson, 1996). Therefore, the responsibilities are moved to concerned department and the process will reduce the functional activities from designers which will facilitate them in more creative activities. Centralized purchasing will be able to reduce the logistical cost significantly. The mission of the central group is to facilitate

the consolidation of similar buying requirements and standardize buying processes at the various facilities (Monczka, Handfield & Giunipero, 2008). Also the professional purchasing expertise can be achieved through centralized procurement.

The CP will be also operated through the IT platform. There will be a certain communication through IT platform between CP and CIC. The requirements from different brands or product lines will be processed through the central database and software related to procurement activities. For example, if a designer likes to order some particular fabric, it would search in the database first and order the required quantity to the CP. CP will then check for same or similar requirements from other brands and also, if some other order to be processed from the same supplier. These processes can be handled electronically by using the central database. However, if immediately not available, the final requirement processing could be done manually instead.

## 5.6 Concentration on core resources

The complexities of the apparel production in an expensive arena have already been described in many ways. Additionally, earlier chapters also represented the tough challenges exerted by the less expensive producers. So, it is important for the apparel firms in high cost arena to find out and concentrate on the most resourceful unit(s) where they are really compatible. It will let the organization to exist and will let to grow further.

The results of the analyses in previous chapter have found that a big portion of sales committed from the continuous models or Never Out of Stock models. It was also found, that the sales and volumes are quite stable for this group. As the company has fixed facilities and manpower, it is quite important to organize stable work around the year. As the portion of continuous models is big, it helps the organization to provide jobs in different departments. It was also found, that the production rate of the continuous models is very high compared to other types, and these products are also easy to produce. Raw materials for these products are available in-house almost always. Not only that, but products also should be always deliverable from stock, as it is named as NOS. For many reasons, it has been found that this product type could be core resources for the company.

The study has revealed that very little effort is paid for continuous NOS models during PD. Also it has been noticed that there are almost no market research for this core

product type. While comparing these types of products in the stores with the similar product ranges from the competitors, much potential has been found, where the company should improve the product quality. Interestingly, there are not many things to do with the product, but the presentation of the products should be improved. The company could take advantage by letting the customers to know, that the product is produced in a trustworthy area, Finland and Estonia, which could give confidence to the retailers and final consumers.

The company has worked extensively on environmental friendly processes. For NOS articles the developments were found even more profound. Almost all the current models under NOS are being produced with low energy and water saving methods. The company has a great possibility to capitalize those valuable developments by informing the consumers. As the consumers are getting more and more environment conscious, the environment friendly NOS products could make a place among those users. These criteria will also be able to differentiate their products from the low cost products. Marketing requires putting more effort in analyzing the present condition of the products in different stores, compared to competitors' similar products. At the same time, more concentration is required in order to find out the steps needed to be taken for improving those products and introducing new products. The company should also allow more efforts and resources in PD for NOS articles. There are potential possibilities to establish deeper technical cooperation with the fabric producers. It will help the organization to improve their products that could make more space into the market. All of the efforts can reduce the product costs and can improve product quality, which will cause higher profit for the company. It is to be noted that for this specific product type, both risks are comparatively less and dependency on supply chain external partners less. Thus growth of this product type will stabilize the position of the company.

## 5.7 Summary of recommendations

The main purpose of the study was to find out the way to smoothen process during PD and agile processing in production. Generally the PD processes and the production processes studied at the case company were quite efficient. But this research work tried to assist by pointing out the improvement possibilities, and also by showing the possible ways to do it. Also oftentimes, there was a gap noticeable between PD and production in terms of transfer the knowledge.

In this study, it has been already recommended several improvements with details in concurrent PD in association with production, rearranged group layout for process smoothness, centralized pattern and fabric compilation, centralized procurement and concentration on core resources. It is to be mentioned here that those recommendations are interconnected and it is believed that the complete implementation will significantly improve the processing capabilities especially in PD process. It will reduce the PD processing time and at the same time save cost. The implementation can be done through some pilot project. For example, some models or a small group of models can be made by following the format of CPD in the production line. It is not necessary to apply the method completely by reorganizing the sampling department and also the production line. Once successful with the primary project, another pilot project can also be taken for other methods following the same way.

### 5.8 Suggestions for further research

Due to some limitations and time limits, it was not possible to do extensive study on many specific subtopics. The research work perceives those limitations and feels that further work can be done on those areas. Further studies will reveal some more profound issues, which will help the organizations to be more agile in product development. In this section, some of those points will be presented where improvement possibilities exist.

This particular thesis project has not performed extensive research on sales data. The non-availability of vast sales data was one of the factors. However, it was found out that more specific statistical analysis knowledge is necessary for this kind of comprehensive analysis. The further analysis will surely help in finding out relationships among some more factors. Some of the factors from the interview work were mentioned and analyzed already in this research, but during the study it was found that there are more issues and factors related. Further study on those more specific issues can provide improved direction and better concepts.

There is also possibility to check the effect of introducing a new product type or product group. This could be checked through sales data with the new product, timeline of the entire process and efficiency. It is also possible to check and measure the performance in terms of sales, agility, and quality of the product for the existing products. It might help in understanding the agility of the processes. This study has not gone for

the performance measurement of the agility of the process. So, concentration in this area would be most beneficiary.

While analyzing the existing processes, especially the sewing process for group layout, it was not done by considering each and every machine in the line. Normally sewing line consists of a large number of machines. So, a comprehensive analysis of the tasks performed by each machine is required. This deeper analysis could represent an actual layout that could be implemented. However, to do this, a good knowledge on the sewing technology and related experience is required. This particular research has concentrated only on the major and basic steps in a sewing line. The dimension of this study work would not support this deep analysis. So, additional assessment and investigation is necessary to depict a real operational layout.

This research also studied the transition of PD to production. It was found out that a proper and efficient production planning and scheduling is the key in terms of agility in the production. Agile production process asks to deal with smaller lot sizes and rapid action. To execute the orders with these conditions, an organized production planning system is a must. But due to limitation, it was not possible to go through and check deeply the production planning system. However, some work was done on the present planning system. It is the area where further research is necessary. It will help in achieving a good system, which will support the progress towards an agile manufacturing system.

## 6 CONCLUSIONS

This study took around six months to get finished. Without the researcher's own experience it would have needed more time to accomplish the task. A large portion of the time was spent to study the earlier works on product development, agile production, lean production, apparel PD, apparel production, concurrent product development and many other issues related to the "On Demand" product development and customization for production. Interviews were taken and data were collected. All of those inputs have worked out comprehensively. Many issues were revealed and many opportunities were seen in terms of agility.

The intention was to find out some ultimate recommendation that could be implemented to organizations which need agility in PD process and production. This specific study demanded for more practical implications rather than theoretical framework. This work is a blend of theoretical analysis with practical implication. As it is mentioned that there are very few studies found on agile product development and production for apparel products, this research might be able to add some dimension towards agile product processing in apparel industry. It is to be mentioned here that, though the work has considered a single case company, the concepts and implementations are also applicable in many other cases to the organizations with similar kind of format and activities.

Results and discussion chapter has presented the key findings, where efforts are required. Recommendation chapter has recommended some improvement methods. The study understands that more effort is required on NOS products. At the same time it is noticed that, apparel firms have to depend a lot on the suppliers. Putting more effort on NOS products could help to reduce the dependency on suppliers, as materials and accessories for NOS products are usually always in-house. So, firms are not in a hurry to procure those and therefore dependency on suppliers is less. Interviews have revealed that, two different locations for PD often create timetable inconvenience. If implemented CPD, any product can be produced in any production line. So that it will be possible to get products from any location as per necessity. CPD will also help in interaction between PD and production, which will help in transferring PD knowledge to production. During the interview processes and data analyses, it was seen that the company does not have a proper PD knowledge transfer method. By practicing CPD, it is even not necessary to have a transfer method. Pro-

duction personnel are already familiar with the upcoming products, as the products are produced on the production line.

The key findings of the research work are the consideration of the timetable and a proper organization of all the activities. Obviously, “On Demand” product development meant agility in the process, therefore maintaining timetable will be the key. But just sorting out the inconveniences related to timetable, schedule and steps to solve those problems, alone cannot solve those then. The overall work has clearly shown that effort on proper organization in activities is a vital tool for solving those problems. Concurrent Product Development is such a kind of tool that was revealed as appropriate for this type of organizations, where they deal with varieties type of products, and brands, and especially in small lots. On the other hand, centralized fabric and pattern bank implementation will reduce a lot of activities in PD process. It will reduce the extent of repetitive works, which is often done for different brands. The entire PD cycle will be shorter for a particular season. The compilation will also facilitate more options and possibilities for NOS products, which is a very important product type for the company.

“No Interval Coherently Phased Product Development” model was the major consideration from operational point of view. The study framework was built based on NICPPD. Other models like Concurrent Product Development and literature regarding production and agility was in a supportive role with the base framework. Together with the supportive concept and NICPPD, this study literature aims to a practical framework which can be implemented by remembering few important considerations. These practical considerations are such as: location of apparel factories in critically expensive arena, a considerable numbers of product varieties and brands to be handled, critical lawful barrier that restricts the use of many economically inexpensive products, infrastructure etc. However, it is believed that this research work and concepts are implementable within these constraints and these findings will make the organization professionally and economically more sustainable.

## APPENDIX 1: INTERVIEW CONSENT

This is the formal invitation for taking part in the research study of “On Demand Product Development Customized for Production”. The research study is being done by me, Shahriare Mahmood. I am a student of Master’s Degree Program in Industrial Management at Savonia University of Applied Sciences. Your valuable participation in the interview process will assist the research study to reach its goal. It is expected to deliver a unique result by the research process that will help the product development process agile and reproducible in production.

The interview consists of a thorough discussion session about the product development process in a specific brand or line that is related to interviewee. The interview session will be audio recorded and (or) written for the data record and accuracy purpose. All the data and information related to the interview will be kept confidential and believed to be no personal risk involved. However interview participants have the possibility to review the materials. The interview data will be refined and analyzed through some qualitative data analysis method. The extracted result will be the main resource for the ultimate findings of the research. The interview is expected to last for 30 minutes to 1 hour.

If you have any question in connection to the interview, please feel free to contact by email to [shahriare\\_mahmood@hotmail.com](mailto:shahriare_mahmood@hotmail.com).

Thanks for your time for the interview and considering it.

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Date

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Signature of the Participant

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Date

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Shahriare Mahmood



## APPENDIX 2: RESEARCH INTERVIEW QUESTIONS

<b>Organization</b>		
<b>Interview</b>	<input type="checkbox"/> In Person	<input type="checkbox"/> Telephone
<b>Data Record</b>	<input type="checkbox"/> Written	<input type="checkbox"/> Recording
<b>Interviewee Name</b>		
<b>Position</b>		
<b>Brand/Department</b>		

1. How long you are working for this company and in this position?
2. Do your brand / department have a Product Development strategy? Do you only work for a specific brand or you also serve for private labels?
3. What is the role of the customers and also the suppliers in different stages of product development process? Why it is important?

**Trend Research:**

4. How do you collect trend information needed for your brand and who are involve in this process? Do you involve some external parties / services also for trend research?

**Product Foresee & Development:**

5. What is the product development process for the line (brand) you are working for? Who are involved in your brand product development process and what is your role?
6. What is the process you follow to synchronize the trend forecast and research to product development?
7. What is the most critical step in product development?
8. What is the influence of product pricing in product development?
9. How do your customer involved or evaluated in the process? Why it is important?
10. Do your company is up to the mark with technologies required for each steps in product development?

**Finalize Product Range:**

11. Who are involved in finalizing the product range and how it is done?

**Customization for Production**










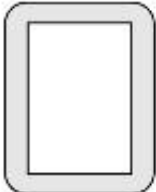
12. What is the process of transferring the PD knowledge to production and how do you synchronize PD with production?
13. How is the Production planning done and executed as per promise to the customers. Is the production planning capable enough to react to the fast demand from the market and organize?
14. How much do the suppliers' effect in your production planning and promise to your customers?

**Product Development in General:**

15. What obstacles do your firm or company encountered relating to the PD activities?
16. How important it is to involve production personnel in PD and what are the obstacles to involve all those parties?
17. What is the effect of delay in product development and how your company / brand will be benefited by speeding up the process?
18. How organized and agile is product development process in general to react with the fast market demand especially for the private labels?



## APPENDIX 4: NICPPD Model Legend

	Product Development
	Merchandising
	Marketing
	Production Planning and Control
	Multiple Functional Units
	Information Source
	Decision Point
	Documents/Products
	Alternative Processes
	Fuzzy Gate

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