Fit Enterprises: Novel Fitness indices for continuous improvement

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By

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Abstract

The release of new products to the market goes through a process of Research and Development (R&D), manufacturing, and service respectively. Much research has been done on improving manufacturing processes. This research focuses on enhancing current Manufacturing Strategies by making three important and related groups of contributions within R&D and service.

The aim of the research was to develop tools and techniques to increase the 'Fitness" of a company. The first contribution relates to a Fit Development Toolbox (FDT) to identify the interdependencies between the 11 well-known tools of Toyota's Product Development (PD) system within R&D. Using the proposed FDT a new framework has been developed for implementing Toyota's PD system more efficiently based on the primary data collected from 112 companies.

The second contribution deals with all sources of Unfit demand and how waste affects the flow of processes within R&D. This has been achieved by developing the Fit Flow Index (FFI) using primary data from 322 companies to measure the flow of the PD system at any stage of the project. The proposed index decreases the chances of creating queues and bottlenecks within the PD system which in turn enhances innovation and productivity.

The third contribution concentrates on formulating a Fitness index for evaluating quality of services provided by Starbucks after adopting Lean principles. A Fit Customer Satisfaction (FCS) score was calculated using primary data collected from 822 surveys, which in conjunction with the proposed Fitness Index (FI), enables companies to measure their Fitness level in response to applying continuous improvements.

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DECLARATION

This work has not previously been accepted in substance for any degree and is not concurrently submitted in candidature for any degree.

Signed ……………………..…………………….. Date 30-1.2014

Statement 1

This thesis is being submitted in partial fulfillment of the requirements for the degree of PhD in Industrial Engineering.

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Statement 2

This thesis is the result of my own independent work/investigation, except where otherwise stated. Other sources are acknowledged by explicit references.

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I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summery to be available to outside organisations.

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- CHAPTER 1 -
Introduction

1.1 Background

Globalisation and technology mesh with each other, and each effects the development of the other in many ways. For instance, advances in communication can make the world appear a small village while globalisation acts as a force pushing technological change at an ever increasing pace. The rate of change can make it very difficult for individual national economies; countries might lose a sector of their manufacturing base because, for example, end users are able to print their product at the work face using digital 3D printers.

Such machines as 3D printers will revolutionise the industrial world and could change the global balance of power. For instance, China has flooded the world with low cost goods because its labour power is so cheap that the cost of production is significantly reduced. However, should machine replace worker, the practices of every company and country will change qualitatively. Unemployment will certainly rise and traditional markets may collapse. Hopefully, new opportunities will emerge and companies should proactively prepare themselves for these.

In this thesis, it is argued that in this new manufacturing climate it is vital for commercial companies to focus on New Product Development and improve their Research and Development. To obtain a competitive edge in the market place companies must innovate and develop new products and new solutions to current problems before their rivals. Such developments must be achieved in a short time span at minimum cost to obtain a first-mover advantage. In this way a company will have the capacity to overcome the inevitable challenges of the market place swiftly and effectively.

The author believes that the ‘Fit Enterprise’ strategy discussed in this thesis contributes to improving manufacturing systems, it challenges old thinking and even current best practices. Critically examination of the status quo has driven this research into new territory and opened the researcher’s eyes to a new kind of knowledge. Lean tools used within a plant have invariably been the subject of long research and the likelihood of further optimisation is low. Hence, new doors have to be opened in order to challenge the status quo and optimise plant production. ‘Fit’ is a new research term presenting significant opportunities for advancement, and the investigation is focused on issues that have not been researched until recently, such as new product development. However, being Fit in R&D (Research and Development) and Manufacturing capabilities does not in itself guarantee a company’s success or survival.

Looking at the overall picture enabled the author to establish new links between different parts of the organisation. Two thirds of this thesis is dedicated to optimising Product Development. The remainder focuses on Customer Service and the After Sales chain of the organisation where many important actions and inter-actions take place. All three stages of the process are interconnected. Default in any one could have disastrous consequences for the organisation.

1.2 Aims and Objectives

The author’s hypothesis in this thesis that “An Enterprise can improve its performance and increase its ‘Fitness’ by adapting and implementing lean manufacturing tools and by applying and transferring them to areas of R&D and services.

The aims of this research are to improve current manufacturing strategies by introducing Lean Thinking into the organisation's Research and Development environment. The author also aims to construct viable and solid indices for the measurement of performance and so to enable continual improvement. Finally, a vital target for the author is to improve the implementation of cost-reduction strategies by focusing more on customer needs and requirements.

The objectives for this thesis are threefold:

1- To develop more effective product development tools that can serve a wide range of companies in different industrial and commercial environments.
2- To optimise R&D by better identifying failed demand and removing waste.
3- To improve the implementation of Lean Thinking and narrow the gap between theory and practice.

1.3 Research Methods

The author had used a combination of methodologies to acquire robust data and achieve optimum results. Both primary and secondary data were used and gathered through traditional and contemporary channels. All data collected in this research went through a process of qualitative and quantitative statistical analysis. Surveys and interviews were used to obtain a clearer picture and an in-depth understanding of the problem. The questionnaires (Appx1,2,3) were chosen through systematic and scientific selection to accurately reflect the population. Statistical packages were the tool by which the author achieved his results, insights and conclusions. Finally, case studies for different leading companies were used to improve the quality of the research by validating the contributions and indices.

1.4 Outline of the thesis

The thesis commences with a literature review in Chapter 2. The first section outlines the building blocks of Fit Manufacturing and establishes the basics of Fit Operations and their evolution by using an analogy with human fitness. Next the author discusses Toyota's product development tools. The final section presents an investigation of sources of waste and failure in R&D.

Chapter 3 explains the research methodologies used to test the hypotheses and to validate the results.

Chapter 4 focuses on the R&D stage of creating a product within companies, when initial ideas and technologies are tested, and resources and investment decisions made. This chapter discusses and improves on the School of Toyota and its development of new products by investigating the interdependence of different design tools within this school of thinking. The author was able to develop a map of all the tools and named it the Fit Development Toolbox (FDT). This determined the nature of the interactions between all components in the box which allowed the creation of filters for the FDT depending on the time available, the ease of use and value of the contribution of each tool.

Chapter 5 investigates the more technical aspects of R&D in order to optimise the system still further. A new Fit Flow Index (FFI) is developed to measure the flow within the R&D system so that companies have a clearer understanding of efforts to reduce waste and unfit demand.

Chapter 6 examines the Service part of the process. Data was collected to establish if the intervention has a positive impact on customer experience. In other words, is the customer getting value for money and is the customer experience one of an improved product every time they make a new purchase. For this purpose, Fit Customer Satisfaction is measured on a numeric scale so that firms can use it to establish their position during the implementation process. Finally, the author creates a Fitness Index which combines of a number of measurements to reflect the economic health of the enterprise.

Conclusions and Recommendations are presented in Chapter 7. A number of interesting and useful observations have been made in this work and conclusions drawn that will contribute to the body of knowledge on the topic of Fit Manufacturing Strategy. Each stage of the thesis represents a very important basis for future work and research, especially in Fit Manufacturing. However, more data needs to be collected so that the picture will become clearer, which in turn will improve future solutions.

Literature Review

- CHAPTER 2 -

2.1 Fit Manufacturing:

Analogy of Human Fitness Components

Preliminaries

"No new idea springs full-blown from a void. Rather, new ideas emerge from a set of conditions in which old ideas no longer seem to work" James *et al.*, (1990). In manufacturing, new ideas and strategies arise continually and because they are tested against reality only the best survive and spread. A fundamental principle of manufacturing strategy is that no single strategy continues to be effective in a rapidly changing business environment. For instance, as 'the industry of industries' – the automotive industry - has developed it has used very different manufacturing strategies. Naturally, some strategies endure for longer periods of time but invariably new external factors emerge and the manufacturing companies are forced to review current strategies. In the modern increasingly challenging and ever-changing business environments the capacity and willingness to adopt new manufacturing strategies is necessary for a commercial organisation to survive.

The evolution of manufacturing strategies can be seen as proof of the above proposition. After World War I, Henry Ford and Alfred Sloan of General Motors revolutionised world manufacturing and replaced craft production with mass production. After the destruction of Japanese industry in World War II, the recovery of the automotive industry was greatly accelerated by the introduction of the Lean production concept of Eiji Toyoda and Taiichi Ohno.

Here, the author introduces the idea of a new manufacturing strategy: Fit Manufacturing. The word 'Fit' itself has several meanings as an adjective, verb and noun. As an adjective, Fit means: (i) a thing of a suitable quality, standard, or type to meet the required purpose, (ii) to be in good health, especially because of regular physical exercise. Fit as a verb means: (i) to be the right shape and size to meet a need, (ii) to put something into place and (iii) to be in agreement or harmony with something. Finally as a noun, Fit means the particular way in which a thing matches something else, or in modern parlance a Fit person is an attractive person (Oxford Dictionary, 2010).

Generally, human fitness (or physical fitness) is the capacity to perform physical activity and its measurement uses a range of physiological and psychological qualities. In an earlier definition of human fitness, Lamb *et al*., (1988) interpreted human fitness as the aggregate of the absolute values of indicators of positive health.

In the manufacturing context 'Fit' was introduced by Pham and Thomas (2008). They defined Fit Manufacturing as 'A company's ability to survive and prosper in a sustainable manner through the manufacture of high quality products facilitated by an integrated, robust, highly responsive and reconfigurable lean manufacturing system that returns high product quality and reduced internal and external manufacturing costs' (Pham *et al.,* 2008).

This chapter presents four topics that develop the concept of Fit Manufacturing. The first section is an overview of existing manufacturing paradigms. Next, in Section 2.1.2, the concept of Fit Manufacturing is approached using the analogy of human fitness, this includes a comparison of the human fitness system and manufacturing system. The details of the fitness components and their inter-relationships are discussed. Section 2.1.3 discusses and analyses the similarities between human fitness components and the concepts contained in existing manufacturing paradigms. Section 2.1.4 discusses those human fitness components that may possibly be adapted into a manufacturing system. This chapter closes with the conclusions of the results obtained from the analogue study.

2.1.1 Manufacturing Paradigms

This section briefly discusses the three most popular manufacturing paradigms all of which have been the subject of recent studies: Agile Manufacturing, Lean Manufacturing, and Sustainable Manufacturing. The main purpose of the discussion is to study the concepts of the paradigms and find a relationship with human fitness components that will be discussed in the next section.

2.1.1.1 Lean Manufacturing

Doing less with more is a generic term to describe lean manufacturing. It was developed at the Toyota Motor Company in Japan after World War II in order to lower costs, though improved quality and shorter lead-times are other benefits of lean manufacturing. According to research by Karlsson & Ahlstroem (1996), there are three main determinants of a lean production system; (i) the actions taken, (ii) the principles implemented and (iii) the organisational changes made to achieve the desired performance through the application of lean principles (elimination of waste; continuous improvement, zero defects, Just-in-time (JIT), pull instead of push, multifunctional teams and vertical information systems).

2.1.1.2 Agile Manufacturing

There are various definitions of agile manufacturing in the literature but a common factor is the capability of the agile manufacturing enterprise to quickly respond to market requirements (Ramesh & Devadasan, 2007). Agility is the strategy whereby an enterprise is capable of surviving and thriving in a competitive and unpredictable environment where change is continuous (Sanchez & Nagi, 2001). The agile enterprise is able to respond quickly to sudden changes in the market driven by customer-based evaluation of products and services.

The main driving force behind agility is change. Yusuf *et al*., (1999) have identified five main drivers: (i) automation and price/cost considerations, (ii) widening customer choice and expectations, (iii) competitive priorities, (iv) integration and proactivity and (v) achieving manufacturing requirements. Important components of agility are core competence management, a virtual enterprise capable of re-configuration, a knowledge-driven enterprise capable of achieving the necessary attributes of agility (integration, competence, team building, technology, continuously improving product quality, ability to manager change, partnership, ongoing education and updating of staff, welfare) (Yusuf *et al*.,1999).

2.1.1.3 Sustainable Manufacturing

Sustainable development has been defined as a holistic approach integrating economic, ecological and socio-political needs to improve human living standards without depletion of natural resources (Seliger *et al*., 2008). In the context of engineering, sustainability can be described as the application of science and technology to meet human needs in different societies worldwide without detracting from the ability of future generations to meet their own needs. These definitions of sustainable manufacturing follow that of Allwood (2005); the development of technologies that do not use non-renewable or toxic materials, that transform materials without emitting greenhouse gases and do not generate waste.

Research by Seliger *et al*., (2008) into sustainable manufacturing for the future has highlighted the development of use-productivity in the total product life cycle. Seliger *et al.,* (2008) proposed three strategies for increasing the implementation of use-productivity: application of innovative technologies, improvement of use-intensity and extension of the product life span.

2.1.2 The Human Fitness System versus the Manufacturing System

This section investigates the similarities between the human fitness system and the manufacturing system. Figures 2.1 and 2.2 illustrate how the both systems work towards a similar purpose - to achieve a certain minimum level of performance. The process begins with recognising the importance of a continual input to both systems to produce the desired outputs. For the human fitness system, oxygen is a crucial input. It is well understood that humans would die rather rapidly if deprived of oxygen. What for manufacturing companies is comparable to oxygen? Definitely, it is their product orders.

'Input processing' is the process whereby both the human fitness system and manufacturing process their 'Input'. The incoming oxygen is absorbed into the blood, the oxygenation process. A demand for more oxygen by the muscles will cause the heart to beat faster and increase the blood flow. This is similar to a manufacturing company receiving a greater number of orders. This increase in orders requires a higher rate of production, and this must be interpreted in terms of quantity, quality and delivery time.

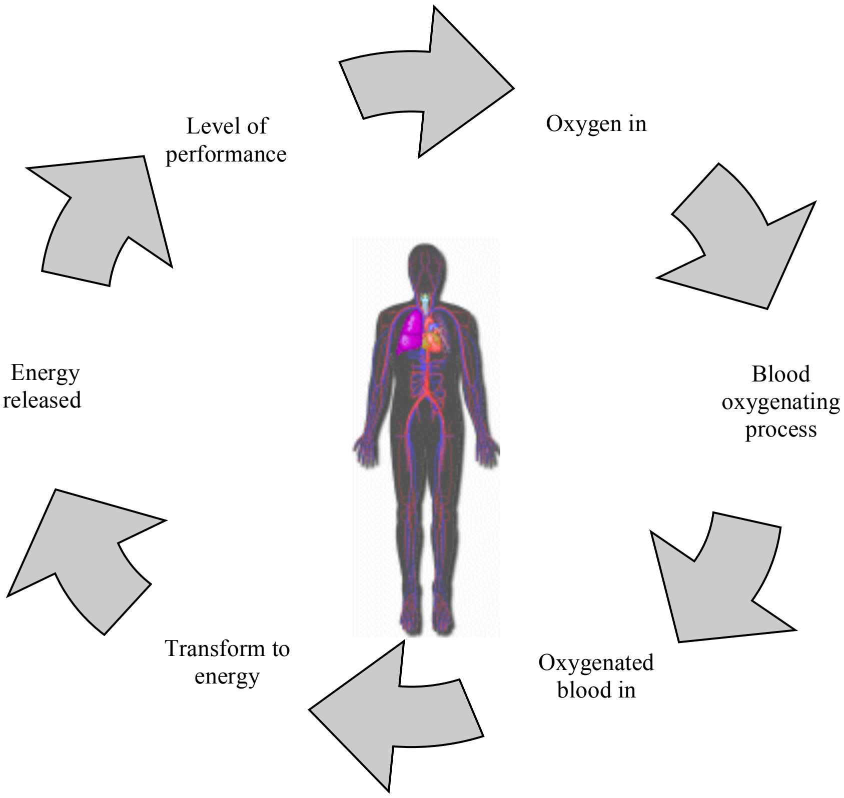

Figure 2.1 Fundamentals of the Human Fitness System

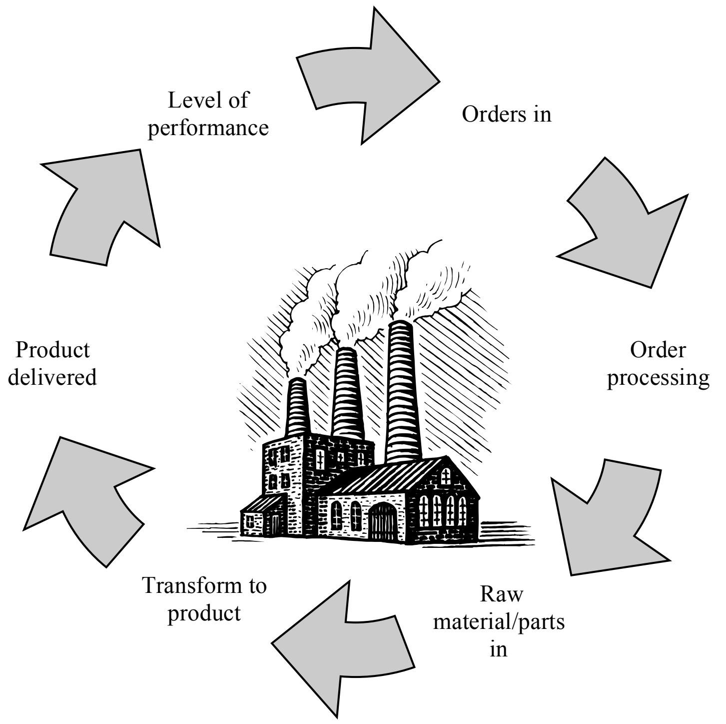

Figure 2.2 Fundamentals of the Manufacturing System

After the oxygen and orders have been received the processed inputs will be sent to the working mechanisms. In the human fitness system, oxygenated blood is pumped by the heart to tissue, organs, muscles and nerves through a network of blood vessels. The blood, via capillaries, releases oxygen which is used by cells to produce energy. In a manufacturing system in a similar process the orders are distributed to relevant departments for action. The result from the 'working mechanisms' operations is the system output. Energy is the output for the human fitness system whilst a product is the output for the manufacturing system. The output from each system for a given input determines the performance that can be achieved. For example, with a human fitness system, large amounts of energy are required to perform rapid motions and high load carrying activities. The performance of manufacturing system is usually assessed by the quality of the product, its cost and whether delivery is on-time.

However, there are other performance indicators which include agility, flexibility, responsiveness, etc. Thus any final evaluation of performance would require an assessment of all the requirements imposed by the business environment in which a manufacturing company is competing.

2.1.3 Analogical Study of Human Fitness Components

This analogical study includes the components that contribute to the fitness of the system. The Oxford Dictionary defines fitness as 'the quality of being suitable to fulfil a particular role or task' (Soanes & Stevenson, 2009). Here, this general definition is applied to both the human fitness system and the manufacturing system. The purpose of this study is to clarify whether human fitness components are suitable for describing the components of a manufacturing fitness system. The relationships between the ten human fitness components have been identified and are shown in Figure 2.3.

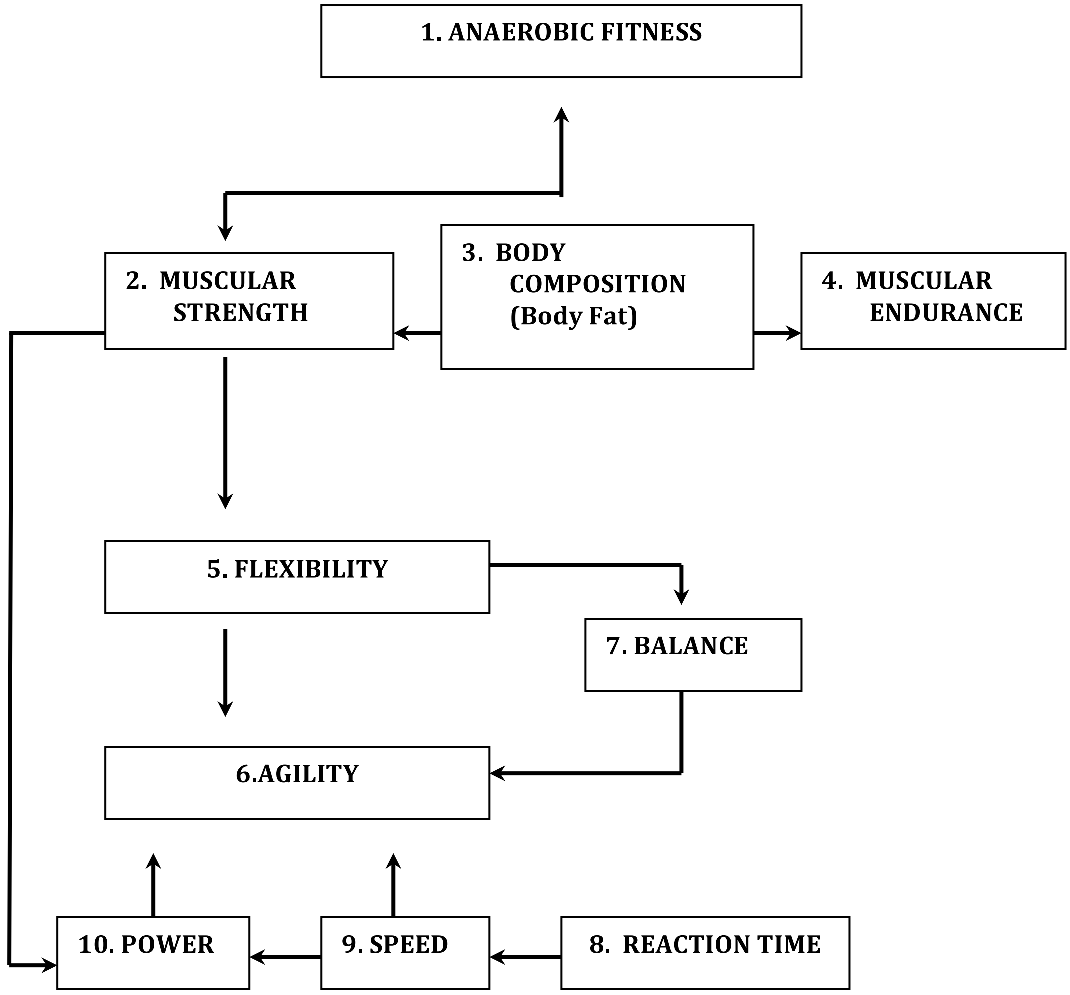

Figure 2.3 The Ten Human Fitness Components and their Relationships

2.1.3.1 Anaerobic Fitness

Anaerobic Fitness is the combination of oxygen utilisation (Cardiovascular fitness) and oxygen transportation (Cardiorespiratory fitness) (MacKenzie, 2008). An efficient oxygenating process is a crucial pre-requisite for the efficient pumping of oxygenated blood around the body. Lack of oxygenated blood will invariably lead to a lower fitness level and if sustained would affect the human health, especially when the body was working to the limits of its ability.

Within the manufacturing system, an efficient order processing system is vital because the processed orders will be transmitted to many other parts of the organisation such as production planning and control.

2.1.3.2 Muscular Endurance

Muscular Endurance defines the capability of muscles to work for a long period of time. The longer the work can be sustained, the longer the body can provide the needed output (Lamb *et al*., 1988). Muscles are one of the working mechanisms in the human body and it essential for them to have the ability to sustain 'work' for long periods in order to achieve a desired or necessary performance. However, Muscular Endurance and performance depend on the amount of oxygenated blood that has been received.

The same applies to the manufacturing system. Production lines/machines as the working mechanisms should be able to operate continuously without disruption to avoid adversely affecting the output of the manufacturing system. However, disruption of production can be planned or unplanned. Good management of planned disruption (maintenance schedules) plus being able to identifying possible unplanned disruption (machine breakdown) is key to maximum production utilisation.

2.1.3.3 Flexibility

Flexibility in the context of human fitness is defined as the ability to bend joints and stretch muscles through a range of motions (Lamb *et al*., 1988; MacKenzie, 2008). The flexibility of a muscle is limited by muscle bulk and extensibility, the more supple the muscle the greater the degree of flexibility.

Flexibility in manufacturing has always been defined as the capability of the system to carry out a variety of production operations and not being limited to only minimal processes (Slack, 2005; Shewchuk & Moodie, 1998). However, flexibility may be limited by the capabilities of the manufacturing organisation, often due to resource limitations.

2.1.3.4 Balance

Balance in the context of human physical fitness is the ability to maintain a stable position, either static or dynamic (Biddle, 1987; Corporation, 2008). Static balance refers to the ability to hold a stationary position whilst dynamic stability is the ability to maintain equilibrium while moving. Balance is closely related to flexibility and agility. To achieve balance and execute the desired task the body must exercise the appropriate amounts of flexibility and agility at the right times using the correct muscles (MacKenzie, 2008). Flexibility improves balance and balance affects agility of movement (dynamic balance). Sports that require sudden changes in movement need good balance.

To generate optimal profit levels a manufacturer must balance the different requirements of the production system. According to Pham *et al.*, (2008), a Fit company has to balance between being lean and possessing the agility to meet quality, cost and delivery requirements. The company must achieve this whilst ensuring its manufacturing strategy meets the needs of its current customer base. In terms of company performance, the balance between inputs and outputs is critical. Balance is a crucial element especially given the sudden changes that can take place in volatile markets.

2.1.3.5 Muscular Strength

In the context of human physical fitness, muscular strength refers to the maximum force that a muscle or group of muscles can exert in a single exertion (Corporation, 2008; Hoffman, 2006). A muscle can be represented as an entity or element in a manufacturing system and the strength of the manufacturing system is the capability of meeting the required demand. The quality of being capable to physically, intellectually, financially and/or legally perform set tasks is defined as capability.

2.1.3.6 Body Composition (Body Fat)

Body composition refers to the amount of fatty tissue relative to fat-free tissues such as muscle, bones and organs (Biddle, 1987; Corporation, 2008; Hoffman, 2006; Thomson *et al*., 2003). Most athletes keep their levels of body fat to a minimum as the higher the percentage of the body fat, the poorer the performance (MacKenzie, 2008). Reducing body fat improves cardiovascular fitness. Body fat can be represented as waste in the Lean Manufacturing concept. Being 'Lean' in a manufacturing system means 'doing more with less' which implies continuous improvements in maximising utilisation with minimum resources (Radnor & Boaden, 2004).

2.1.3.7 Agility

Agility has been specifically applied to human fitness as a dynamic quality (MacKenzie, 2008; Hoffman, 2006; Biddle, 1987). Agility is the ability to change the body's direction of travel accurately and speedily while moving rapidly (Hockey, 1977). Achieving agility requires the accurate combination of power, strength, balance and speed (Walden, 2008). These descriptions support those of Lamb *et al*.,

(1988) who studied indicators of a positive health state but used the four basic internal criteria: change, accuracy, quickness and rapidity of movement, which are related to power, strength, balance and speed. Agility is crucial for success in competitive sports such as rugby, soccer, cross-country cycling, etc., where body movement can be the key to victory.

The term agile or agility is also used in the manufacturing industries and is intended for application to competition in a rapidly changing environment. An Agile Manufacturing system is defined, Bottani (2008) and Kidd (1996), as: “The ability to thrive and prosper in a competitive environment of continuous and unanticipated change, to respond quickly to a rapidly changing market driven by customer-based valuing”. These concepts are purposely designed for the dynamics of a competitive business environment. Flexibility, quick response and speed are the general criteria of Agile Manufacturing. Additional terms have been introduced to support the general criteria, these include adaptable, reconfigurable and responsive.

2.1.3.8 Reaction time

Reaction time in human fitness is defined as “the time taken to respond to a stimulus” (Biddle, 1987), it is a factor that contributes to the response level of a system whenever changes take place in the local environment. Reaction time in a manufacturing system is defined as “The time taken for the system to respond to a stimulus” (Ortega *et al*., 2008). However, the term ‘quick response’ is widely used instead of reaction time and is the term used in the comprehensive definition of Agile Manufacturing. Obviously, reaction time is a measure of the responsiveness of both human and manufacturing systems.

2.1.3.9 Speed

With human fitness, speed is a component which helps define the ability to execute movement quickly (Hoffman, 2006; Biddle, 1987). Speed is the rate at which a person can propel his/her body, or parts of the body, through space (Lamb *et al.*, 1988) and is determined by measuring the time taken for a body or an object to travel a specified distance. Speed in a manufacturing system relates to such performance measures as production rate, time for the introduction of new products, production change rate, etc. In this case, the time is compared not to distance but to other variables (e.g. total number of items produced in a given time). As in human fitness speed also relates to agility. Here, it contributes to the responsiveness level (reaction time) of the Agile Manufacturing system. In fact, speed is one of the competitive advantages of an Agile Manufacturing system (Wanyu, 2004).

2.1.3.10 Power

Generally, power is the ability to perform to maximum capacity effectively. In human fitness power is the ability to release maximum force in the shortest time. Here, power is generated by strength and speed as shown in Figure 2.3 (Lamb *et al.*, 1988; Walden, 2008). However, the term 'Power' has never been directly used in manufacturing systems, but would exist in manufacturing as a combination of effectiveness (speed and quick response) and efficiency of the manufacturing system. In this case, 'Power' may be defined as achieving maximum potential in the form of flexibility and agility at minimum cost.

2.1.4 Fit Manufacturing Components

Companies must have a stable financial platform to maintain their business. This can be achieved only through coordination of many different functional mechanisms within the company system. This is crucial to achieve optimal performance of the company's operations.

All the components of human fitness shown in Figure 2.3 have been used as manufacturing concepts but in separate manufacturing paradigms. This chapter now proposes combining the fitness components into three possible manufacturing systems: (i) A Lean Manufacturing system representing Anaerobic Fitness, Body Composition (body fat) and Muscular Endurance, (ii) An Agile Manufacturing system (including Reconfigurable, Responsive and Changeable Manufacturing systems) representing Agility, Flexibility, Reaction-time, Speed and Power, and (iii) A Sustainable Manufacturing system representing Muscular strength, Balance and Power.

The three systems are actually the three pillars of a Fit Manufacturing system. Coordination between the two manufacturing systems and the Sustainable Manufacturing system is essential in achieving a 'Fit' manufacturing system.

In a Fit Manufacturing system, the inclusion of Lean Manufacturing is justified by the need to control the 'fat' in the system, where 'fat' is defined as waste. Both the human fitness system and Lean Manufacturing system are purposely designed to control the 'waste' in order to achieve the desired performance indicators which will vary with application, e.g. 100m runner and heavyweight boxer (human fitness system), and seasonal market demands, e.g. automotive and steel industries (manufacturing system).

Integration between a Lean Manufacturing system and an Agile Manufacturing system would ensure achieving the desired performance. Here the coordination between the fitness components in both systems is crucial. This is where the third pillar of Fit Manufacturing should also be integrated with the other two. The role of the Sustainability system is to ensure balance between manufacturing capabilities (muscular strength) and potentialities (power). In this way the system would continually achieve the desired performance.

This analogical study provides the components that are most likely to achieve a 'fit' manufacturing company in a rapidly changing business environment. Both systems (see Figures 2.1 and 2.2) need an essential input to be transformed into the desired outputs. A continual input is crucial for guaranteeing the system's circulation. Figure 2.3 demonstrates how the ten components of human fitness are inter-related, however, it represents the physical-fitness model in general. Different fitness models could emerge depending on the desired performance. For instance, the human health-fitness system requires only the first three components: anaerobic fitness, body composition (body fat) and flexibility (Lamb *et al*., 1988). The basic human health–fitness involves relatively passive activities such as breathing and walking. By analogy, therefore, there may be more than one fitness model in the manufacturing system too.

Summary

This analogical study has shown that a manufacturing system is comparable to the human body and has explored the compatibility of human fitness components with existing manufacturing paradigms. Most of the components already exist in two separate manufacturing systems: Lean Manufacturing and Agile Manufacturing. However, integration of the two manufacturing systems requires a third system as 'coordinator' to ensure achieving and sustaining the desired performance. This additional system is Sustainability. Successful integration of the three systems is known as a Fit Manufacturing system.

In conclusion, Fit Manufacturing as a concept is the coordination of Lean Manufacturing, Agile Manufacturing and Sustainability. This integration guarantees the continued existence a manufacturing system that will be able to cope with the demands made on it. Of course, the fitness model will depend on the desired performance of the system and that is influenced by the specific industry, company size, etc.

The next part of the literature review will focus on implementing Lean in product development and how Toyota removed waste from its NPD.

2.2 Fit New Product Development

Preliminaries

Modern Companies operate in a very competitive environment where innovation and creativity are increasingly necessary requirements for survival. The time between consecutive product launches has dropped dramatically and the only way for a company to survive is to produce new and innovative designs at a fast rate whilst optimising product variety (Eizenberg, 2014). The automotive industry has adopted what is known as micro-segmentation, customers are offered a large number of varieties of any particular model with a small number of sales for each specification or variant (Gaston-Breton and Matin, 2011). This now same applies to manufacturers in the majority of markets.

Product development and R&D operations within a company are subject to the same constraints concerning quality, cost, and time but because they in the forefront of producing new ideas and concepts usually have greater pressures upon them. A realistic analogy for this situation is when a child goes to a fete and plays the well-known game 'Hit a Mole'. The nature of the game is such that the child cannot keep all three 'moles' under control. In a business environment there will always be a problem balancing quality, cost and time and, traditionally, this is how product development was practised within companies which struggled to keep up with ever-changing customer demands and needs. Even leading companies with a dominant position in the market operated in this way and often ran into severe difficulties.

With product development in the automotive industry a well-known and essential element is the development cycle or the time required develop a car from the design stage to a finished product. Minimising time-to-market is everyone's goal in

R&D and all companies in all industries are continuously attempting to reduce this time which effectively increases R&D output. According to Morgan & Liker, (2006), the average cycle time to develop a car had fallen by a third since 1980 to 24 months.

Unfortunately many companies have tried to reduce product life-cycle without bearing in mind the impact on quality, and this can result in a high number of returns with consequent additional costs because of repairs, transportation and so on. Such a result could mean the introduction of a new product has failed and public criticism and loss of consumer confidence could mean a loss rather than a profit on money invested. Keeping all the above warnings in mind would help R&D managers make better decisions and provide a good platform for improving the design and product development process and reducing the product life-cycle.

In addition to cycle time, cost issues can arise possibly due to increased complexity of the product and a drop in sales. In the case of a product with a high sales volume the company will try hard to minimise development cost so that it is significantly lower than the selling cost.

Toyota is at the heart of Fit Manufacturing and looking at their superior performance makes competitors uncomfortable because, for example, Toyota can launch a car in half the time needed by its American competitors. The Fit Development Toolbox (FDT) can be used to address the types of problems are associated with the eleven tools used in Toyota product development and go some way to overcome the different challenges that might arise in becoming a Fit Enterprise (FE).

In Section 2.2.1 the author discusses issues related to the eleven components in the FDT and after that discussion and analysis of the data gathered by the author will be presented. The improved framework developed in this thesis will enhance innovation and improve the flow of product development which will make a company's processes more cost-efficient and Fit. Economic sustainability will improve because of the greater efficiency of R&D will, in the long run, help the company to grow and increase its chances of survival during any possible financial crises.

2.2.1 Components of FDT

After reviewing the literature on all different approaches to product development by Toyota, it is clear that apart from Morgan and Liker (2006) the majority of authors focused on a relatively small number of specific tools to improve R&D, rather than highlighting all eleven components. For example, Ward (2001) and Kennedy (2003) focused on the same four tools when discussing the effectiveness of Toyota's product development system. Additionally, Brown (2007) and Schuh (2008) picked six tools and built their framework upon them without including the other five tools. The only research that shares a similar vision with this author is that of Morgan and Liker (2006). They show an appreciation of the importance of each component within the toolbox and do not dismiss any tool unless it is found not to be needed.

The next section will investigate the eleven tools shown in the list below to provides a good foundation for later discussion and analysis. The tools are:

1-Strong Project Manager.

2-Specialist Career Path.

3-Workload Levelling.

4-Responsibility-based Planning and Control.

5-Cross-project Knowledge Transfer.

6-Simultaneous Engineering.

7-Supplier Integration.

8-Product Variety Management.

9- Rapid Prototyping, Simulation and Testing.

10- Process Standards.

11- Set-based Engineering.

This thesis will attempt to highlight the importance and the rise of the Fit Development Toolbox. However, whether an intervention by R&D is successful will depend on a manger's grasp of the relationship between the different tools in the Fit Toolbox. In this work the author argues that having a clear understanding of the tools and the order of their implementation of the FDT tools is vital for achieving a company's goals and for it to evolve organically for continuous improvement. Additionally, an in-depth systematic analysis is needed to develop an efficient framework for Fit Development. The interdependence between all tools within the FDT will be made obvious.

The end product of the FDT pyramid is a framework for utilising the eleven tools of the FDT, which can be used both for academic purposes and for practical guidance. Thus members of the R&D departments in companies could benefit from utilising our understanding of the tools even if they do not initiate a particular process. The ease of use of each tool is not covered by the open literature so this will be identified to demonstrate in advance the magnitude of the challenge facing R&D managers. Having this information as well as knowing the company's capabilities and resources will enhance the chances of successful implementation.

It is an important goal of this thesis to investigate the time to implement the different tools in the FDT both individually and in combination with other tools. Each tool has specific uses and benefits; it is essential to find out how people view each tool and whether they find it useful in moving product development forward or disruptive of the system and its flow.

The following section will investigate the eleven tools of Toyota's PD and the FDT which will make a good foundation for subsequent discussion and analysis.

2.2.1.1 Strong Project Management (SPM)

Strong Project Management (SPM) is a concept that originated in Japan's defence industries and taken over by Toyota in the 1950s (Morgan & Liker, 2006). Originally it went under such names as the Heavyweight Project Manager (HPM). According to Morgan & Liker (2006), SPM is where an experienced project manager (PM) takes responsibility for leading the development of the project (preferably from start to finish) and is ultimately responsible for its success or failure. Such a PM must be involved in designing the product and ensuring that budget and delivery targets are met.

However, there are several aspects of SPM that differ from conventional R&D management (Womack and Jones, 1990) such as, customer requirements used to be identified through market research by the marketing department and then passed to designers as a starting point for developing a new product, but in Toyota's system the SPM is responsible for acquiring and defining customer values and ensuring the flow of this information to and throughout the product development system.

From the received information a team led by the Chief Engineer (CE) will process customer requirements and develop these into a concept to be presented to and discussed with management (Ward, 2007). It is then possible for the CE to define goals for functional engineering and that is acting as the Voice of Customer (VOC) (Haque and James-Moore, 2004). Regular checks by the CE to ensure performance measures and costs are within acceptable limits are essential.

Regular, frequent communication is vital between engineers and the CE, during this time additional technical inputs can be improve the product. The CE’s main duty is to make sure that value is flowing through the system by ensuring that the value stream is aligned across different functions. Some say that the CE should be the most experienced and knowledgeable person on the project (Ballé and Ballé, 2005).

However, the CE often has less authority than many would expect even though s/he is ultimately responsible for every aspect of the project (Ballé and Ballé, 2005). For instance, at Toyota, the CEs have limited power and influence because they are integrated into a matrix organization which makes function managers supervise engineers, giving them more authority than the CEs (Morgan & Liker, 2006). For this reason the CE needs to be compensated by giving them more informal power.

2.2.1.2 Specialist Career Path (SCP)

Companies use what are termed function teams to enable engineers who share the same interests and responsibilities to exchange knowledge and experience. Womack and Jones believe that a division of a company where staff carry out much the same functions acts as small school where knowledge is gathered and practices are enhanced continuously. In this way the engineers can attain a standard skill set which makes them fulfil their duties more effectively (Ward, 2007).

The norm in most traditional firms is that engineers do not stay a long time in the same division, either being promoted to management or moving to gain additional skill sets. Certain lean companies such as Toyota, however, ensure engineers spend between 10-12 years before being considered for a first-level managerial position

(Morgan & Liker, 2006).

New employees after a tough selection process must spend six months each assembling and selling cars. Thus, people who work at Toyota understand how value is created from beginning to end (Ward, 2007). A further 3-4 years intensive training is required for engineers to be eligible for membership of a team. The status of a first-rate engineer is achieved only by spending a further 5-6 years on the job during which time rotations across functions is unlikely (Morgan & Liker, 2007). Interviews take place every 6-8 years with the aim of improving performance in addition to the usual annual evaluation. According to Morgan & Liker (2007), Toyota's management hierarchy is skilled-based, and this combined with the well-established career path at Toyota is an important factor in enriching and building an organisational culture which affects positively all workers' behaviour.

As a result, executives and managers at companies such as Toyota are proven engineers and teachers who thrive on developing the workers for whose work they are responsible.

2.2.1.3 Workload Levelling (WL)

Workload Levelling is concerned with planning the allocation of resources to individual projects so they are available as and when required. In conventional R&D, activities can start at random points of time and so a number of activities will cause variation in the use of different resources and this may result in an overburdening of part of the system. Uneven demand for resources leading to high peaks at certain times is one of the biggest enemies of flow in product development. Levelling the workflow by knowing the best start point for a specific activity can be help minimise production costs through an even use of resources.

The inability to level workload due to highly cyclic product development has negative consequences due to either over-utilising or under-utilising resources – at its simplest level a copying machine fully used but with a queue, or three copying machines used concurrently but only for about one third of the time (Morgan & Liker, 2006). The same principle applies to the work force and according to Ward (2007) over-burdening workers is a type of over utilisation and will eventually cause a drop in the quality of R&D.

Over-utilisation will create bottlenecks which will disrupt overall product development flow and LD. Morgan & Liker, (2006) have quantified this problem and have demonstrated that to maximise flow from a system perspective means to utilise individual capacities up to only 80 percent of maximum, otherwise queues will grow exponentially and without control. Ineffective workload management is tightly connected to a reduction of productivity that will add costs to the system.

2.2.1.4 Responsibility-based Planning and Control (RPC)

There are two contrasting methodologies for planning R&D projects. The first is the conventional way, which is a top-down approach. The project leader takes total control by setting detailed goals and generating a specific plan using a Gantt chart which is then passed down to the engineers to follow step by step without having a meaningful input to the project because there is little or no room for negotiation. The second approach is responsibility-based planning where the project leader's job is only to set goals and milestones and to pass these down to engineers. Based on this, engineers formulate the plan and estimate duration and then report them back to the leader to start negotiations. At Toyota, this is called "Hoshin Kanri" which means translating higher-level goals to lower-level detailed activities across all functions by negotiation (Morgan & Liker, 2007). Therefore, engineers not managers control the detailed activities and are relatively free to allocate the start date of the project.

Due to the iterations required in responsibility-based planning, communication tends to be longer and the process needs additional resources compared to the top-down approach. However, many references can be found in the literature supporting responsibility-based planning on the grounds that it adds more value to the product development process than can be achieved using conventional means. Some research supports responsibility-based planning because of the motivation and sense of accountability it can give engineers. Ward (2007) refers to this approach as "Scientific management" where engineers are involved from the birth of an idea and throughout the developmental process. Using RPC methodology engineers set targets that they themselves have designed and hence a sense of ownership is created (Kennedy, 2003).

Ward (2007) suggests that enabling lower level personnel to become involved in the planning process will makes schedules more robust, which would mean fewer course corrections at later dates. RPC plays a vital role in the continuous improvements process because engineers within the firm are best placed to determine how to improve their processes. Organic innovation and improvements within R&D can be one of the benefits of efficient use of this tool.

2.2.1.5 Cross-project Knowledge Transfer (CPKT)

Cross-project knowledge transfer is a tool developed by Toyota to document potential gaps in the product development system and fill them through capturing, reviewing, updating and generalising methods, designs and tools successfully used elsewhere. Some have claimed that there is a strong correlation between CPKT from old projects and innovative products.

One of the most effective ways of using this tool is by rotating engineers between projects that have similarities. By so doing, organisations avoid re-creating knowledge already available within the organization which is considered a waste of resources. However, transferring engineers between projects is practiced only to a limited extent and not at all in some companies. Many firms tend to assign engineers to a limited number of projects which also limits knowledge transfer. The most efficient way of utilising CPKT if the company is not willing to transfer engineers is to document best practices and lessons learnt in a comprehensive and user friendly way.

Firms nowadays use smart tools to capture the knowledge generated by old projects by building technological platforms online, the entry to which consists of easy checklists. It is really important to update this database frequently with both good and bad experiences generated by all projects whatever their importance. For instance, Toyota developed a comprehensive visual system providing detailed information of car components and their creation (Morgan, 2006). Functional managers make sure that this database, where it relates to their project, fully reflects the knowledge accumulated throughout the years. Hence it could be said that Toyota's designs are based on old knowledge and contemporary best practice in the car industry.

2.2.1.6 Simultaneous Engineering (SE)

In traditional sequential engineering, an activity is triggered by the completion of the previous activity, which is effective but does not give the shortest duration of product development. Simultaneous Engineering (SE), also known as Concurrent Engineering, was first introduced in the Japanese manufacturing sector (Clark *et al.*, 1987). It promotes the concept of carrying out a number of activities in parallel to reduce the lead-time for a product development project. Activities are not conducted one after the other as in sequential engineering but overlap.

However, SE requires a high level of communication between functions to coordinate activities effectively. Cross-functional teams and frequent meetings are the most common features of SE. The team consists of all stakeholders who have been involved since the creation of the project (Womack, 2009). In this way all sorts of minds work on the same project which minimizes the risk of getting it wrong. For instance, considering a company's abilities and constraints at an early stage of the project will avoid redesign at a later stage (Liker, 1996). SE is thus a good tool for minimizing costs and improving quality.

At Toyota, fostering communication is achieved through a special room called an "Obeya" where the chief engineer meets with functional group leaders to keep everyone updated about a project. This room changes its location within the company depending on which stage the project has reached. But the concept is the same in all Obeya rooms. Toyota uses smart technology to display relevant results, graphs, simulations, performance, etc., on the walls of the Obeya rooms

2.2.1.7 Supplier Integration (SI)

Automotive companies have been outsourcing parts for their cars to external suppliers for a very long time and in some cases 70-80% of car parts were made outside the companies' boundaries. To optimise the development process it is vital to provide an interface to involve those suppliers.

Traditionally western car manufacturers provided clear and detailed part specifications and characteristics and then awarded the contract to a supplier depending solely on price (Liker *et al.*, 1995). Normally carmakers use their power in the market to lower the price and at the same time they require the supplier to give them a clear idea about how they make this part. However, suppliers resist exposing their secrets to anyone, especially carmakers, so that they do not weaken their position when negotiating price.

On the other hand, companies who understand Lean thinking tend to adopt a different approach. Most of these Lean companies have a limited number of suppliers with a strong relationship that has been built through the years. This relationship has trust at its core and so suppliers are involved in the development process from an early stage of the project by being part of the cross-functional team.

According to Morgan & Liker (2006), Toyota has four categories for its suppliers:

1- Contractual supplier: can provide simple parts such as spark plugs, nuts, bolts, etc.
2- Consultative supplier: specialized in more complex parts such as tyres.
3- Mature supplier: more skilled than the previous categories and capable of supplying Toyota with customised parts that fit their cars only.
4- Partner supplier: capable of contributing hugely to Toyota because they are capable of developing, producing and supplying complete high quality subsystems.

Only the last two categories are integrated into the development process. Toyota inspects the parts supplied to them by constantly testing them against the required quality, cost and mass. Toyota sets annual cost reduction targets to their suppliers and expects them to work hard to achieve them. Potential suppliers do not win a large contract with Toyota until they have successfully won and completed a number of small contracts after which they are promoted and trusted (Morgan & Liker, 2006).

To sum, it is important that a company does not outsource the production of too many of its critical parts because by so doing they can lose control of a core processes. In addition, the knowledge loss due to missing out the learning process associated with developing certain game-changing parts could be damaging to the company because knowledge is a competitive advantage that cannot be compromised.

2.2.1.8 Product Variety Management (PVM)

Companies have to have a clear idea of how they are going to compete against their rivals. Some differentiate themselves by lowering their prices, others by enhancing performance or increasing quality, some add services and some combine all of these factors. As a result, the company might compete by producing new varieties of their product different from the old ones and succeed in selling them. However, this high variety in product development comes with costs, added complexity, increased testing and prototyping that together make it difficult to reach economies of scale over the product lifecycle.

PVM (Product Variety Management) is a tool that solves the problem of managing a high variety of products in the product development pipeline. Figure 2.4 illustrates the four important elements of PVM.

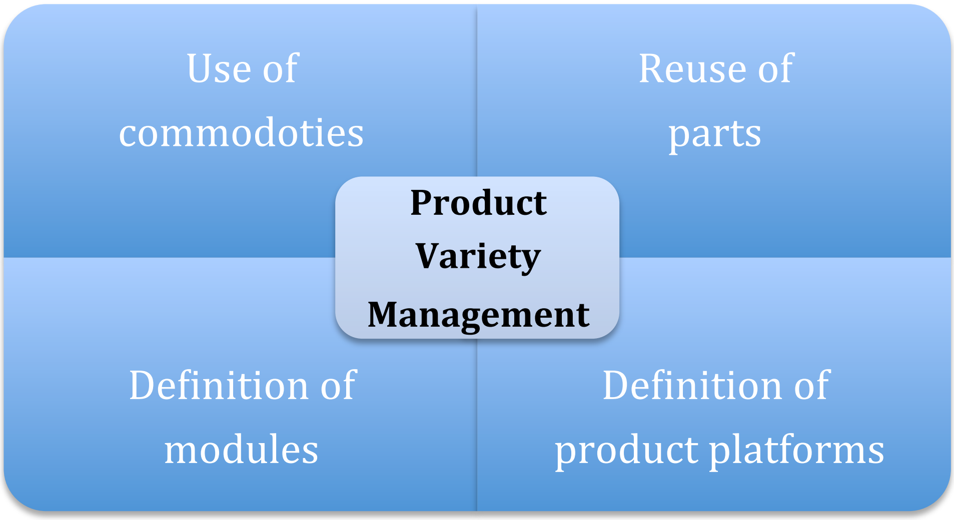

Fig 2.4 PVM elements

Firstly, the firm could reduce part variety by the use of commodities that can be ordered via a catalogue because the part is not considered a critical differentiating feature by the customer. The knowledge obtained from the supplier, who will usually have long experience in developing and producing the part, is added value.

Secondly, reusing previous and proven parts is a safe way of utilising PVM. The risk of introducing a new technology which might damage their image is a real fear for companies like Toyota. Therefore, two third of components in any new car are parts that have been successfully used previously, this increases the chances of reaching economies of scale.

Thirdly, the use of highly integrated complex systems means purchase of off-the-shelf components or re-use of components designed for previous models is less likely. Lean experts therefore recommend dividing the product into distinct modules with a standard interface. This method is reduces maintenance and repairs and lessens complexity. It also encourages learning and helps leads to continuous improvement.

Fourthly and finally, it would not be possible or beneficial to have several modules for a number of products without having a platform to act as a carrier for the subsystems. Additionally, this will help by enabling the building of parts for different product lines on the same platform. However, this product platform must be designed cautiously to be able to act as an effective carrier for a number of modules. For example, Toyota uses the same platform for seven cars and launches a new one every fifteen years (Ward, 2007).

To conclude, PVM is a tool for optimising and managing variety in product development projects. This can have a positive impact on the operation of the system. However, there has to be a balance between re-use and innovation with new designs and products (Morgan & Liker, 2006).

2.2.1.9 Rapid Prototyping, Simulation and Testing (RPST)

The design stage of all product development projects pass through a problem solving phase. The RPST tool is a suitable method for solving a problem that has not existed before. At its heart is Deming's well-known Plan-Do-Check-Act (PDCA) cycle. Plan is the defining of product requirements, Do refers to the execution of the design task, Check means conducting simulation and testing exercises and Act is deciding whether changes or refinements are required.

Traditionally, companies used to evaluate and rethink the design by producing a prototype which Ward (2007) has recommended should be built at an early stage of the project. Nowadays, companies cut the time for producing the model by using 3D printing and that has revolutionised industries around the world by allowing design problem to be solved at a much faster rate.

According to Morgan & Liker (2006), Toyota's way of developing a prototype includes interacting with participants representing all the functions to create a sense of worker involvement. In addition, personnel specialised in prototyping will collaborate with production engineers, industrial engineers, QA experts and designers to establish the limitations and faults in the initial design.

The customers' needs and requirements should always be the paramount feature of any product but technology alone cannot tell if these have been properly satisfied. In sum, while the use of RPST is critical for success of product development it is essential to include the human element.

2.2.1.10 Process Standardisation (PS)

Product development projects have the common feature in that each can be unique due to the creative and innovative factors introduced through R&D. Each project creates a distinct body of information that differs from any other project either inside the company or outside. Variation is a natural feature of product development and the degree of variation depends on the scope and goals of the project.

However, Lean thinking proposes that while the detailed information about each product differs from any other, the procedure and methodology used can be identified and categorized due to the consistency of approach used in product development (Morgan & Liker, 2006). The success or otherwise of process standardization depends on the company's ability to identify recurring tasks in the planning and execution of projects.

Standardizing tasks will improve performance as well as reducing scrappage due to errors and unacceptable variation. It is therefore considered a basis for process improvements and optimisation (Morgan & Liker, 2006). Senior engineers and shop-floor workers at Toyota have the right to suggest improvements to standard procedure through the transparent system of Kaizen or continuous improvements.

However, random variation in this case is a bad thing and engineers at Toyota are provided with standardized procedures and tools to help them to develop a unique design. According to Ward (2007), it is a balance between total standardization and total chaos that will optimise efficiency.

Standard procedure has been a building block of Lean operations for a long time and being committed to this has served Toyota well in many areas and environments. But if it is applied too widely in product development it will cause overregulation that will clash with other tools.

2.2.1.11 Set-based Engineering (SBE)

Finally, Set-based Engineering is the last tool in the Fit development toolbox. Set-based engineering or Set-based Concurrent Engineering can best be described by comparing/contrasting it to its opposite, Point-based Engineering. The latter depends totally on small number of alternatives that satisfy initial requirements only and is unlikely to suit future updated requirements. Supporters of the old school of thought in manufacturing would find themselves in deep trouble if they discovered at an advanced stage of the project that the model developed did not match the requirements. This would cause endless loops of iterations due to the continuous modification of drafts, design and prototypes (Ward, 2007).

This calls for an alternative methodology that overcomes point-based limitations. The Set-based approach starts similarly to point-based engineering by dividing the disassembled products into modules and subsystems but this time the former generates a large number of options and alternatives that are not reduced quickly until the later stages, unlike the point-based approach. Using Set-based engineering will keep the window wide open because the tool box is full of viable ideas that will serve as “Plan B” should problems occur.

It is clear that the traditional way of thinking does not suit Lean thinkers and ideologies, especially the amount of waste that is the result of inappropriate resource management. By applying Lean thinking and Set-based engineering and avoiding iterations, the company will notice big and positive changes in quality, cost and the scheduling of product development.

It is important to say that the success of using SBCE depends on various factors such as how long the company has been using concurrent engineering, quality functions deployment, and interdependent part development (Ward *et al*., 2012). Therefore, it is hard for SME's to adopt SBCE without having all the resources needed to utilize it. Moreover, research found that SBCE is used widely is Japan compared to the US which could be justified by the relation of concurrent engineering and SBCE in the Japanese industries (Ward *et al*., 2012). Our knowledge of SBCE at Toyota is limited because it is not defined clearly and well documented which makes it hard to implement elsewhere. Hence the need for a complete theory about SBCE is needed otherwise companies will continue blaming it for poor decision-making which lead to wasting time and money (Ward *et al*., 2012).

Toyota has had a long history of teaching its employees and train them for a long time which resulted to having an unusual engineering expertise, therefore it is not recommended for companies with low or average skill level to adopt SBCE due to the difficulties they will face (Ward *et al*., 2012).

Toyota is a world leader in and champion of SBE, it brings a large number of components, parts, subsystems and platforms from previous projects and applies this tool to the critical ones. Careful documentation of this process is vital if it is to capture the new knowledge and methodologies used to develop it (Ward, 2007). Hence, it is logical to argue that Toyota has a large bank of knowledge and information like no other automaker in the world which gives them a significant competitive advantage.

After discussing the tools that Toyota uses to develop its products, it is worth discussing some of the challenges that faces Toyota today. The company has been experiencing some problems with recalls which are related directly to quality issues in Toyota. In 2009, Toyota recalled 3.8 millions US cars triggered by the death of a customer because the accelerator got stuck which led to another 8 million recalls globally to solve this issue (www.wsj.com). Additionally, the company had to recall another 3.4 million vehicles in the US market at the end of 2009 for the same problem. The media all over the world played a big role in making this story a headline which changed the perception toward the brand that was well know for its building reliability, good quality, durability, and value.

According to Cole (2011), the source of this problem can traced back to two causes: firstly is the rapid growth since the appointment of the new president Hiroshi Okuda in 1995 who aggressive growth strategy got out of control and led the this crises, secondly is the high complexity of Toyota's car which are linked to governments legislations on safety, fuel consumption targets, and customer's demand for "green" cars with high specifications. Both factors played a big role in affecting the quality of Toyota's vehicles which led to a dissatisfied customers in addition to the bad publicity.

An increase from 37 to 53 overseas manufacturing facilities between 2002-2008 gave Toyota's management small chance to adapt its system to the huge expansion and increase in sales by 9% on average per year (Toyota, 2008). Furthermore, this growth affected production, product development, and supplier management because the company was focused on gaining more sales, increasing profits, and meeting delivery rather than quality as a first priority Cole (2011).

Toyota experienced an increase of sales in North America from 1.7 to 2.9 million cars between 2000-2007 with a rise in models from 18 to 30, and to cope with this growth in sales the company slashed lead time between design approval and launching to market to less than 20 months Cole (2011). This has put a hug burden on Toyota's production system in addition to the strain on its development system and in turn humans recourses were pushed to the limit that caused quality failure. Additionally, due to the unsystematic growth which led to a rise in sales Toyota had to commission design work to engineers outside the company who are not familiar with Toyota's strict standards and procedures Shirouzu (2010). Furthermore, new and temporary engineers were hired in Japan which goes against their culture of not hiring an engineer until s/he pass the rigorous training program which ensures they understand the company's culture, standards and the way of doing business.

According to Fujimoto (2010), collaboration between Toyota and suppliers on different levels is one of the factors that contributed to Toyota's success and distinguishing it from it western rivals, however, the company failed to apply its strict testing and evaluating some parts designed by suppliers outside Japan which contributed to the quality crises. As a reaction to all pervious issues, Toyota took the following measures in order to overcome the crises:

1- Overseas engineers were reduced to 10%.
2- Giving management in North America more power in order to improve quality.
3- Slowing down product development process and creating a new team of engineers around the globe to respond quickly to any quality broblem that may arise in the future Cole (2011).

Summary

The author has critically reviewed the 11 Toyota tools used for product development. However, using these tools without understanding the relationship between them would be a big mistake because unlocking the potential of one element depends on using it in conjunction with other elements (Ballé and Ballé, 2005) (Haque and James-Moore, 2004) (Sobek *et al.*,1999). In this thesis it is argued that understanding the interdependence of the 11 tools will enable the development of a framework or guide which integrates their implementation, thereby increasing the chances of developing truly innovative products at a feasible cost and launching them at the right time before rivals. The following Section 2.2.1, investigates the sources of waste in product development and their impact on flow.

2.2.2 Unfit Demand Themes in New Product Design (NPD)

After discussing Toyota's product development system in the previous section of this chapter, this section will discuss different types of unfit demand in new product demand (NPD) and try to show gaps in the literature which provide opportunities for new research. Creating flow in NPD is vital to the delivery of innovative products within budget that solve customers' problems and fulfil their needs. Developing an effective Fit development framework will depend on how people in R&D manage waste or Unfit demand in their processes.

2.2.2.1 Defining Unfit Demand and Waste

The eight kinds of waste identified by Womack and Jones can be easily identified in manufacturing environments. However, waste in NPD is hard to identify and especially failure demand or "Unfit demand". This is due to the complex process of identifying value in a new product project. For instance, in R&D built around the environment of testing of product quality, rework and inspection could be considered not to be value-adding activities (processes that the customer is willing to pay for it)

(Letens *et al.*, 2011) even though their activities boosts the probability of the end product meeting customer demands. It is always a target for elimination in R&D. In manufacturing, defining non-value adding activates is simple to a certain extent, however the distinction between value adding and non-value adding in PD is the tricky part (Letens *et al.*, 2011). In PD, activities that are linked with risk reduction and interim deliverables “atoms of value” are value-adding which makes it a more direct definition of value in PD (Browning, 2003). Additionally, Browning (2003) emphasised on focusing our efforts on identifying the important characteristics of interim deliverables.

Some authors, such as Reinertsen (1997) and Browning (2003), believe that reducing or eliminating waste in a NPD process should not be focused on the definition of value only and activities should not be considered as ‘adding value’ unless they are related and connected to the creation of deliverables that enhance the projects’ value and decrease the risk of failure.

Researchers are divided in their attitudes towards variability. Some are hostile and others find it interesting and important. For instance, quality movement wishes to eliminate variation from the design process (Mader, 2002). On the other hand, Reinertsen (2009) suggests that a certain amount of variability or failure in NPD will enhance learning and innovation. His view is shared by Deming who argues that life is full of variation and that is what makes it unique. Different authors consider waste in NPD in their own way. Figure 2.5 shows Mascitelli’s (2004) eights kinds of unfit demand.

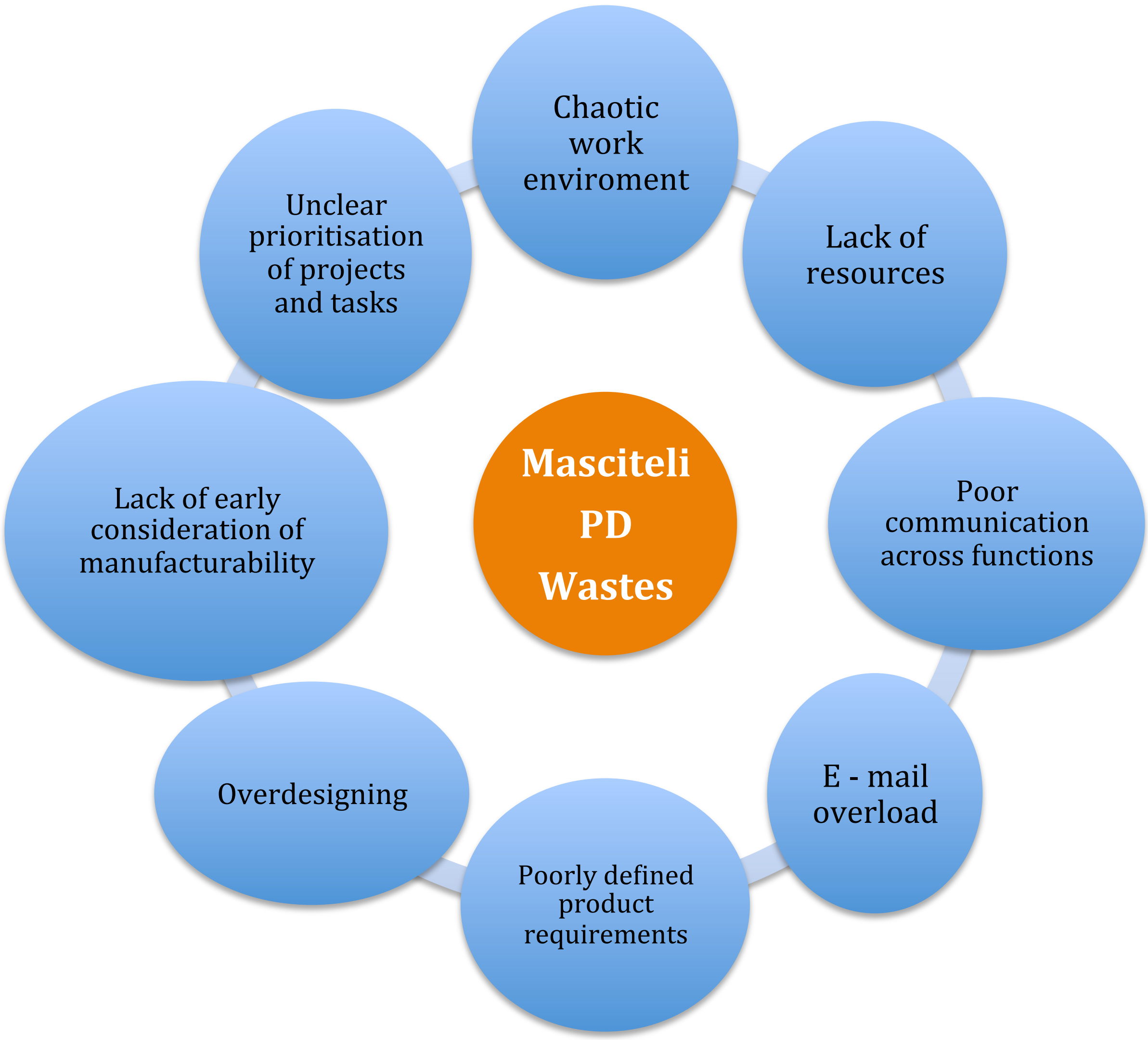

Fig 2.5 The eight sources of waste in NPD according to Mascitelli (2004)

Reinertsen (2009) has defined twelve areas of waste that cause dysfunctionality in NPD;

- "Failure to correctly quantify economic considerations,
- Blindness to queues,
- Worship of efficiency,
- Hostility to variability,
- Worship of conformance,
- Institutionalisation of large batches,

- Under-utilization of cadence,
- Managing timelines instead of queues,
- Absence of WIP constraints,
- Inflexibility,
- Non-economic flow control, and
- Centralised control."

The author has developed Figure 2.6 to show all types of waste mentioned in the literature and is considered a cornerstone for the survey of Unfit Demand in R&D. In the next section the author will investigate each type in-depth to provide a clear picture about how they are generated and cross-linked to other types of waste.

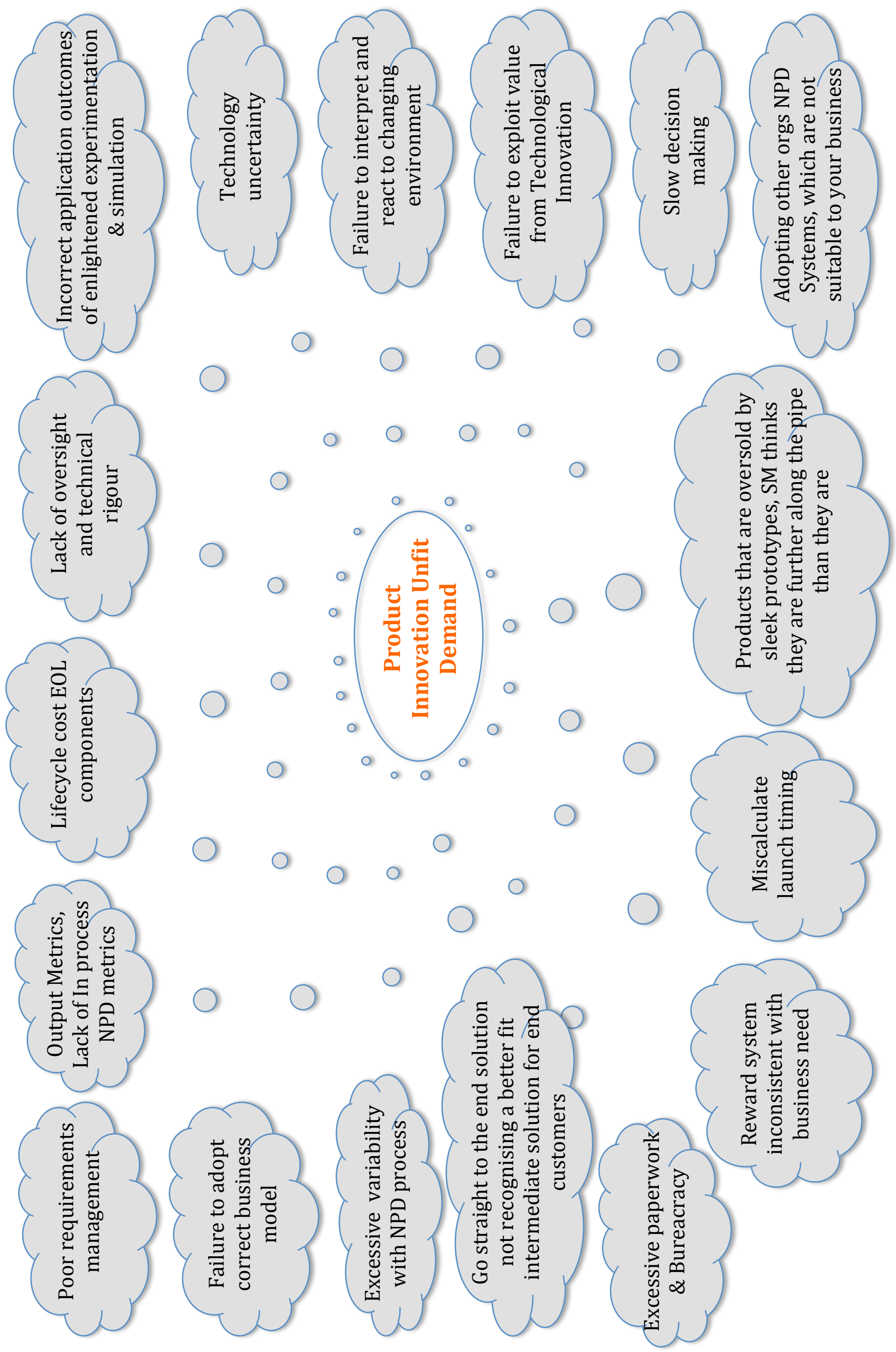

Fig 2.6 Sources of Unfit Demand in NPD

2.2.2.2 Sources of Unfit Demand

2.2.2.2.1 Failure to innovate

Jones (1992) explored the challenges arising from innovation and argued that a big mistake when designing a product is basing one's ideas upon available current data to predict the future because this method does not get it right most of the time. Also, it is rare for companies to develop and launch new products that are truly unique though it is known that the biggest driver of profitability is launching an innovative product at the right time to the right segment of the market (Cooper, 2011).

According to Davila *et al.,* (2006), incremental innovation and sustainability is the result of 80% investment in innovation, this view this is supported by Cooper (2011) who termed it "Radical Innovation". Thus companies maximize their capital investment and brand equity believing these to be an essential pillar to innovation. Use of Disruptive Technologies is a way of advocating breakthrough innovation and is discussed by a number of researchers such as Cooper (2011) and Christensen (2006). According to these researchers, failing to innovate in most firms is caused by not adopting this methodology with system-oriented solutions as seen in the development of the Apple iPod.

By the time Apple launched the iPod there were 44 MP3 players in the market, so they did not invent the MP3 player. Nonetheless, they knew customers' needs and combined this with system solutions to get an MP3 player which is easy to use, easy to buy songs for, while having a contemporary and fashionable look (Cooper, 2011). Companies such as Apple, Sony, GE, Procter & Gamble (P&G) use a specific strategy called Playing to Win (PTW) or Play Not to Loss (PNTL) which emphasises being more risk oriented by investing heavily in R&D so the company may absorb high failure rates but eventually increases innovation (Davila *et al.*, 2006). On the other hand, looking at Apple's 2007 R&D investment as a percentage of sales, it was just 3.2% (Sehested & Sonnenberg, 2011). It is not a viable belief, therefore, that the R&D budget alone determines a company's innovation ability.

Finally, it is vital for corporations to have First Move Advantage (FMA) which means they achieve much better financial figures than to their rivals. FMA enables this to happen not only by entering a market first but also by entering the market in a way that makes it difficult for others to follow and compete successfully (Liberman & Montgomery, 1988). Some clear example for understanding FMA is Xerox with fax machines, Sony with personal stereos, and Gillette with safety razors (Suarez and Lanzolla, 2005). However, FMA needs a deep analysis of the environment that encircles the proposed new product category, additionally, knowing your resources and how strong are they are two vital issues to decide which type of FMA is achievable (Suarez and Lanzolla, 2005).

2.2.2.2.2 Failure to meet customer requirements and over engineering

For a Lean journey it is important to start with investigating and determining customers' needs and wants, and then to commence the process of improving customers' lives (Hafer, 2011). Collins (2009) has given a number of examples of blue chip companies that failed to understand this concept and lost out to their competition. Companies such as Motorola that dominated the market for a long time with a 50% share, is a prime example. StatTac was their cell phone with an analogue platform that was a hit until customers demanded cell phones with a digital platform. However, Motorola's sense of superiority made them ignore the swing and by 1999 their share had fallen to 17% of the market.

There is a different view on failing to understand customer needs proposed by Breillat (2008), who pointed out that Apple does not do market research to understand customers' needs before it starts designing a product. On the contrary, they only use focus groups and VOC to understand their customers. Apple have argued that they understand the customers' needs better than the customers do and this is why each new product is a surprise (Breillat, 2008). This approach was neatly summed up by Henry Ford "If I'd have asked my customers what they wanted, they would have told me: 'A faster horse".

Customer value is an important pillar of Lean thinking, but what needs further research and clarification is matching customer needs with product functionality and purpose. In some cases companies add more functions to their products than asked for by their customers; the question is which approach creates waste and which follows Apple and Henry Ford.

2.2.2.2.3 Failure to manage portfolio

According to Kavadias & Chao (2007), NPD portfolio management is the most effective way of managing resources and allocating them for innovation. The portfolio will consist of a mix of small changes, incremental improvements and radical developments. Kavadias & Chao, (2007) suggest a number of considerations that need to be borne in mind:

- "Strategic alignment: NPD is a complex and ambiguous environment that depends on the ability to effectively communicate strategy down to project level.
- Resource scarcity: could constrain flow in NPD, especially in a multi-project environment. This constraint can take different forms such as budget, testing

capability and people. It may well result in queues or bottlenecks.

- Project interactions: firms normally develop multiple products in related market sectors, which means that they can either complement or compromise their effectiveness in the original market segment.
- Outcome uncertainty: uncertainty is a main characteristic of product development programs and managers are often faced with the challenge of non-adoption by the ultimate customer.
- Dynamic nature of the problem: an NPD environment is chaotic by definition and targets are moving all of the time, which means programs evolve on different trajectories over time".

Portfolio management is not a new discipline but many managers still do not apply it well enough. The real problem is the lack of methodologies available, even with the existence of software such as Monte Carlo and Decision Lens. Mello *et al.,* (2006) argue that these tools offer indications that do not truly assist classifying, contrasting and monitoring existing products instead of predicting the future content of the portfolio. Such software fails to capture the data essential to use as a customer value as a fixed measure for the evaluation of portfolio decisions (Mello *et al.,* 2006).

Strategic thinking plays a vital role in NPD optimisation. However, "strategic planning", as Mintzberg argued, was constraining strategic thinking. Managers who think that analyzing past data under stress will improve future performance are mistaken (Munt, 2010). Corporate NPD decision-making is often dominated by unwritten and unstated rules, past experience is valuable but only if previous mistakes are recognized, political undercurrents can change the direction of the project, there is the unbalanced enthusiasm of those initiating the project, and all too often "NPD managers abandon common sense for common wisdom" (Topin, 2011).

2.2.2.2.4 Failure to integrate suppliers and third party innovators

Firms nowadays have to have many good ideas if they are to survive and thrive. These good ideas can be either organic in the sense that they originate from engineers and designers within the company or they could be provided by an external entity ("outsourced") which might be a competitor, entrepreneur, university, inventor, investor, scientist, researcher or supplier.

Hansen & Birkinshaw (2007) asked if companies utilised the option of outsourcing ideas and they discovered that many of them did not, which can cause lower levels of innovation and missed opportunities. They argued that Sony is a very good example of what they called the "not invented here syndrome". Sony was very fond of the development of in-house products such as the Walkman (1979) and Playstation (1994) an approach that pushed their profits sky high until well into the 1980s. However, failing to use external sources for design innovation began to have a seriously adverse effect on their design capabilities and started to drag the company backwards. Sony missed several opportunities in the MP3, TV and camera markets due to a lack of understanding of the benefits of outsourcing product development and being fed new and good ideas that could revolutionize the market (Hansen & Birkinshaw, 2007). The result was a big loss in market share during the late 1980s and early 1990s and Sony concluded "outsourced ideas are not good enough".

According to Capgemini (2010), more than 50% of companies nowadays are keen to outsource ideas and are constantly looking for help from external parties. The struggle is to understand why the other 50% are not doing the same! The answer for this question might be found in Mahr & Rindfleish (2009)'s work where they gave at least a partial explanation of this behavior by explaining that using external ideas required a high level of openness and transparency from both sides. This open environment is a big challenge for many companies due to their fear of losing data, information or knowledge to rivals.

According to Emden *et al*., (2006), NPD collaboration is triggered by technological alignment, and alliances are effective when technical skills are used to generate unique capabilities. However, a relational misalignment damages the collaboration process and Emden *et al*., (2006) suggested the following as sources of this misalignment:

- "Changing requirements can make potential partners unwilling to adopt and accept the new situation.
- Not sharing the same language, norms or work routines or having different standards of behaviour can hinder flow and impede understanding.
- A positive long term outcome requires ongoing collaboration, and inputs from both sides, but some partners are after short term gains and are reluctant to collaborate and be open".

Most of the literature emphasises being proactive and collaborative with suppliers and third party innovators. A good example for adopting this strategy is P&G, who installed state of the art software for outsourcing ideas and making knowledge available online, which greatly contributed to an increase in sales and profits of 43% and 85% respectively between 2001 and 2006 (Hansen & Birkinshaw, 2007).

2.2.2.2.5 Failure to create flow

Different authors emphasise the relationship between waste and other factors. Reinertsen (2009) supports the idea that the heart of the problem is flow and not waste. Flower (2011) believes that the most significant driver of success in product development is in creating flow and this is illustrated in Figure 2.7.

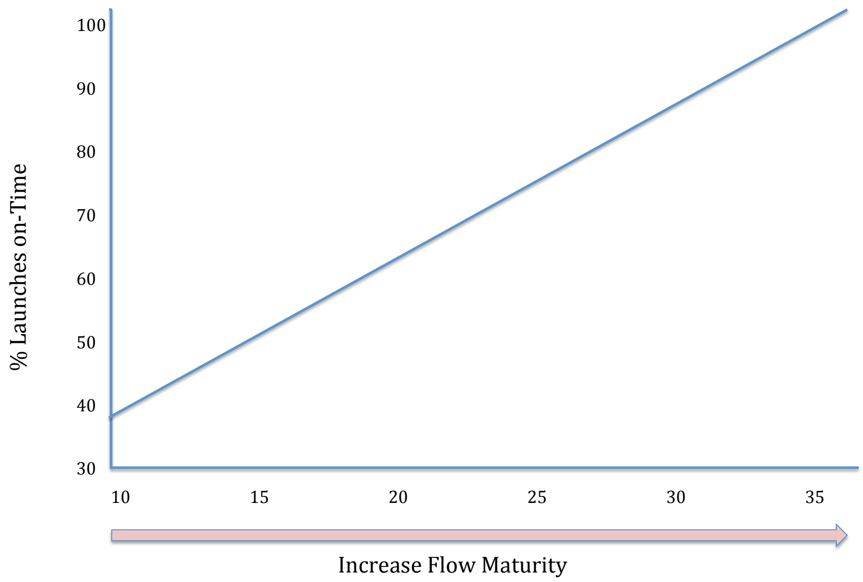

Fig 2.7 Flow behaviour (Flower, 2011)

The biggest enemies of flow are queues, large batch size and the ambition of product development management to eliminate variability. The impact of queues will take different forms such as increasing cycle time, expense and risk, slow feedback, reduced quality and decreased motivation (Reinertsen, 2009). All these factors are sources of unfit demand. Moreover, the effect of high capacity loading/utilisation on queues is tremendous and this shows in manufacturing lead times (Reinertsen, 2009)

Reinertsen's methods of addressing the behavior of queues in product development are similar to the techniques used in lean manufacturing (Figure 2.8). The aim is to establish a better system flow based on the M/M/n/∞ multi-server queuing theory, where there are single/multiple queues and a single/multiple capacity processing center.

Processes in R&D behave differently that processes in manufacturing due to the high variability in R&D. Therefore, the time spent in the queue rise sharply as utilisation of resources in R&D increases (Fig.2.8). Additionally, Waiting time more than double as utilisation moves from 80% to 90% and double again as it moves from 90% to 95% (Thomke and Reinertsen, 2012). This is the nature of R&D where predictable work is combined with unpredictable work and the result is queuing problems. Unfortunately not all R&D managers realizes this problem cause they believe the fallacy that high utilisation of resources will improve performance.

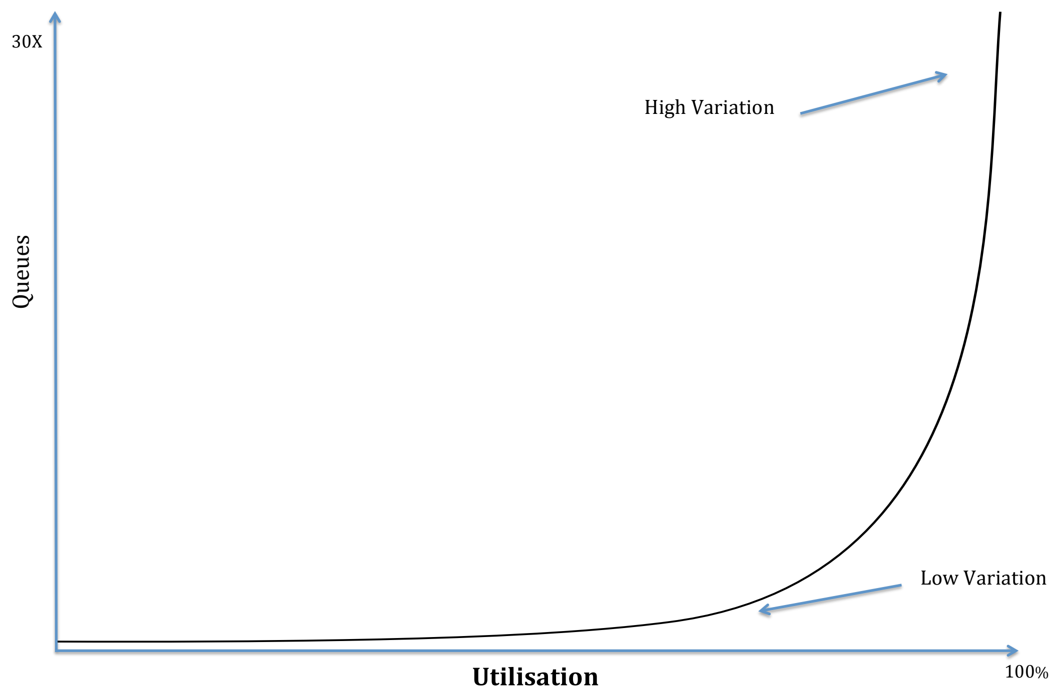

Fig 2.8 Utilisation and queues

Reducing queues, accelerating feedback and minimising the impact of quality issues in product development can be achieved through a reduction in batch size and development in progress (DIP). This is a great opportunity for improvement because developers often do not recognize batch size as an important issue (Reinertsen, 2009).

Summary

This chapter has discussed Toyota's product development tools that represent an important methodology for optimising NPD. Additionally, a review of different schools of product development has been undertaken. This led to the investigation of sources of Unfit demand in product development processes and a critical review of product development measurement has been provided. Additionally, the author showed the importance of managing flows and what factors can hinder this flow and create bottlenecks in the product development system.

The following section will review a very important case study for implementing Lean manufacturing concepts and tools in the service sector. This will form a solid basis for future research and there is also proposed a Fit Index that can measure the success of the intervention.

2.3 Lean Intervention

Preliminaries

This, the last section of the literature review, introduces an application of Lean manufacturing to the service industry. The Starbucks coffee chain offers a good example of the implementation of a Lean intervention to better survive the general financial collapse of 2008. A review is presented of how Starbucks realised that to stay in business and ensure future growth it had to continuously cut waste and implement efficiency improvements.

2.3.1 Policy Deployment

"Hoshin" or policy deployment is the most efficient way of implementing Lean operations which ensures that all efforts are moving in the same direction with full commitment from all part of the system (Bicheno and Holweg, 2009). It is difficult to copy a company without knowing the way they followed to execute its strategy, hence, companies are interested in understanding the science of Lean operations and the most efficient way to implement it. According to Bicheno and Holweg (2009), there are two ways of Hoshin:

1- Top down happened normally in a command and control organisations with little discussions focusing mainly on financial indicators and ways of improving it.

2- Systems way by realising the needs understanding why the company is using Lean thinking in order to overcome challenges and meet customer requirements.

To ensure that objectives are doable and achievable, joint analysis and two-way communication are utilised at all levels in the organisation during the deployment process (Leo, 1996). Furthermore, Hoshin needs either cross-functional or horizontal alignment to work properly and not vertical alignment which is associated with achieving few goals (Shiba *et al*,. 1995). Policy deployment askes workers to contribute during Hoshin by setting their own objectives which plays a vital part in achieving the main goal as in the case of Xerox (Witcher and Butterworth, 1999).

2.3.2 The Call for Lean at Starbucks

Starbucks was launched as a public company in 1992 and today is the world's leading coffee roaster and retailer. Starbucks has nearly 17,000 stores in 50 countries, employs more than 150 thousand baristas serving more than 50 million customers a week, generating an annual net revenue of nearly US$11 billion (www.Starbucks.com). Over the last decade Starbucks has seen a significant drop in sales due to poor customer retention with a corresponding drop in share price.

Starbucks was deeply and adversely affected by the global economic crisis of 2008 with a consequent 10% drop in sales in the first quarter of 2008, see Figure 2.9. One explanation is that consumers generally did not have sufficient budget surplus to buy premier products (e.g. Starbucks' coffee).

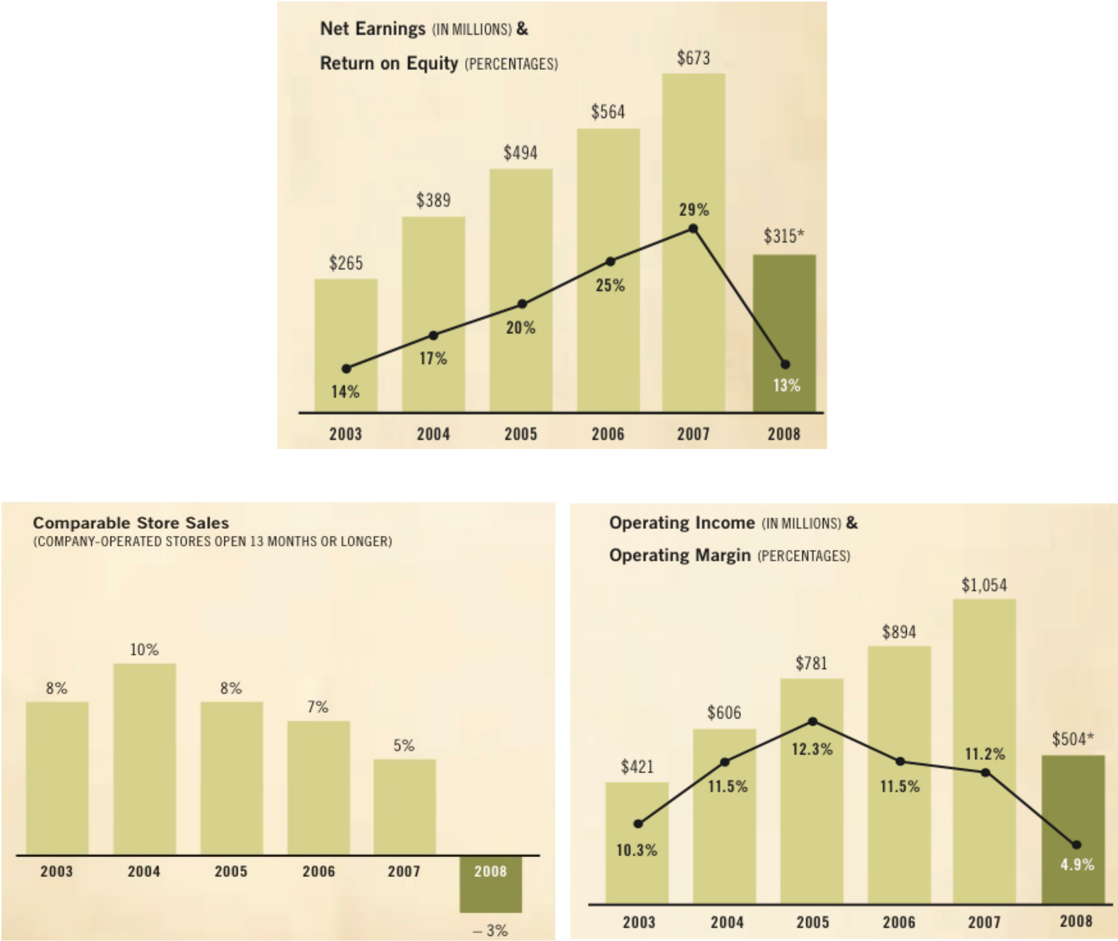

Fig 2.9 SBUX Fiscal 2008 (www.Starbucks.com)

The Wall Street Journal (WSJ) research centre reported a big change in consumer spending; in 2009, the proportion of people in the US putting money into savings was 28%, up 13% from six months earlier (www.wsj.com). Such a massive change affected all companies in the food and drinks sectors. Those who survived best were those having the initiative and capabilities to make big changes quickly. Starbucks was under additional pressure from the growing relative success of rivals such as Dunkin' Donuts and McDonalds, who are competing for customers by offering cheaper specialty-coffee drinks. As a result of these factors, in 2009 Starbucks slowed the rate at which it was opening stores (in the US down from a projected 200 stores to 140, down internationally from 270 stores to 170). In addition stores failing to meet expectations were closed; 600 in the USA and 300 internationally. Starbucks was forced to enter the value-meal competition by offering combinations of breakfast sandwiches and hot drinks at a cheap rate for the first time in its history.

On 14 February 2007 Starbucks' Chairman Howard Schultz sent an email to the Chief Executive Officer, Jim Donald, criticising decisions made during the expansion of the company which, as Schultz put it, had led to a "watering down" of the Starbucks' experience (www.wsj.com). The company accepted the authenticity of the email after it was leaked in the Wall Street Journal.

The email (www.businessweek.com) argued that by focusing on the bottom line those factors which had made Starbucks so popular and successful in the beginning (the quality of its coffee and a good customer experience) had been so diluted that customer loyalty had been lost. The argument was that optimising business operations, company expansion and cost reduction were all essential but had to take place within an understanding of what does and what does not add value to the customer experience.

Within a year Donald would have left the company and Schultz had replaced him as CEO. The Financial Release from Starbucks announced that Schultz saw his task as saving the company from collapse based on acknowledging that growth strategy and infrastructure investment had resulted in core business being disregarded. Three main problems were identified: excessive bureaucracy, insufficient focus on the customer experience and bad alignment of back-end costs. Schultz stated that his agenda for addressing these problems contained four key strategies (investor.starbucks.com):

1- “Contributing to the improvement of the US business by supplying employees with better training and tools to cope with new challenges. This should be supported by optimising store design through new concepts to “give customers a superior experience”.
2- Re-establishing the emotional attachment between customers and Starbucks, in the form of the baristas, coffee, the brand and the store.
3- Streamlining management, re-focusing the company to help make smarter decisions and bring products to the customer faster, as well as reducing costs and reallocating resources to more customer-focused initiatives.
4- Utilising the untapped potential for their brand through accelerated expansion outside the US using capital saved by slowing down expansion in the US and closing underperforming stores”.

It is obvious that Lean Operations are suitable tools for the successful implementation of these four strategies. Firstly increasing staff (barista) efficiency can be done using Training Within Industry (TWI), a Lean tool that systemises the training process and establishes standard working procedures. Secondly customer flow can be maximised and store layout design optimised using Lean tools. To successfully implement the third key strategy requires reducing the time taken to make the product, giving the barista time to interact with the customer and personalise the experience. Finally, a Lean intervention can bring management closer to baristas and customers and so reduce the delay in acquiring feedback, which will enable a shorter response time to market trends and needs.

2.3.3 Lean Intervention

Priolo (2012), has expressed surprise that a group of people located in Seattle have been able to successfully create a standardised work system and routines applicable to every Starbucks store in the world because it is the nature of the Starbucks' chain that each store is unique, with different sales patterns, rates of work and layouts.

Six challenges that Starbucks faced and had to overcome in their Lean journey were:

- Over 17,000 unique stores world-wide employing more than 150,000 baristas.
- No staff training process in place and no place for training in its culture.
- Greater demand at peak than could presently be met.
- Traditional batch thinking, with a command and control management system.
- Top down management meant problem solving was not seen as a desirable staff requirement.
- No place for employee input into the improvement process.

Starbucks began testing Lean operations in Oregon (USA) in 2007, at one of its busiest drive-through stores. Tara Jordan, the store manager, reported the new methods as having a profound impact on performance. She claimed an average time saving of 23 seconds per order, which allowed an increase in customer throughput of 10% in the nine months from September 2008 to June 2009 (www.wjs.com).

Heydon, Starbucks' VP of Lean Thinking, was interviewed by the Wall Street Journal in 2010. In the interview Heydon discussed and evaluated the Lean intervention and outlined certain of the tools and concepts used to eliminate waste from the Starbucks processes, free time for staff to interact and communicate with customers and so improve the Starbucks' customer experience.

Core concepts required differentiating between the motion of the baristas and productive work. The investigation revealed that as much as 30% of a baristas' time is motion (movement, bending and reaching) which the customer is not willing to pay for, because it is seen as not adding value (NVA). A Lean intervention ought to reduce this wasted time through capability and capacity utilisation and so enable the company to increase the production of drinks with the same number of staff and so remove, or at least reduce the need to hire more staff in high season. The value of this is underscored when it is remembered that labour costs were about 24% of at Starbucks' total revenue in 2008 (www.Starbucks.com).

In 2009, Starbuck's Fiscal Report revealed that store sale growth (rate of increase) decreased steadily from 2005 to 2009 and in both 2008 and 2009 was negative (company sales were contracting), see Figure 2.10. The figure also shows the drop of Capital Expenditure from over US$ 1 billion in 2007 to less than half that sum in 2009 (www.Starbucks.com). On the other hand Cash from Operations was a maximum in 2009. These diverging trends are taken to be a clear signal that the Lean intervention had meant spending less but retaining cash inflow. The operation is leaner it has less "fat" within it.

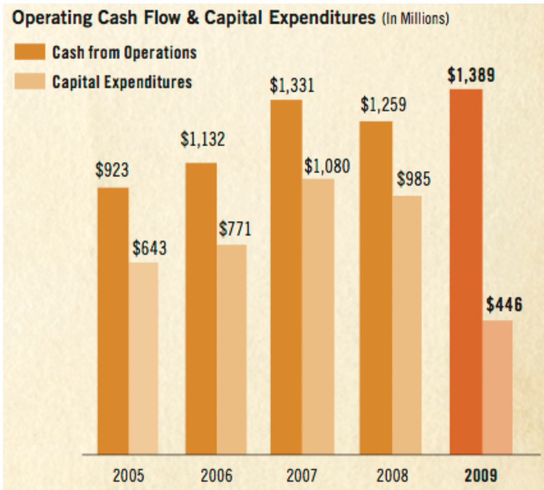

Fig 2.10 SBUX Sales Growth, Operating Cash Flow, and Capital Expenditure (www.Starbucks.com)

In his 2010 Fiscal Report Schultz stated "*the adoption of new technology platforms and Lean principles are helping to improve the partner and customer experience. Customer satisfaction scores for partner friendliness, speed of service and taste of beverage continue to increase*" (www.Starbucks.com).

Figure 2.11 which comes from the 2010 Fiscal Report gives a picture of a company which is not only surviving but is doing relatively well during an economic storm.

Fig 2.11 SBUX Store Growth (www.Starbucks.com)

2.3.3.1 Lean Teaching Model

Heydon in his 2011 Report he conformed that the changes promised in Schultz's 2010 Fiscal Report had been largely achieved, see Figure 2.12.

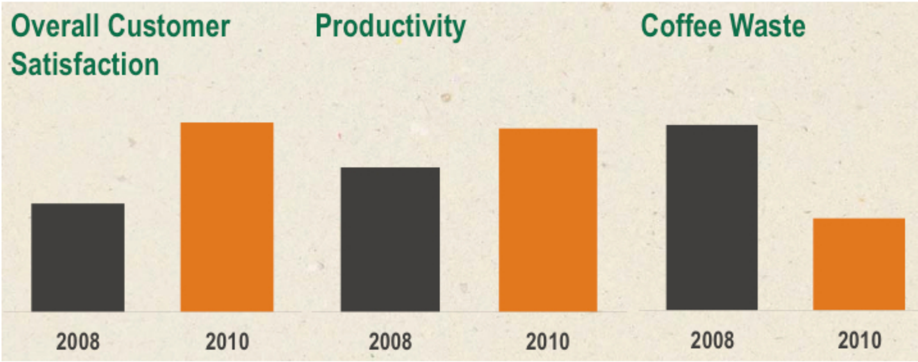

Fig 2.12 Lean results (Heydon, 2011)

Figure 2.12 shows that between 2008 and 2010 productivity increased by 13% and overall customer satisfaction by 18% (Priolo, 2012). The figure also shows that between 2008 and 2010 coffee waste was cut by more than half due to a range of activities, one of which was to request managers to cut coffee waste in half. They achieved this target in four months.

Starbucks had a four year plan for the Lean intervention, see Figure 2.13. Beginning in 2008 began its experiment with Lean intervention in a relatively small number of stores in different districts in the USA. 2009 was the year during which problem solving and Lean leadership were the focus with the goal of reducing coffee waste and reducing excess motion. 2010 was the year when beverage routine was added to Lean leadership and problem solving. The Lean journey ended with a sustained effort to try and ensure the changes were maintained and a continuous improvement culture was established.

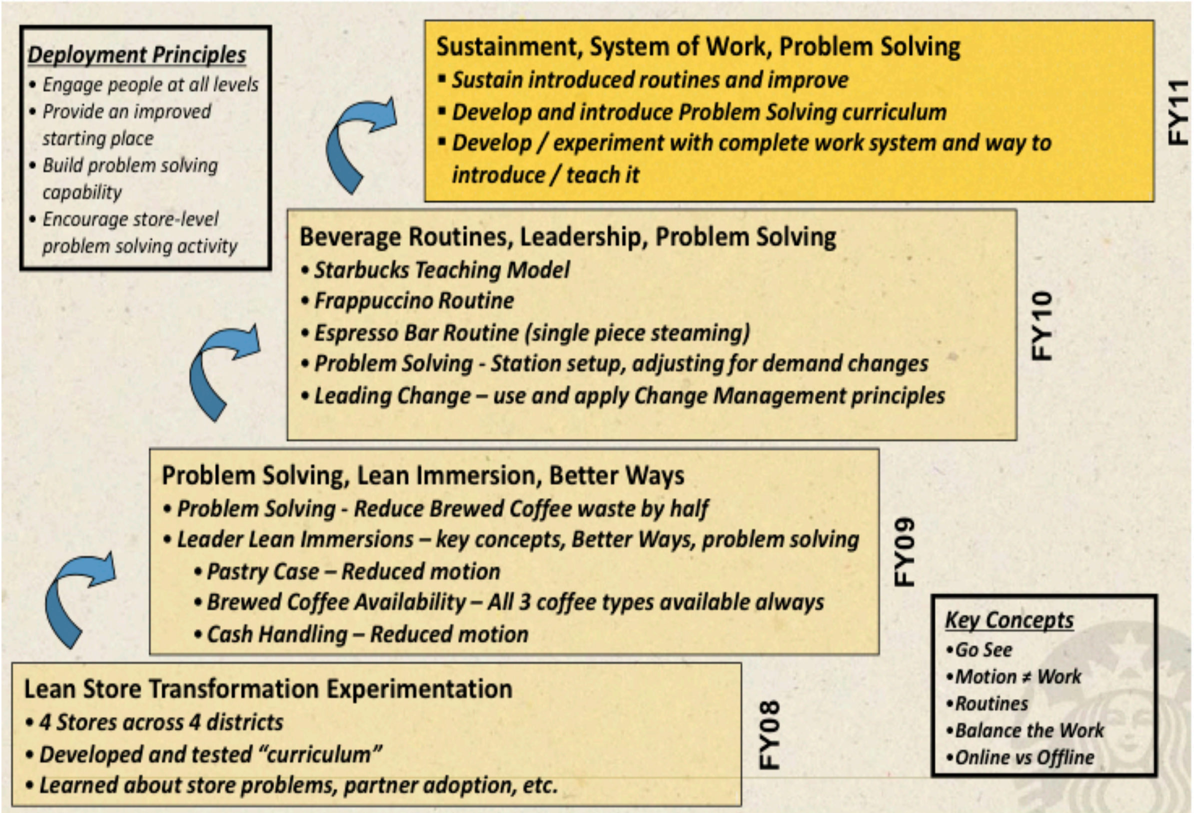

Fig 2.13 SBUX Lean Roadmap (Heydon, 2011)

2.3.3.2 Training Within Industry (TWI)

The adequate and appropriate training of baristas is vital if Starbucks is to ensure that the standards it sets are met and that processes keep on improving. Figure 2.14 shows the barista training structure Starbucks now uses to ensure a satisfied and happy customer. The framework consists of a consistent method of work and a consistent method of training, integrated with the capacity for improvement to be made at a store level. The final outcome should be a consistently high quality of drinks and greater barista engagement with customers. Customers should be served quickly with a tasty drink with no defects.

Fig 2.14 SBUX Framework. (Heydon, 2011)

To ensure a consistent method of work which has a positive impact on barista performance, Starbucks breaks down the work done into three categories.

i. Major Steps: Logical segments of work that advance the process. This category is not meant to be a complete time and motion study.
ii. Key Points: To ascertain the key elements for accomplishing any particular step properly and systematically. This category includes every factor that could make the work easier, could improve the job or could injure the worker.
iii. Reasons Why: This category is an explanation of the "why" behind each point.

The procedures whereby work done at Starbucks is broken down into its constituent elements are:

i. Multiple observations of each task.
ii. Line list the steps.
iii. Break into chunks.
iv. Having completed steps i, ii and iii, observe the work process yet again and capture key points.

v. Observe the work process once more and summarize reasons why the key points are important.

vi. Document, test and observe. (McHugh *et al.,* 2011)

Starbucks' TWI training model was introduced as part of the Lean intervention to ensure both new and existing baristas learned standard work methods correctly from the beginning. TWI was the chosen as the foundation for Starbucks' training as it is directly related to the work situation and represents the practical application of standard routines and activities between groups. For example, Starbucks' staff are taught the approved routines for making an espresso beverage in groups of three, see Figure 2.15. One prepares six drinks while the other two observe the quality of the drinks and the time required to prepare them. Next the standard routine is demonstrated and the baristas are then asked to prepare the same espresso drink again. These sessions achieve the goal of learning to make the espresso using the correct technique by practice.

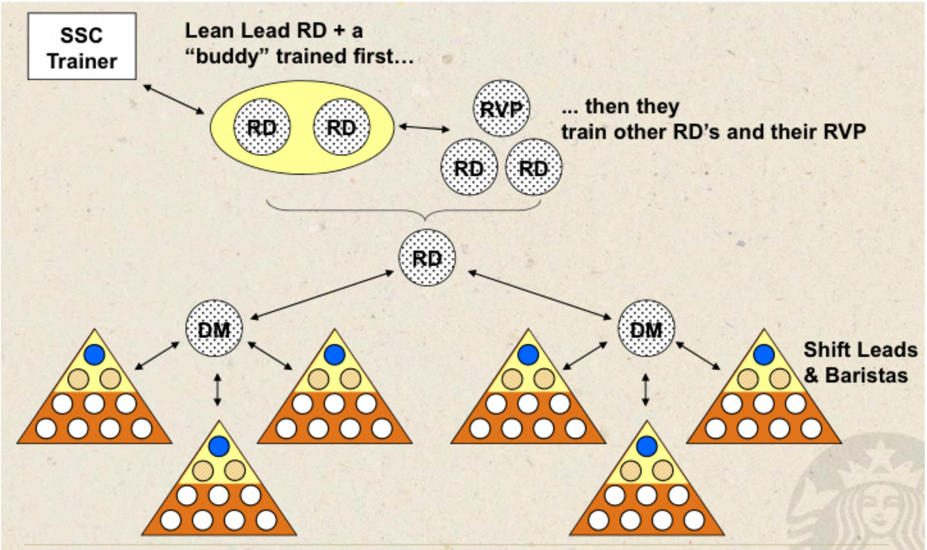

Fig 2.15 SBUX teaching model (Heydon, 2011)

Starbucks' training consists of four steps;

1- Prepare.

2- Present twice:

- First demonstrate the major steps.

- Next represent the major points supported by the key steps explaining the reasons for that step.

3- Practise three times:

-Silent demonstration only.

-Describe and demonstrate the major steps.

- Verbalising and demonstrating major steps, key points and reasons why.

4- Follow-up.

Figure 2.16 presents typical improvement in barista performance after training using with TWI (Heydon, 2011).

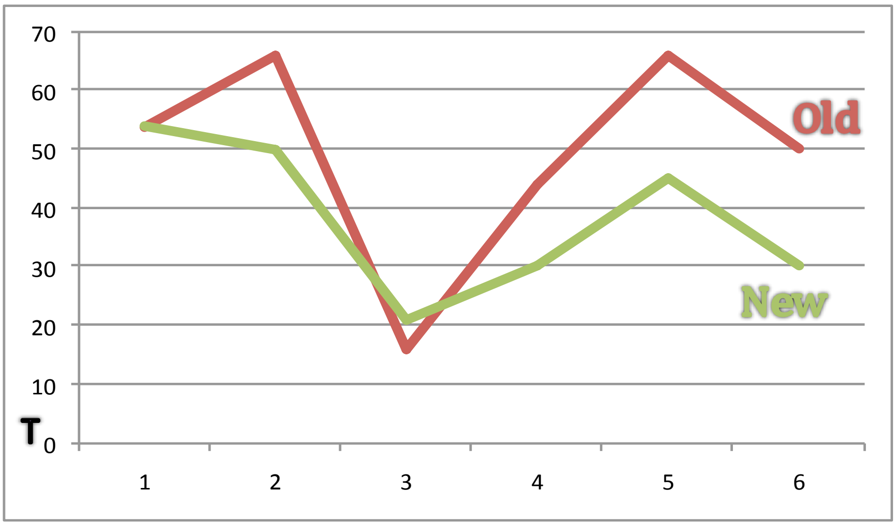

Fig 2.16 Barista's Performance (Heydon, 2011)

Different beverages are served in a sequence at the same time. The X axis is the duration of preparation each drink and the Y axis represents a mix of hot and cooled drinks.

2.3.3.3 Store Layout

Heydon (2011) has claimed that 30% of baristas' time is not spent usefully serving customers. This time is waste because it does not add value to the product and so is time for which the customer is unwilling to pay. Elimination of this waste was thus a good point from which to start improving interface time between customers and baristas. Starbucks began the Lean process by identifying NVA activities and their causes, then attempting to remove these causes and so reduce NVA activities.

Traditionally at Starbucks making drinks was inefficient because the barista wasted time looking for necessary items because they were never in the same place. One of the remedies adopted to solve this problem was to identify commonly used syrups and move them adjacent to the drinks preparation station. It was also found that topping the drink with whipped cream and drizzle was slowing down the overall process flow and moving these processes closer to where the customers collected their drinks removed eight seconds from the forty-five seconds normally taken to complete the process. This increased the rate at which customers were served and thus a positive effect on store revenue.

Possibly the largest reduction in wasted time was elimination of the high level of unnecessary movement from espresso bar to back counter. A 90% reduction in movement was achieved by placing ice bins so they were convenient for baristas working at the espresso bar and converting the cold-water dispenser into a pitcher rinse unit. The result of these changes enabled the barista to remain at the espresso bar and maintain production, while reducing his/her walking and stress. Customers were more satisfied because they were served in a shorter time and the business profited from a higher transaction rate.

The Lean team found that before a store opened the baristas could make as many as 40 journeys carrying baked goods to the pastry case. Not only was this tiring for the baristas it could take as long as an hour and a quarter. After consideration the Lean team took the decision to place a moveable pastry rack next to the pastry case to reduce wasted time and unnecessary motion. The change improved health and safety levels in the store and the time saved was better used to serve customers.

Summary

In conclusion the author would maintain that the Lean intervention at Starbucks was a program that had total and serious commitment at levels within the company. However, in reality there is gap between theory and practice and this exactly what the author is trying to discover specially in the case of Lean implementation at Starbucks.

The next chapter presents the research methodology and data gathering techniques used to collect the data required to investigate the research objectives.

- CHAPTER 3 -

Research Methodology

Motivation

Research is a detailed systematic study undertaken in order to establish new facts, discover new information or reach a new level of understanding. Research into business and management issues not only advances knowledge and understanding generally but can also address practical business issues and current managerial problems so that as questions arise so answers will be sought. This chapter will describe the research methodology selected for this project and the ways in which the data were obtained and analysed.

Research has three essential features:

- A clear purpose.
- The data are collected systematically.
- The data are interpreted systematically.

There are two primary approaches to research:

• Deduction: Usually involves investigating and testing new hypotheses or established theories using the information collected.

• Induction: Uses the data collected to generate theories and ideas that improve the understanding of a topic or situation.

Table 3.1 presents the major differences between deductive and inductive approaches to research:

Deductive	Inductive
- Based on scientific principles. - A pre-existing theory is used to design the experiment which produces the data. - Attempts to explain causal relationships between variables. - Quantitative data is collected . - The experimental conditions ensure the validity of the data. - The rationalisation of concepts to ensure clarity of definition. - A highly structured approach. - The research worker is independent of what is being researched. - Samples of sufficient size must be used to generate general conclusions.	- The observer detects patterns and regularities in the collected data to gaining a better understanding of the meanings humans attach to events. - Qualitative data is collected. - The experimental structure should be sufficiently flexible to allow for changes of research emphasis as the project progresses. - The research and research worker is or can be part of the research process. - More specific to the test situation, less concern with the need to generalise.

Table.3.1 Relative benefits of deductive and inductive research (Saunders *et al*., 2009)

3.1 Defining the Problem and Research Objectives

The research should address well-defined and relevant questions to act as a good starting point to the problem solving process. In this project it is believed that changes and improvements to tools such as Lean operation can make a positive difference to companies in many industries. However, in the coffee shop sector of the hospitality industry, is Lean philosophy being applied in such a way that improvements are justified because they make sense from the customer's perspective? Or is a new philosophy needed to keep up with market changes?

3.1.1 Research Objectives

Objectives for this research can be divided into three, as follows:

1-Fit Development Toolbox (FDT)

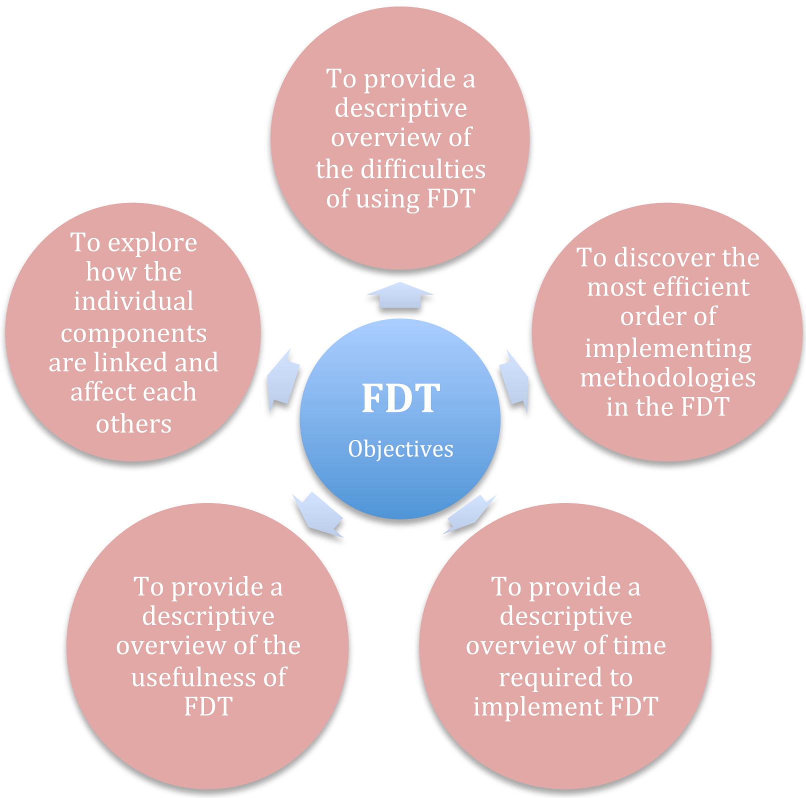

Fig 3.1 The five FDT objectives

2-Fit Flow Index (FFI)

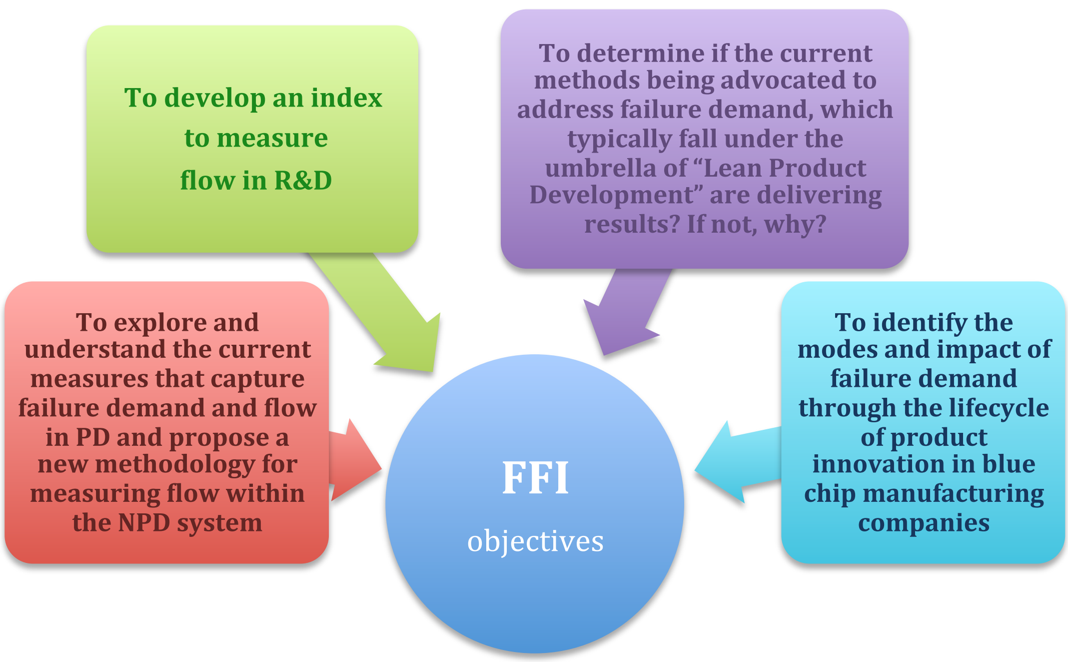

Fig 3.2 The four FFI objectives

3- Fit Customer Satisfaction (FCS)

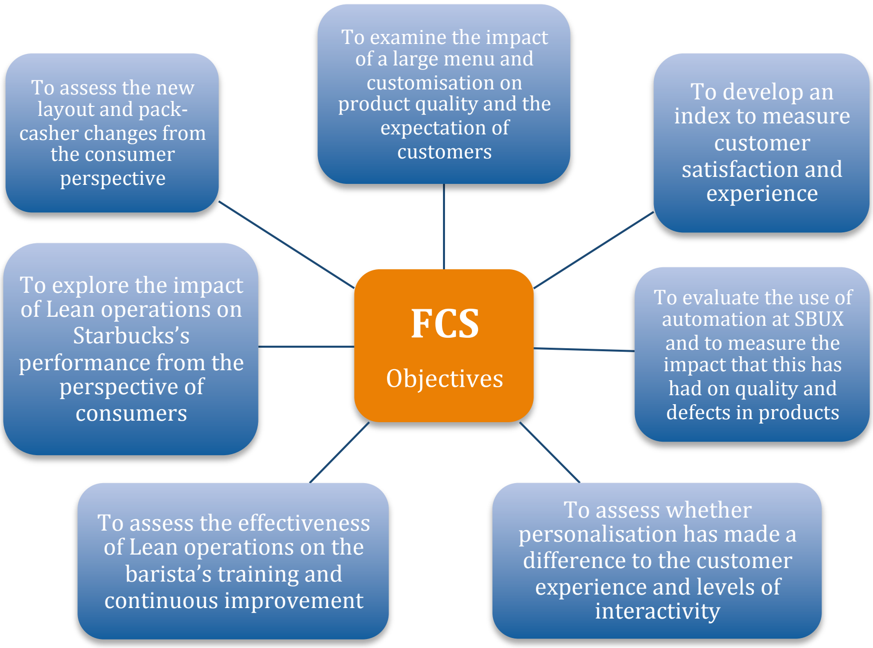

Fig 3.3 The seven FCS objectives

3.2 Qualitative and Quantitative Research

Both qualitative and quantitative research methodologies will be used in this chapter. Qualitative research is usually used where only a small sample is available whereas quantitative research usually uses a large sample of participants so the results are statistically significant (Kotler *et al.*, 2002). Table 3.2 distinguishes between qualitative and quantitative data.

Quantitative data	Qualitative data
- Results are quantified. - Data is usually numerical and standardized to a known level of confidence. - Analysis usually conducted using statistical packages.	- Based on descriptions and meanings as expressed through the written word. - Data collection is usually non-numeric requiring classification into categories. - Analysis conducted through the use of concepts.

Table 3.2. Quantitative vs Qualitative data. (Saunders *et al.*, 2009)

It is important to select the research method that best meet the needs of the project. Kotler *et al*., (2002), have divided research approaches into observational, survey or experimental. In this research, the survey method was selected because human feelings and opinions are what are of interest and would have been difficult if not impossible to explore the relevant issues in an effective manner by experimental or observational methods given the resources available. Additionally, the objectives of this research are descriptive, making them well-suited to a survey approach (Kotler *et al*., 2002).

The survey can be a postal questionnaires, a telephone interview, Internet data collection or personal interviews (Kotler *et al*., 2002). Information had to be collected quickly and respondents from a geographically wide area had to be surveyed. The first stage was personal interviews of customers at the store because this was easiest and most useful for the research. The main intention in the second stage was to generate sufficient data to provide a detailed understanding of the current situation.

According to Basch (1987), face-to-face interviews are particularly well suited to defining problems, collecting qualitative data, collecting in-depth data concerning individual opinions, feelings, etc., associated with personal experiences. The interaction between interviewer and interviewee will be a function of the inter-personal dynamics which may result in interviewees divulging opinions and emotions that may not emerge from a less personal interaction, a postal questionnaire for example (Mendes de Almeida, 1980).

During the interviews to investigate attitudes to and understanding of the ideas behind changes and improvements a positive and open atmosphere was maintained to better obtain the desired information.

3.3 Gathering Data

3.3.1 Secondary data collection

Data gathering began with the collection of secondary data about the firm, this included historical and financial data and records of performance measurements. The range of secondary data obtained included:

1. Written materials: articles and interviews in trade journals, communications circulated by the organisation, newspaper articles, and internal company documents.
2. Non-written materials such as video recordings.
3. Surveys by the company itself, government and academia.
4. Internet resources, books and online databases.

Secondary data can be collected more quickly and at a lower cost than primary data and can provide information that the author could not directly collect himself (Kotler *et al*., 2002). However, the information available in the public domain may not be sufficient (it may not exist) or may be of dubious reliability and objectivity (e.g. the author could be seeking to prove a pre-conceived idea) (Kotler *et al*., 2002). Some secondary data can be difficult to access, not match researcher's need, nor match the quality of the research. Table 3.3 illustrates the advantages and disadvantages of secondary data.

Advantages	Disadvantages
- May have fewer resource requirements. - Provide an unobtrusive measure. - Longitudinal studies may be possible. - Can provide comparative and contextual data. - Can result in unforeseen discoveries. - Permanence of data	- May be collected for a purpose that does not match the researcher's need. - Access may be difficult or costly. - Aggregations and definitions may be unsuitable.

Table 3.3 Advantages and disadvantages of secondary data (Saunders *et al*., 2009)

3.3.2 Primary data collection

Primary data is the data collected specifically for the given research project. Different ways of collecting primary data include; experiments, focus groups, observational studies, personal interviews, questionnaires and surveys. Limitations on the collection of primary data include the cost and resources required and possible constraints that could prevent either publication of the results or production of quality research. Moreover, research errors such as sample bias or observer bias could be a significant factor threatening the quality of the findings.

Additionally, with qualitative surveys the data may be so unique that the researcher may be unable to compare the results obtained with other populations. Primary data can also pose ethical dilemmas for the researcher which may require referring the project to the relevant ethical committee of his/her organisation with consequent delays and extra work. On the other hand, primary data has a number of important advantages, such as uniqueness and direct usefulness to the project.

3.3.2.1 Questionnaires.

Questionnaires are the most common instrument for social research as they are relatively cheap to draw up and deliver, are sufficiently flexible to be used for many different types of investigation and can deliver very useful results (Kotler *et al.*, 2002). A questionnaire should be carefully designed and tested in order to identify errors and each question checked for its compliance with the research objectives (Kotler *et al.*, 2002).

There are two main types of questionnaires:

- Self-administered: postal questionnaires including internet and intranet-mediated questionnaires, and questionnaires delivered to the recipient and collected afterwards.
- Interviewer-administered, either a telephone questionnaire or a structured interview which is based on a list of questions from which the interviewer should not deviate.

Table 3.4 shows the important advantages and disadvantages of using questionnaires in a research project (Saunders *et al*., 2009):

Advantages	Disadvantages
- Questionnaires are objective if the answers are gathered in a standardised manner. - Efficient means of collecting a large amount of data from a large number of people in a short period of time. - Can be structured so that results can be analysed in a short time using a statistical computer package. - Are suitable for testing new theories and hypotheses.	- Questionnaires normally arrive after an event so respondents may forget important relevant issues. - With postal questionnaires it is not possible to explain the questions so respondents may misinterpret a question. - With long questionnaires there is a high probability that responses will be superficial. - Time is required for data collection and processing. - There is a cost associated with questionnaires. - The need to automate data entry may influence the integrity of the questions.

Table 3.4 Advantages and disadvantages of questionnaires in research (Saunders *et al*., 2009)

Questions can be open or closed. In this thesis, closed multiple- choice questions and rating scale questions were used because they are easier to answer and to process. The fact that they do not require respondents to think about writing in their own words means that they typically require less time to answer, which makes their use more convenient.

Rating scale questions where the respondent tick a box on a scale are very convenient ways to measure and collect opinions. Here a five-point Likert-style rating scale was used in which respondents were asked how strongly s/he agreed or disagreed with a statement; 1 (strongly agree) to 5 (strongly disagree). The questions were designed to be neutral so that respondents were not guided towards either a positive or negative statement.

Two versions of the survey were produced, one in English and the other in Arabic. This was so respondents with an Arabic background did not have to translate the questions, wasting time or creating errors in understanding. The translator made sure that questions in both versions had the same meaning. Two independent sources translated the survey and a final version was created which led to an effective wording of the questionnaire. However, this technique is costly due to the cost of translation. The procedure we followed is that the English version is translated into Arabic and then the Arabic translation is translated back into English. Then the two English versions were compared and found out that they are the same which meant that the Arabic translation is correct.

3.3.2.2 Questionnaire design

Questionnaire length generally influences the response rate, people who value their time do not care to waste it on long and multipart questionnaires (Helgeson *et al.* 2002, cited in Cobanoglu & Cobanoglu 2003, p.310). Therefore, the number of questions was limited and a compromise established between the complexity of the issues under investigation and a satisfactory response rate.

Priority was given to obtaining answers to those questions considered the most important. Because the more questions contained in a questionnaire, the less important any single question seems so just five core questions were asked. The number and content of the questions was deemed sufficient to meet the needs of the research and to generate the data required to answer the research questions which investigated five important dimensions. It is expected that the increased response rate due to the smaller number of questions asked will increase total data received.

3.3.2.3 Surveys

The questionnaires (see Appendixes 1, 2, 3) included different questions designed to measure:

1- The interdependence between Toyota's tools for product development. This was done by asking participants to complete a matrix of questions that measured the relationship between all eleven components in the toolbox.

2- Flow and waste in NPD was investigated in three parts. The first asked 3 basic questions about the participant, the second consisted of 24 questions regarding sources of unfit demand and the final part measures the impact of all types of waste on NPD flow.

3- The satisfaction of participants about the changes that have been made at Starbucks. There were eight questions, three of which specified gender, location, and age. The remaining five concerned speed, taste, accuracy, friendliness and waste. Thus, this third survey is a measurement of Fit Customer Satisfaction (FCS), which is a good measure of Lean improvement in the eyes of its customers.

A pilot survey was designed and sent to a sample group of respondents. Their responses and comments were used to revise the structure of the questionnaires and the framing of the questions, to make the questionnaires even clearer, simpler and more logical. In general, the reactions to the questionnaire were very positive and respondents found them clear and self-explanatory.

3.3.2.4 Semi-structured interviews

Semi-structured interviews of customers were used as a second research tool. These can provide in-depth information and insights that were not possible with the survey stage. The purpose of the interview stage is to examine whether customers have noticed the impact of Lean improvement on the products, on performance and customer experience. Participants were told that the aim of the research was to investigate their level of satisfaction with the services and products, although none were told that changes had been made at the store.

3.3.2.5 Sampling plans

"A sample is a segment of the population selected to represent the population as a whole" (Kotler *et al.*, 2002). The effective design of the sample requires three decisions to be made (Kotler *et al.*, 2002):

- What is the parent population to be surveyed?
- How large will the sample be?
- How are the individuals in the sample to be chosen?

3.4 Chosen Research Methodology

In this research project both qualitative and quantitative methods were used, qualitative data were collected of the opinions and preferences using interviews of customers on general issues and quantitative research data obtained from the surveys. Thus the customer experience was investigated in depth due to the qualitative nature. The study of presence and performance in the global market was performed by means of questionnaires and personal interviews which were covered by the both qualitative and quantitative aspects. Primary data were gathered through the process of questionnaires and interviews because they reflect what is happening in real world.

3.4.1 Data gathering

The objective was to gather a range of primary data through questionnaires and surveys. The collected data was analysed using Microsoft Excel and the "Statistical Package for the Social Sciences" (SPSS) because of its capabilities and the different kinds of tests it offers. Survey answers were coded and entered into the software for faster and more accurate analysis. The statistical tools generating improved understanding of the customer experience before and after the implementation of Lean improvement.

3.4.2 Sampling

Who is to be surveyed? The decision was made to survey online through the use of Twitter, Facebook, and email (intranet and extranet). This was intended to maximise the number of responses that could be gathered within the short period of time available for this study. To obtain an assessment of the global market, the survey was sent to participants around the world

How many people are to be surveyed? Our target at the beginning of the project was as follows:

1- More than 200 responses within a month for FDT.

2- More than 300 responses within a month for FFI.

3- More than 1000 responses within a month for FCS.

These numbers were chosen in an attempt to represent the market/sector/industry as a whole but recognising the time and budget constraints that made reliably surveying a higher number of people viable within such a short period of time. Theoretically the use of the internet can provide a sample of unlimited size. However, this process would be easier with incentives and rewards and therefore it was a challenge to outsource more people to be a part of the research.

How are the people in the sample to be chosen? For the questionnaire a non-probability sample was used due to certain limitations and it is almost impossible to measure the sampling error in this case. Every effort was made to target the right people and be sure that anyone who is not interested in our research topic would not complete the questionnaire. Therefore, it was necessary from the beginning to determine how/when/where and who to target.

- CHAPTER 4 -

Fit Development Toolbox (FDT)

Preliminaries

The author structured the results and discussion of this thesis by dividing them into three chapters, this chapter concerns the Fit Development Toolbox (FDT), Chapter 5 focuses on the Fit Flow Index (FFI) and Chapter 6 explores Fit Customer Satisfaction (FCS).

The eleven tools in the FDT were discussed in Chapter 2 and the case for the use of each tool individually or in combination was made. A number of researchers active in this area have argued strongly that the eleven tools should not be used separately. Balle, (2005), Haque, (2004) and Sobek, (1999) all state that the potential of the FDT cannot be realized if the tools are not used in conjunction with each other. In this chapter the author investigates how the tools within the FDT should be best used and interdependencies between the tools are presented.

4.1 Product Development Optimisation

It is accepted that implementing only one tool from the FDT and discounting the others will result in suboptimal performance and the Lean operation could be compromised. A parallel is what happened when companies implementing JIT attempted to eliminate buffers by requiring suppliers to deliver directly to the production line. Often these companies did not fully comprehend the holistic dynamics of JIT and forgot, for example, to level the workload and avoid peaks in demand. Unexpected bottlenecks appeared and detracted from the production system which, in turn, affected product flow.

Such lessons are vital because they demonstrate the importance of investigating the different elements in FDT as a system of interlinked tools not a collection of independent and separate components. It is essential during the implementation process to understand that the interdependence of the FDT tools plays an important role.

It is also necessary to understand that each component has its own unique impact on the system so that, for example, the current performance of a company will depend on the particular tools it has chosen to use. The interdependence of the tools in the FDT will play a role in determining when in the Lean innovation programme a particular tool is best used. Failure to understand how the eleven tools are interconnected will increase the chance of having and ineffective intervention (Ballé and Ballé, 2005).

Each FDT tool has its own specific weight or strength, which means that when and how it is used will have a greater or lesser effect on the performance of other tools and the effectiveness of the intervention. These factors need to be understood by all those in R&D to ensure efficient systems for the flow of ideas and prototyping. A brilliant R&D leader may understand the ideal time to launch each tool but that does not mean that every tool in the FDT will be used properly and at the most opportune time by the firm.

Every firm has its own customers, needs, products and resources which make it unique and different from all its competitors. Thus, it is logical to assume that all eleven tools will not normally be used in a single intervention. When and whether to use each tool will depend on the strength of the interdependence between the tools and the availability of other resources.

A matrix of all possible interconnections between components is shown as a matrix in Table 4.1. where each tool was rated in accordance to its strength. The rating of a tool's strength ranges from 0 (Not Related), to 10 (Strongly Related).

To what extent does component in row require component in column?	Strong Project Manager	Specialist Career Path	Workload Leveling	Responsibility-based Planning and Control	Cross-project Knowledge Transfer	Simultaneous Engineering	Supplier Integration	Product Variety Management	Rapid Prototyping, Simulation and Testing	Process Standards	Set-based Engineering	Average	Std. Deviation
Strong Project Manager	X												
Specialist Career Path		X											
Workload Leveling			X										
Responsibility-based Planning and Control				X									
Cross-project Knowledge Transfer					X								
Simultaneous Engineering						X							
Supplier Integration							X						
Product Variety Management								X					
Rapid Prototyping, Simulation and Testing									X				
Process Standards										X			
Set-based Engineering											X		
Average													
Std. Deviation													

Table 4.1 FDT matrix showing strength of dependency between tools

The questionnaire asked "To what extent do components in a row require a component in a column?" A measure of the extent to which one tool requires another was established through determining the Specific Weight /Gravity and importance/ popularity of each tool. This weighting of the tools is called "Sensitivity Analysis" and was measured using the FDT matrix.

The row average represents the extent a tool requires or depends on other tools in the FDT. A score of 10 would represent a very high dependency of tools in row on tools in column, and a score of 0 would represent very low dependency. The column average represent the degree to which any specific tool is required by other tools in the FDT. A score of 10 would represent a very high demand of tools in in column to implement tools in row, and a score of 0 would represent a very low demand. The matrix in the survey also determined which tools could impact and affect other tools used in the same programme. The previous method is called "Sensitivity Analysis" (Vester and Hesler, 1980) and it was measured using the FDT matrix, which will help the author either prove his hypotheses or reject it in whole or in part at the end of this thesis.

4.1.1 Survey Results

The author received 112 completed matrix out of 300 sent which represents almost 38% of the sample size. Table 4.2, presents averages calculated for the entries in each row and column and the average SD for both row and column. For the "bubbles" shown in Figure 4.1 the centre of the bubble is given by the (x,y) coordinates shown in Table 4.2 and the radius of the bubble is the corresponding SD.

	Av. Column X-axis. Is required by other tools	**Av. Row Y-axis. Requires other tools**	**Av. of SDs (bubble diameter)**
Strong Project Manager	8.6	3.1	0.63
Specialist Career Path	7.4	4.8	0.65
Workload Levelling	7.6	5.5	0.59
Responsibility-based Planning and Control	4.8	4.6	0.69
Cross-project Knowledge Transfer	5.2	5.9	0.71
Simultaneous Engineering	4.4	3.6	0.66
Supplier Integration	4.2	4.6	0.70
Product Variety Management	3.8	6.8	0.69
Rapid Prototyping, Simulation and Testing	2.5	6.6	0.60
Process Standards	6.4	3.6	0.52
Set-based Engineering	1.8	8.8	0.53

Table 4.2 Interdependency of FDT tools

After analysis of the data, the FDT matrix was presented graphically to have a clearer picture of the interdependence between the tools in the FDT. Figure 4.1 presents the data of Table 4.2 as a bubble chart. The position of the bubble on the X-axis is a measure of the extent to which that tool is requires by others, Thus Strong Project Management is required, on average, by between eight and nine other tools. The position of the bubble on the Y-axis is a measure of the extent to which that tool requires others, and it can be seen that Strong Project Management relies, on average, on only three other tools.

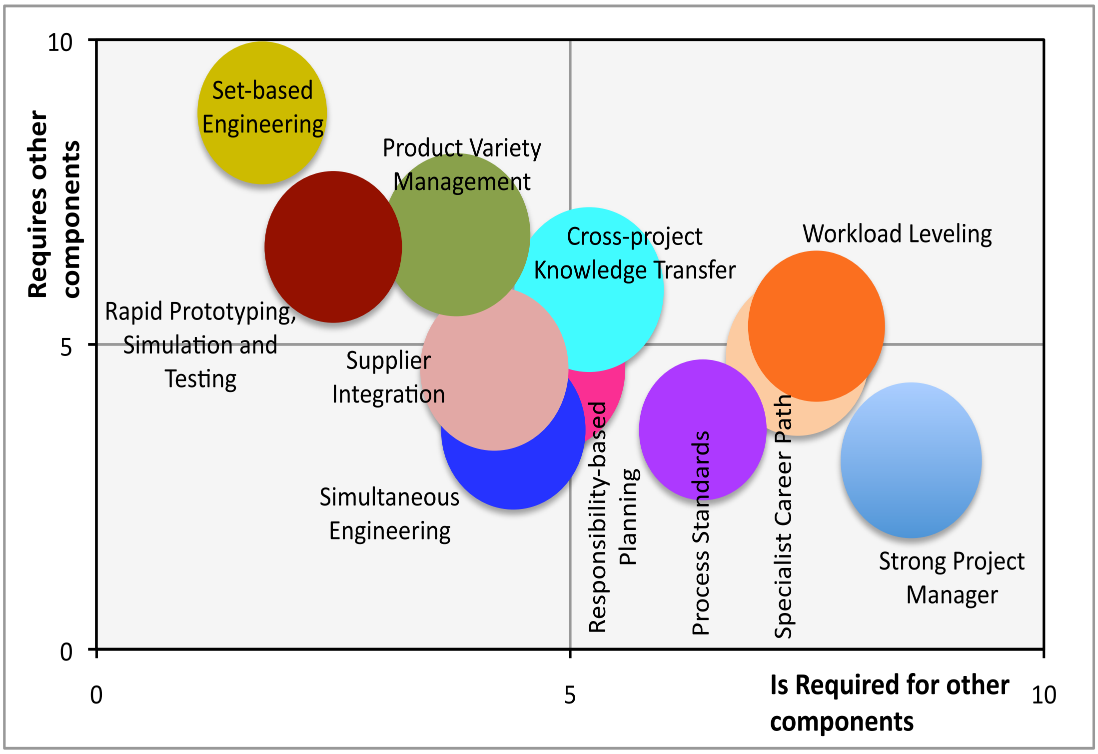

Fig 4.1 FDT bubble chart

4.1.1.1 FDT framework

The bubble chart, Figure 4.1, provides some surprising observations. The tools (bubbles) differ substantially in the degree to which they serve as prerequisites for other tools, as shown by the spread of the bubbles along the X-axis. Additionally, as the tool becomes less of a prerequisite for others it becomes more dependent on having others as a prerequisite, as might be expected. The Y-axis plots each tool based on the degree it requires other tools to be implemented. The bubble chart is divided into four quadrants, the lower-right quadrant in Fig.4.1 tools that are highly required by other tools but need low number of tools as prerequisites to be implemented. For example (Strong Project Manager, Special Career Path, Process Standards, and Responsibility-based Planning). In the upper-right quadrant tools that are highly required by other tools and need high number high number of prerequisites to implement in advance, for example (Workload Leveling and Cross-project Knowledge Transfer). In the lower-left quadrant tools that are not highly required by other tools and does not need a high number of prerequisites to be implemented such as(Supplier Integration and Simultaneous Engineering). Finally, tools in the upper-left quadrant tools that not highly required by other tools but requires high number of tools to be implemented in advance to use it. For example (Set-based Engineering, Product Variety Management, and Rapid Prototyping Simulation and Testing).

It can be seen that the bubbles are distributed around a diagonal line that could be drawn from the right bottom corner (Strong Project Manager) to the top left corner of the graph (Set-based Rngineering). Commencing with Strong Project Management, it is found that that this requires three tools as prerequisites. However, SPM is a prerequisite for all remaining 10 tools in the FDT. At the other end of the spectrum Set-based Engineering is required by only 2 tools. On the other hand, however, it requires a large number of tools (average 8.8) as prerequisites to its own use.

Two important observations can be made based on Figure 4.1, Firstly, seven tools fall in the lower half of the figure and so don't need a high number of tools as prerequisites. Secondly, the four tools that appear in the upper half of the figure are very sensitive because they need a high number of tools as prerequisites but are not required by other tools for their later implementation. These observations will to help determine the most efficient method of implementing FDT.

It is concluded that the most logical way of implementing FDT tools is to commence with one that serves the firm's needs from the bottom half of the graph, because of the limited resources they require to be in place. Also most of the elements in the lower half of the figure can be implemented by SMEs because they don't require workers experienced in R&D.

After beginning with tools from the bottom right of the graph, managers should move slowly and carefully towards the top left. To maximise the potential of the toolbox, managers have to move smoothly upwards towards the tools that are harder to implement. This approach is systematic because FDT tools build upon each other in a harmonious manner. Repetition will be avoided once R&D managers gain experience and understand the sequence in which the tools should be implemented. Figure 4.2 below explains all the previous observations.

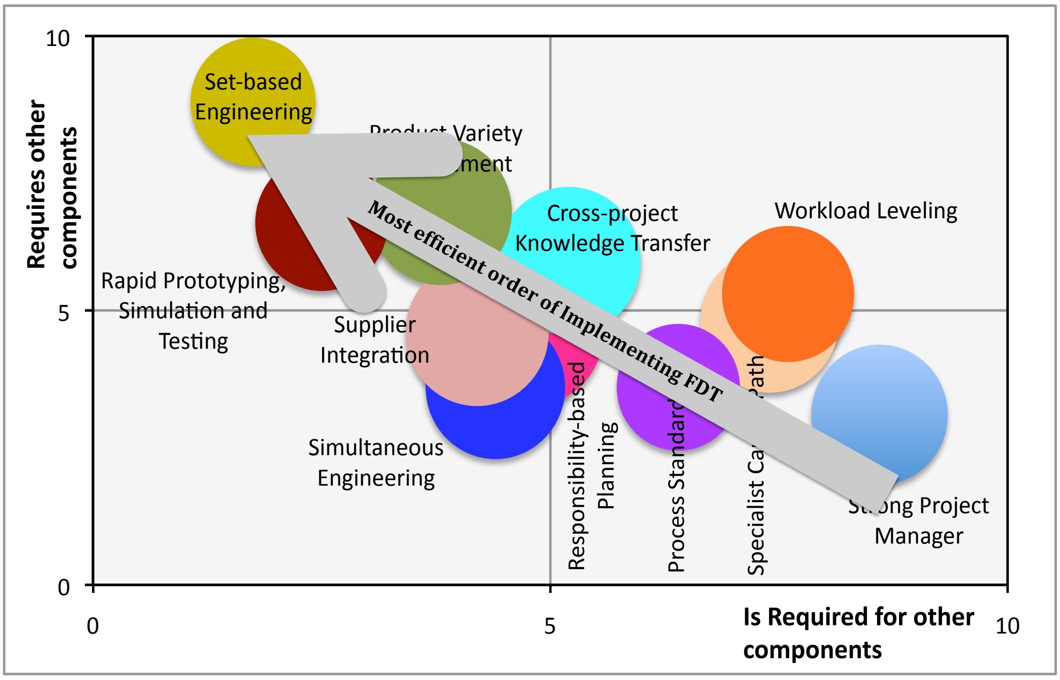

Fig 4.2 FDT framework implementation

It would be not be sensible to argue that all companies in all industries should follow this FDT model because problems in the different sectors of the economy can be very different. However, the model discussed above would be an excellent starting point for the implementation process but there will be variations according to the current situation and problems faced, both of which will be unique to each firm. Therefore, deviating from the proposal is expected and should not harm the long term benefits.

R&D managers should be conscious of the prerequisites of each tool and then build their implementation strategy accordingly and avoid using unnecessary tools and an over-sophisticated process.

In addition to the FDT matrix, participants in the survey were asked to rank the eleven tools regarding Time of Implementation, Difficulty of Implementation and

Usefulness. In the following section a deeper analysis and discussion of results will be provided.

4.1.1.2 Time of Implementation of FDT

Respondents ranked the eleven tools according to which one they applied first and this was denoted (1), and which tool they applied last (denoted (11)) when making a Lean intervention. The average and SD were calculated for each tool, as shown in Figure 4.3. It is clear that Strong Project Management (SPM), Process Standardisation (PS) and Simultaneous Engineering (SE) are used to a wide extent at the start of the process and that can be seen from their low average scores (4.46, 4.50, and 5.29 respectively).

Some tools stand out because of their high average scores, which means that companies applied them in the later stages of implementation. These tools require a higher number of prerequisites to be used properly. Cross-project Knowledge Transfer scored the highest average of (7.96), which positions it at the extreme end of the spectrum next to SBE (6.55). The use of these tools requires a high level of sophistication and persistence from R&D staff and this might explain why they are left until last. Furthermore, many companies, especially SMEs, do not need some of the tools in the upper half of Figure 4.2 due to their limited capabilities, or because their product is not of a high technical level.

It is worth noting the gap (3.50) between the highest and lowest scores in the radar chart shown in Figure 4.3, SPM and Cross-project Knowledge Transfer, is the widest difference found. However, it could be argued that Cross-project Knowledge Transfer can be implemented effectively only when the information gained has been gathered, assimilated and 'written up', so it is natural that it is the last tool to be used.

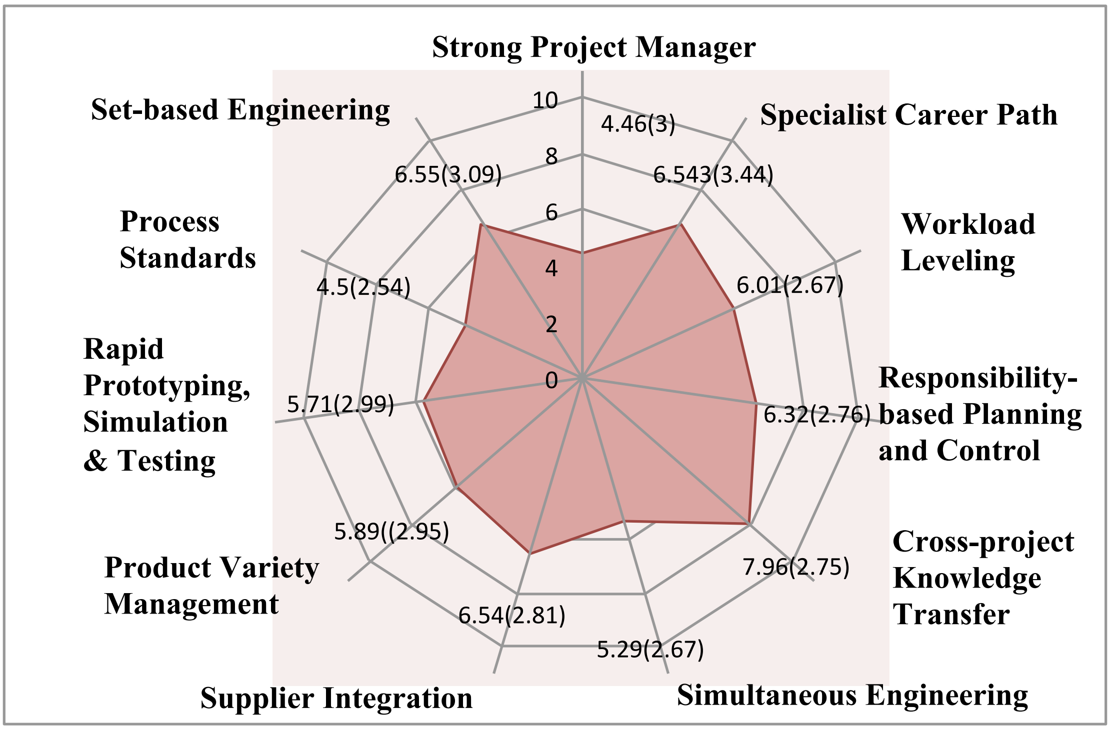

Fig 4.3 Time of implementation of FDT tool

4.1.1.3 Difficulty of using FDT

R&D workers were asked to rank the difficulty of using the tools within FDT with (1) as the Most Difficult and (10) as the Least Difficult. The following radar chart, Figure 4.4, was produced after analysing the data.

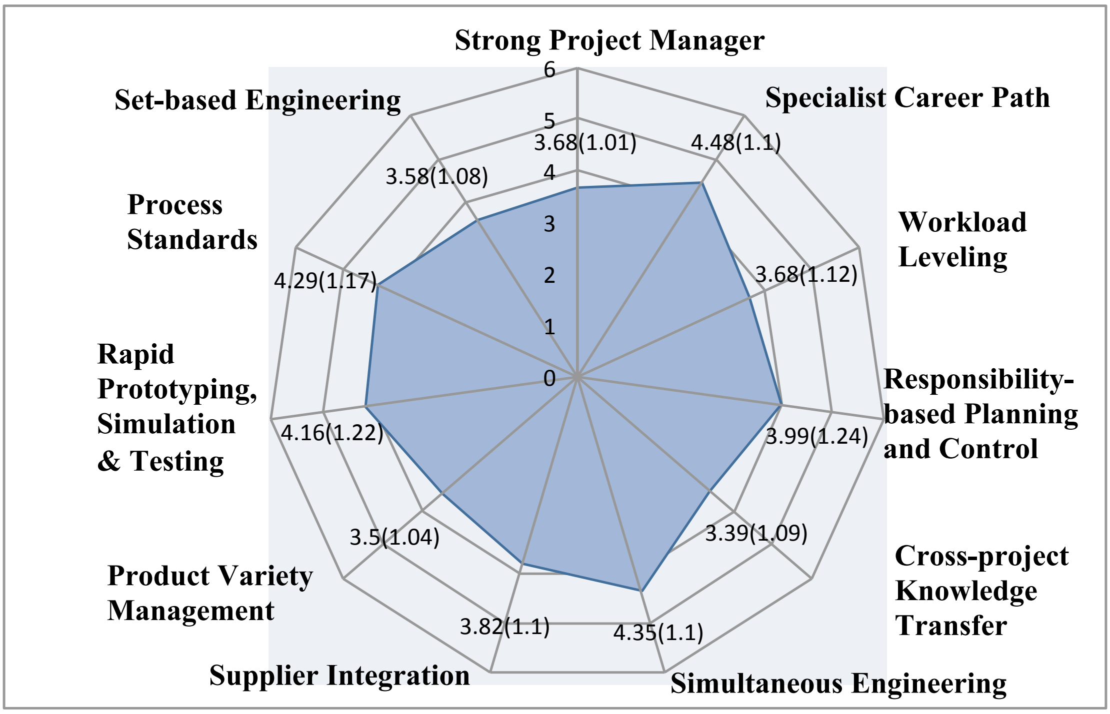

Fig 4.4 Relative difficulty of using FDT tools

The radar chart illustrates the perceived ease of using FDT tools. The three highest scores, easiest to use, are SCP (4.48), SE (4.35) and PS (4.29). SPM has a relatively low and this is as it should be because it is one of the first tool companies implement, see Figure 4.3.

SBE (3.58) and CPKT (3.39) were the two tools that companies apply at the end of the implementation process and they had the lowest average scores in this question which makes them the two most difficult tools to implement. It could be argued that CPKT and SBE are left to last, see Figure 4.3, because they are difficult to implement.

4.1.1.4 Usefulness of Implementing FDT

At the end of the survey respondents were asked to express their opinion on the relative usefulness of the FDT tools. The ranking system was the same as before, where the top score (10) representing "Useful" and the lowest score (1) "Useless".

Figure 4.5, presents the results as a radar chart.

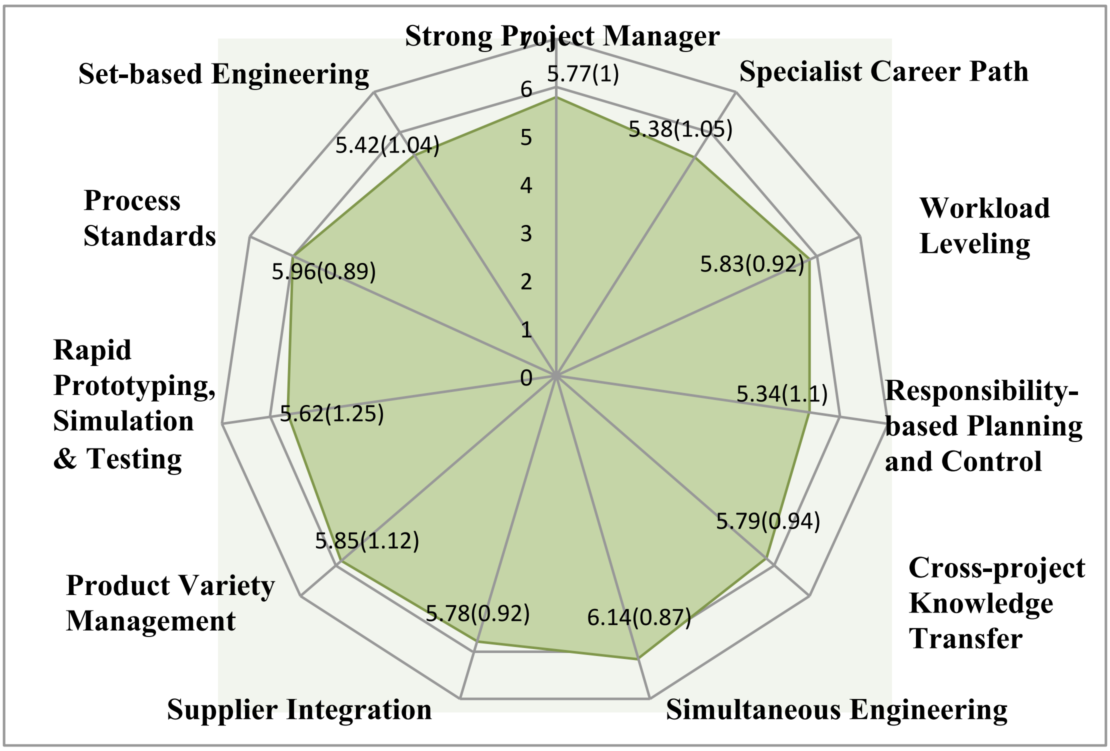

Fig 4.5 Perceived relative usefulness of tools in the FDT

Figure 4.5 shows that two tools scored the highest, which means that they are extremely useful. These tools are SE and PS, with scores of 6.14 and 5.96 respectively. Due to the low SDs these two results are statistically significantly different. These two are followed by PV with an average score of 5.85.

Note that the range between upper-limit and lower-limit for the usefulness of a tool is only 0.9 points, which is small compared to the responses received to the two previous questions.

Understanding the true benefits behind each tool could save time and effort. Our data suggest that SCP and Responsibility-based Planning and Control are perceived as the least useful tools in the toolbox, with average scores of 5.38 and 5.34 respectively. This may be explained by a lack of understanding in the R&D community of the interdependence between the tools. It is possible that some tools will gain an adverse reputation that they are not as useful as others. In part this could be due to SMEs where products and/or my manufacturing capabilities do not require such tools and declare them to be unnecessary or a waste of time and resources.

The four Figures 4.2, 4.3, 4.4, and 4.5 demonstrate that the tools within the DFT are closely connected and intertwined and that attempting to apply one or other in isolation would be a major error. Fit is a goal for which all companies should strive. This requires efficient R&D, manufacturing processes and supply chain. Thus, techniques and tools used independently will not maximize the firm's Fitness. Optimisation of Fitness requires the application of the all tools in the FDT in conjunction and understanding the relationships between them. The successful implementation of FDT depends on understanding the PD system and how to improve its flow.

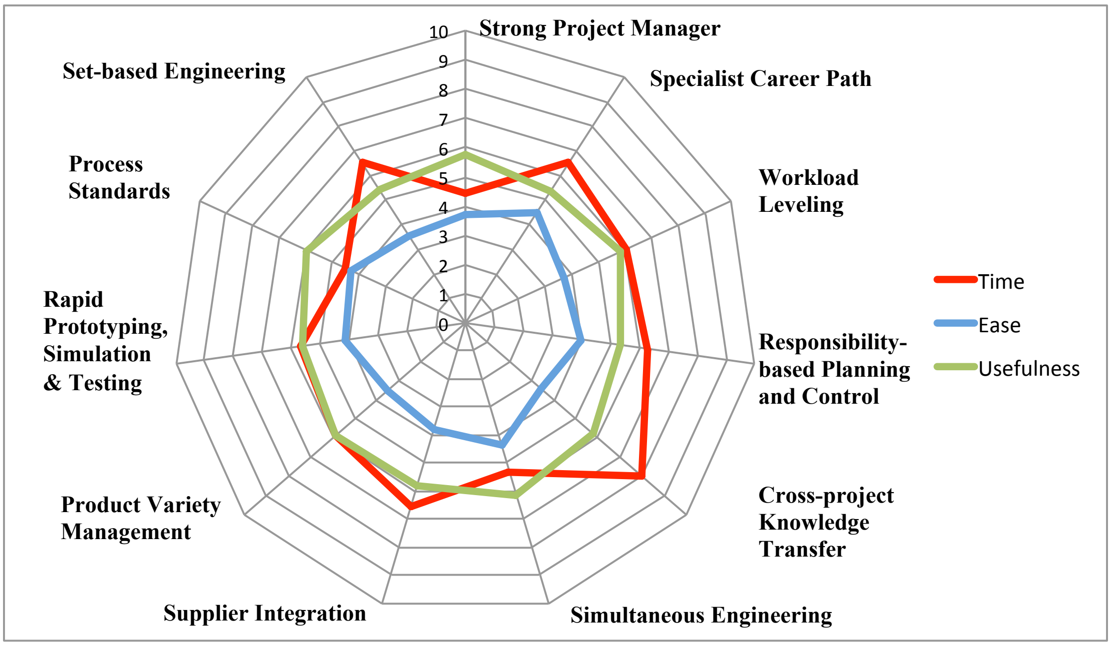

Fig 4.6 Radar chart for all dimensions

One surprising finding which challenges current understanding of R&D is Strong Project Management, which is found to be totally independent and not requiring any other tool in the toolbox because its bubble does not intersect with any other, see Figure 4.1. According to Morgan & Liker (2006), SPM is a very important tool that can decide the outcome and success of the whole Fit intervention. The Chief Engineers are essential cornerstones in Toyota product development because they have the capacity to manage quality, cost, delivery, flow and resources sufficient to promote products to better levels.

However, Strong Project Management is not connected to other tools which argues against Morgan & Liker's statement. Figure 4.1 does confirm, however, that where other tools contribute to the success of the intervention they use SPM.

Dividing the bubble chart into higher and lower halves gave the author a productive way of viewing the process. The spread of the bubbles on the chart was very useful in determining patterns and formations in order to analyse the data systematically. However, the bubbles in Figure 4.2 could move upwards or downwards depending on the industry or sector in which the usefulness of the FDT was assessed. For instance, SE and Cross-project Knowledge Transfer are positioned lower than expected and in conflict with the available literature and conventional thinking. Both tools will be found in the upper half of the graph for specific industries. The real surprise is that CBKT is positioned higher than SE, since the latter in reality requires a higher number of tools than reflected in this research. The author, after studying the literature, expected to find CPKT on the middle line of the bubble chart and not falling into either the upper or lower half.

Some tools such as SE were described and theorised about in the 1980s and since then the topic has been widely researched and practiced. SE's popularity is largely due to the extent to which it is used in a number of industries, which has had a positive impact on how the R&D community perceives its importance which helps explain its wide usage in the early stages of the implementation and the degree of ease of use it has. Being familiar with the tool is an important factor when making the decision of whether to use it or not. This kind of decision is vital to the successful implementation of FDT and it is one that needs very sensitive handling.

Some of the results were as expected but others were surprising. For instance, the author does not advise companies to start Fit innovation projects with Set-based Engineering due to the high number of tools or prerequisites it demands. Late introduction for certain tools is therefore recommended. On the other hand, PS was located in the lower half of the bubble chart, which makes it a popular tool due to the high demand for it. Hence, PS is a precursor of other tools, which means that it is a good platform for future improvements.

This work has shown that both SE and CPKT need further investigation into the reasons why they have been used so widely at an early stage of the intervention when they do not serve as a strong platform for other tools. The data gathered here may tell only part of the story and so the conclusions presented are not 100% assured and further data collection at a micro-level is needed. Further, the author believes that the position of a bubble on the chart is affected by the popularity of the tool and popularity does not always mean best quality. It is believed that marketing campaigns for specific tools by consulting firms means that some tools are over-rated or given more than their value in terms of potential benefit. R&D managers have to pick carefully when choosing from the FDT and should only implement the tools that add value for the customer and the company.

One last remark on CPKT is that the radar chart revealed that this tool and SBE are both are implemented at a late stage, but CPKT seems to be marginally more useful than SBE. At the same time, the data tells us that CPKT is not as easy to implement as SBE, which is surprising because the bubble chart shows CPKT located much lower than SBE. Hence, the author concludes that Cross-project Knowledge Transfer is underrated in its importance to the success of implementing many tools within FDT.

Summary

To conclude, several interesting results had been obtained in this part of the research. The new toolbox is an eye-opener for managers and engineers working on new projects in R&D. The relationships between tools are now more clear. This research has clarified the interdependence between FDT tools and identified a cluster of tools – those in the lower half of the FDT bubble chart – that have greater independence by not having so man y prerequisites. Each of the eleven tools in the FDT was assessed in three dimensions; ease of use, usefulness, and time of implementation. These measures are significant for product development because they can help provide a good foundation for those who are deciding whether and how to use the FDT. The following chapter will investigate the Fit Flow Index.

- CHAPTER 5 -
Fit Flow Index (FFI)

Preliminaries

The main objective of this Chapter is to investigate the questionnaire data obtained relating to the Fit Flow Index, see Figure 3.2, to add to our knowledge and understanding of this topic. The research findings are divided into three distinct groups:

1. Results of the survey on Unfit demand – both quantitative and qualitative,
2. Results of the semi-structured interviews,
3. Validation using a case study based on a recently launched new product by the LS company.

The author conducted the survey through an internal network, sending 322 questionnaires to participants within LS(acronym for the company) via their internal network and outside LS via their international network of suppliers and associates. The response rate was good, with 202 employees returning the questionnaire (Appendix 2). The questionnaire was split into three sections. The first asked about the participants' position in the company. Next were 24 questions in which the participant was asked to agree or disagree with statements related to product development and unfit demand. These questions were divided into eight themes: Customer requirements and needs, Stage-gate processes, Flow, Portfolio management, Rework/retesting/revalidation, Program management, Knowledge conversion, Metrics and measures. The questionnaire focused on measuring the impact of all ten kinds of unfit demand on flow in R&D and in ranking them to understand them better.

Section 5.1.4, focuses on gathering qualitative data using the following questions:

i. What works well in the current NPD process and therefore should be kept?

ii. If you could change one thing in the product development process, what would it be?

5.1 Survey Responses

	Responses	**% of overall population surveyed (322)**
Section 1	202	62.7
Section 2	156	48.0
Section 3	138	42.9

Table 5.1 Questionnaire response rate

The first section of the questionnaire (App.2) was answered by 202 people who represent 62.7% of the total population surveyed(322) which is considered a good response rate. Additionally, the second section was answered by fewer people than section one with 156 people who represent 48% of overall population surveyed. Finally, section three was filled by only 138 people which equals 42.9% of people participated in this survey.

5.1.1 Respondents' Profiles

Section1 What company do you work for?

The author divided participants into three main groups: people who work at the Diabetes Care Frenchise (DCF), people work outside the company (Non LS), and people work for a franchise within LS apart from DCF. The first group represented 67.8%(137) as the highest number of participants, the second group stood for 15.3%(31), and the final group were about 16.8%(34) of the total population surveyed in this study.

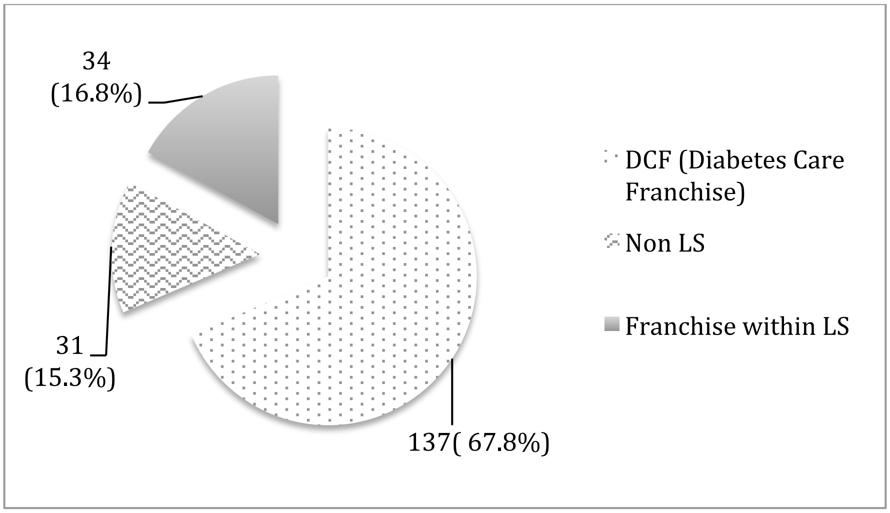

Fig 5.1 Participants' company

What function do you perform?

In this part of questioner, people were asked about which function they belong to. As can be seen in Fig.5.2, depicts the participants in this questioner according to their function: 38.6% (78) of the participating employees work in Development Organisation , 18.8% (38) in Operations Development, 8% (16) in Commercial, and 31.6% (64) in Supply Chain.

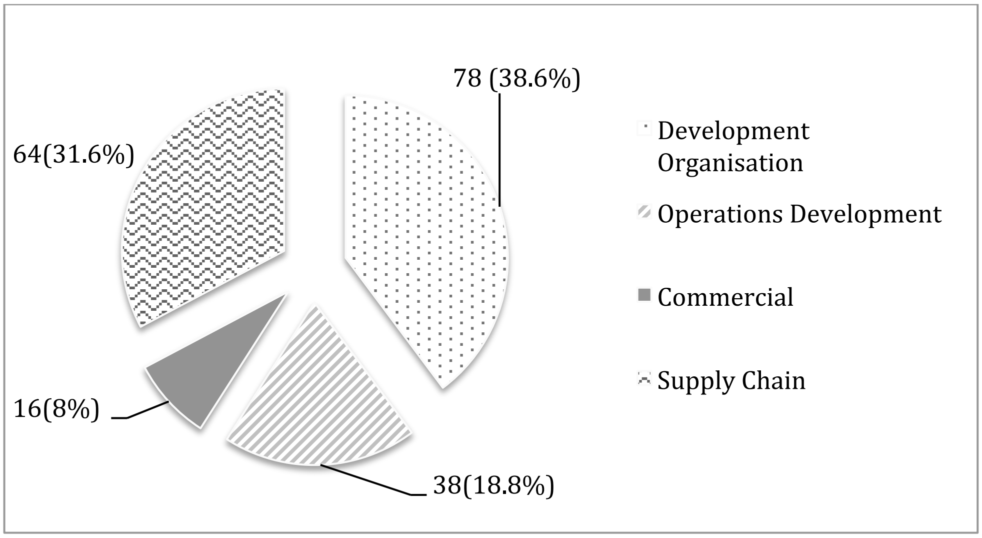

Fig 5.2 Participant's function at work

Please describe your job level

Fig.5.3 divided employees according to their job level. It is obvious that 22.7% (46) are directors and above, 30.6% (62) are Managers, and 46.5% (94) are Professionals/ Individual Contributors.

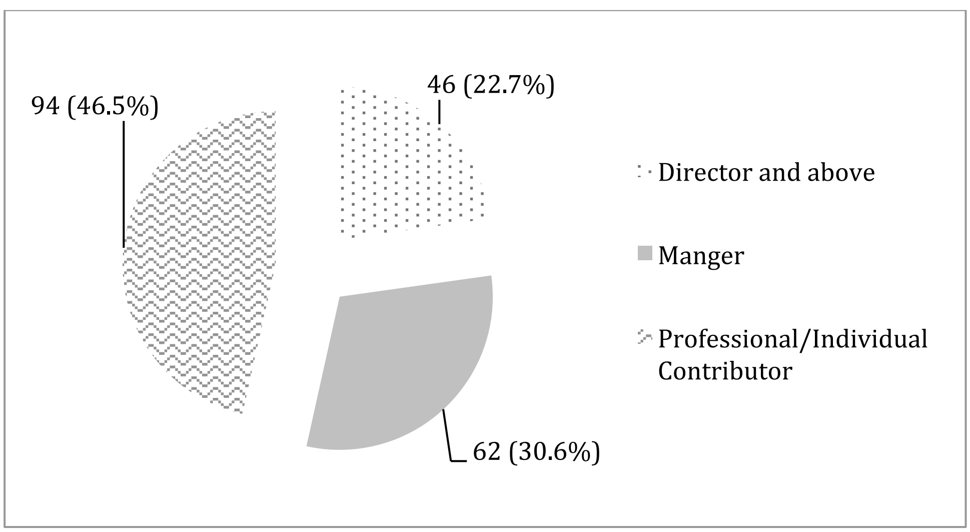

Fig 5.3 Participant's job at work

5.1.2 Responses to Questionnaire on PD and unfit demand.

Questions
The company works closely with customers/users to identify customer needs.
The right level of manufacturing capacity is installed at external manufacturing partners sites based on forecasts in the business case.
A scouring strategy is developed through the NPD process to protect our customers by not going into back order at launch.
We are proactive at integrating our suppliers into our process of developing technical solution.
There is a strong reflections of the impact of external factors such as the reg. environment built in to our product development timelines.
There are well defined cost post launch metrics & post reviews for continuous learning.
We as organization constantly meet our customer requirements.
This organization does not adopt the status quo supply chain model for each new product.
There is a strong business case development process in place with robust outputs.
As an organization we don't over-engineer our products- we only deliver features that the customer is willing to pay for.
There is a high level of governance and rigour applied at the stage gate reviews, Go/No Go decision are made based on data.
The current stage gate NPD process is effective at creating flow through new product pipeline.
We control and monitor work queues/ batches sizes in the NPD process.
In the organization there is a strong ethos of learning, knowledge conversion, and recycling lessons learned back into programs.
We an effective program management system.
A measurement system is in place to determine on how effective a new product lunch is in term of its execution.
Our product characterization and design verification process minimizes any upstream failures at PQ and post launch.
We consistently meet our cost of goods sold target sets out in the initial business case.
There is an effective resource loading and tracking system in place
The creation of flow through identification of value and elimination of waste is integrated into our current NPD system.
We are effective at portfolio management.
There are no inconsistences between our business process and the stage gate system.
Rework, retesting ,revalidation does not create significant level of non value add activity in this company.
There is little unnecessary waste created in the requirements management process.

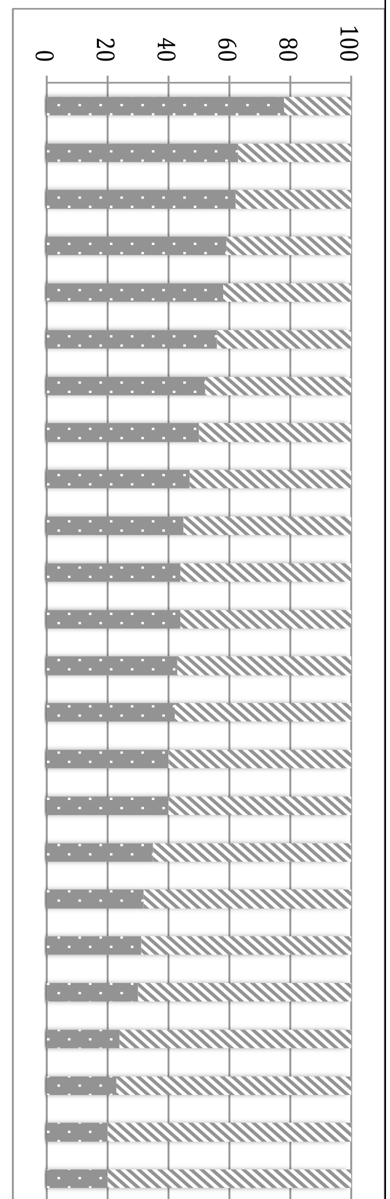

Figure 5.4 Survey responses

Some findings of this survey confirmed sources of failure reported in the literature review. For instance, ineffective program management, rework/ retesting/ revalidation, stage-gate processes, ineffective resource loading and portfolio management are the most significant sources of unfit demand. A clear problem was large batch sizes that created long queues and slowed down the flow. The questionnaire returns show knowledge conversion back into programs is poor, with low-grade up-front characterisation and verification of the product.

The questionnaire, Figure 5.4 leads to the conclusion that the requirements management process is a pool of waste and unnecessary activities across all organisations in the study. However, most respondents agreed that their firms work closely with their customers and accurately identify customer needs, though the majority of participants believe that there are inconsistences between business processes and the stage-gate review systems used by their firms.

It is widely accepted by respondents that suppliers are well integrated within firms and are often used to boost the development of inventive and effective solutions within R&D. It should be noted that statement 16, "A measurement system is in place to determine on how effective a new product launch is in term of its execution", and statement 18, "We consistently meet our cost of goods sold target set out in the initial business case", reflect the agreement of respondents that supply chain strategy is developed as a chunk of the product development process. It is also obvious that an even split exists between participants as to the level of integration of post-launch metrics with reviews of their product development process.

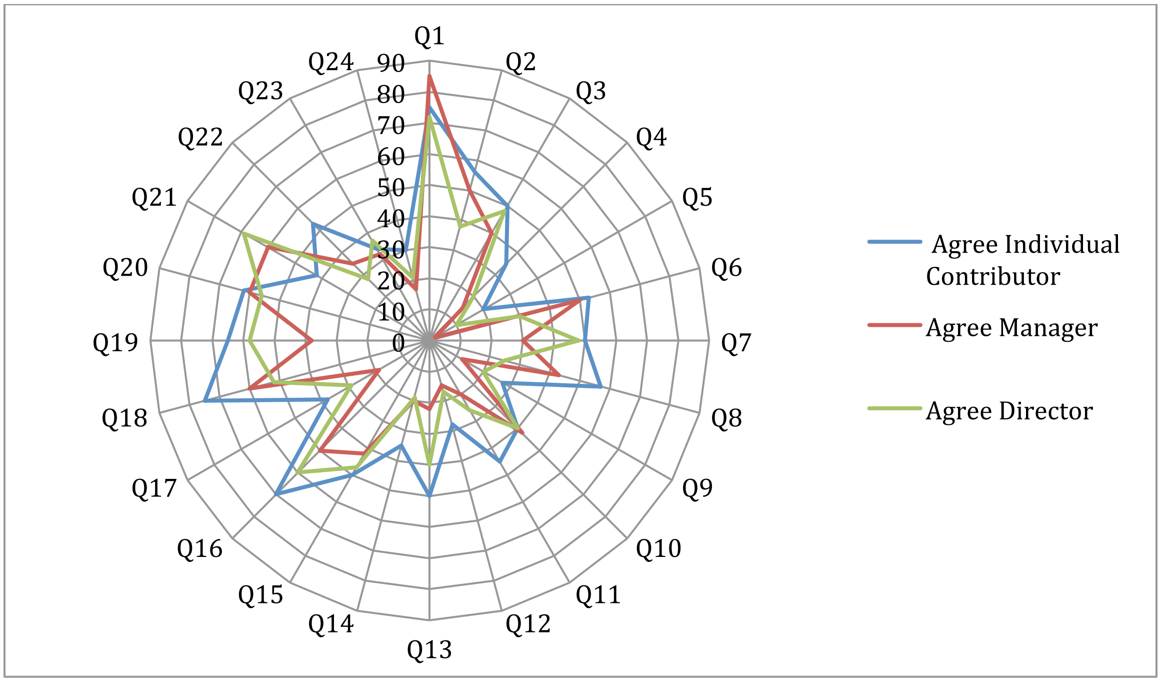

Fig 5.5 Radar chart of responses by organisational level of respondent

For statement 19 "There is an effective resource loading and tracking system in place" and statement 22, "There are no inconsistences between our business process and the stage gate system" the scores of individual contributors are higher than scores of R&D managers and directors. This suggests that individuals believe that the effect of external factors such as the regulator are appreciated by the team when setting a development timeline and that there is no strong ethos of learning and recycling knowledge across programs, especially new ones. However, most managers disagreed with these statements.

With statement 8, "This organization does not adopt the status quo supply chain model for each new product", 60% of individual participants responded by indicating that a high level of rigidity and inflexibility is present at stage-gate reviews. However, only

25% of directors share the same view.

With statement 6, "There are well defined cost post launch metrics & post reviews for continuous learning" directors and managers both have a much more positive opinion than individuals that continuous learning is driven by a well-defined post-launch metrics and review process.

Finally, responses to statement 1, "The company works closely with customers/users to identify customer needs" demonstrates that a robust common view exists at all levels that there is a good connection with the customer.

5.1.3 Impact of Failure Demand Ranking

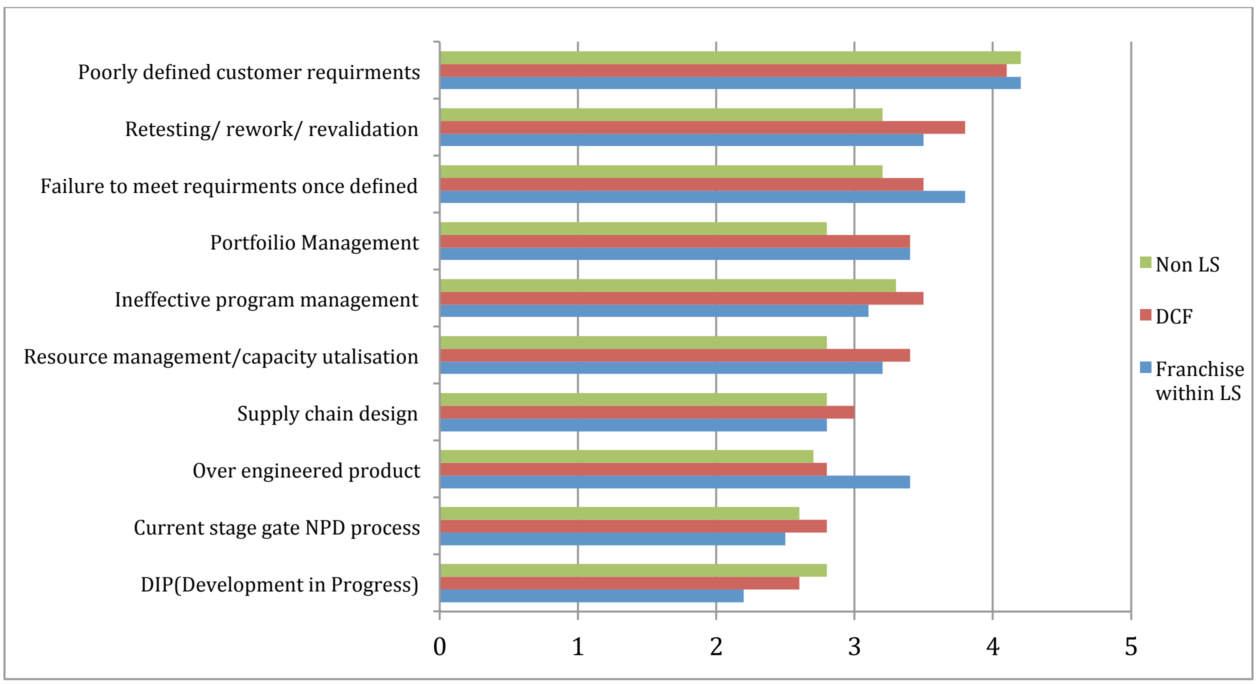

Fig 5.6 Unfit demand impact by organisation

The greatest impact on generating unfit demand is the combination of poorly defined customer requirements and the inability to meet exactly these customers' requirements. Also the impact of ineffective program management has more of an impact than the stage-gate process.

It is clear from the responses that the impact of ineffective portfolio management is greater in LS compared to other firms in the market. Commercial participants believe that over-engineered products are creating more unfit demand than DIP though respondents at all levels agree that DIP had a relatively low impact in generating unfit demand. All classes of participants agreed that retesting/ reworking/ revalidating are significant sources of unfit demand.

5.1.4 Qualitative Data

The author conducted a thorough investigation of qualitative data so that a better NPD process would result.

Fig 5.7 Themes for working well

Sample of comments on what is working well

"We have highly committed teams that work very hard to drive timescales and ensure that the product is correct within the confines of the NPD process."

"The idea of using the time to market process is a good one. We just need to be better at not fudging phase gates."

"We are extremely compliant with our documentation."

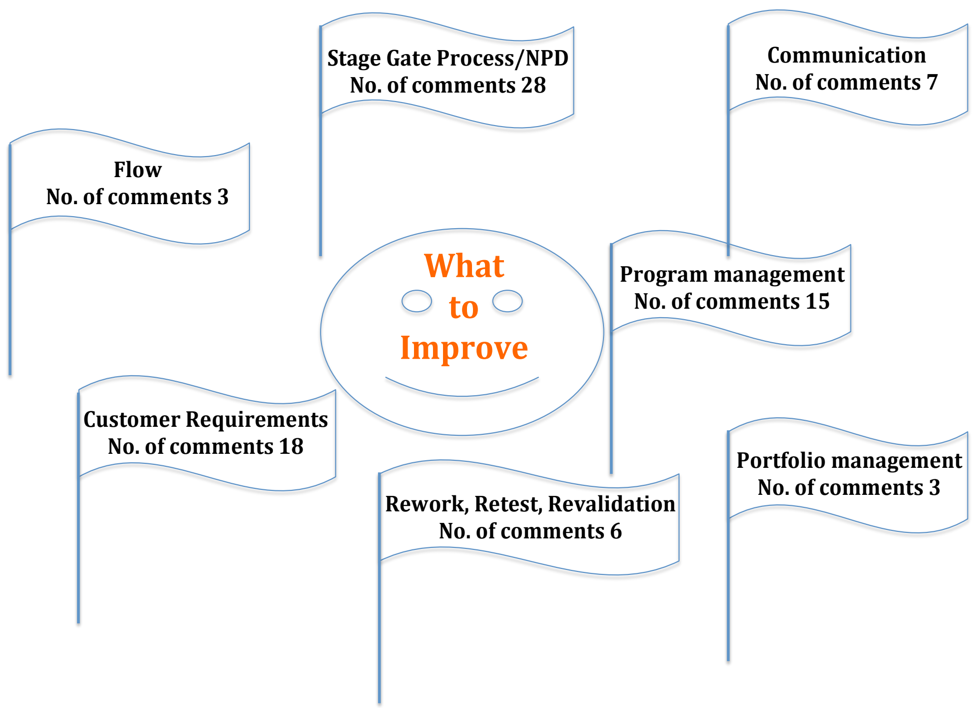

Fig 5.8 Themes for Improvement

Sample of comments on what could be improved

"The focus of the NPD process always seems to be on the outputs of the process and not on the process itself. I would like to find a way of automating the outputs, to focus attention on pursuing the process itself."

"A fairer balance of the recognition the business gives to the people who work on post- launch issues versus pre-launch. Project teams who launch a product get lots of recognition regardless of the amount of recalls, NC's and quality issues related to the product that may arise after launch"

"Establish customer-driven requirements early in the project lifecycle and develop transfer functions and design verification testing to verify that customer expectations are met for the product lifecycle."

5.1.5 Semi-structured Interview Findings

Twenty semi-structured interviews were undertaken where each interview lasted an hour and a half. Participants varied from Vice Presidents to workers in R&D both inside and outside LS. These interviews gave the author a broader understanding of the problem and hence solutions to be developed.

The semi-structured interviews has a framework of ten questions and was the major method of gaining insight into different modes of unfit demand, which the author expected to exist in NPD as evident from the literature review.

5.2 Case Study

This part of the research will provide further analysis of the three research objectives. It will focus on the literature review, and illustrate the qualitative and quantitative analyses and the researcher's own experience.

5.2.1 Impact of Unfit demand

The author developed a 2x2 matrix (Figure 5.10) as a means of analysing the research findings to understand modes of unfit demand and its impact on performance in R&D.

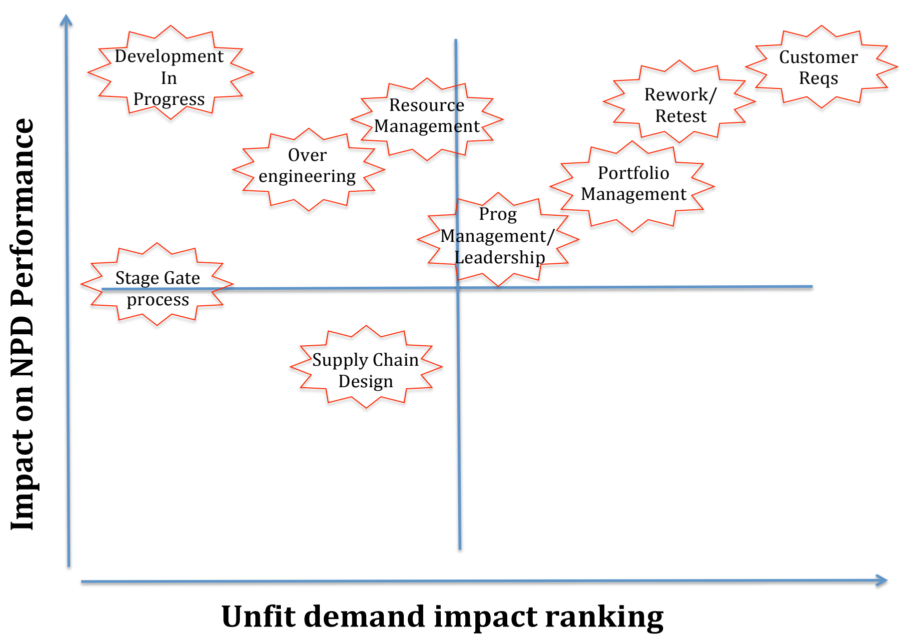

Fig 5.9 NPD Performance / Failure Demand Matrix

5.2.1.1 Customer Needs and Requirements

Data from this study suggests that most of the participants believe their firm is trying hard to identify their customers' needs by being close to them. The hard part is translating and transforming customer needs into a list of requirements that R&D workers can use to deliver good results. What the data reflects here is that failing to do so will have a huge impact on the organisation.

The inability to know the real needs of the customer can result in two things, either over-engineering the product or missing the market. The amount of waste generated by the requirement management process is the root cause of failing to translate the needs of the customers into clear requirements and 80% of participants agree with this. Our own explanation of this is that the requirement process is a multi-layered one, with many types of behavior associated with managing it.

At LS, a high level of queuing, batching, DIP and poor feedback is caused by the documentation and bureaucracy that surrounds requirement management. Reinertsen (2009) argued that this can hinder through flow in the product development process. This author, supported by the questionnaire data, agrees that the single biggest issue here is the initial requirements specified in the top-level documents that are set down in the Marketing Requirements Document (MRD). O'Heocha & Conboy (2010) support this view, stating "waterfall methods do not nurture an innovation space – on the contrary, they tend to severely restrict or even eliminate it."

5.2.1.2 Portfolio Management and Failure to Innovate

The survey found that 80% of participants hold the opinion that ineffective portfolio management is a major source of unfit demand. Ineffective portfolio management will affect firm's ability to innovate smoothly. Our input in this case will focus on a more simplistic approach that is central to any portfolio management as Bicheno & Holweg (2009) stated. Effective management can quantify objectives and will understand the trade-offs required in a product's lifecycle development.

For instance, if a company launched a product with improvements in features way beyond the current product, it will most probably make it more appealing for customers to purchase which improves sales and may increase market share. However, in real life the improvements will cost time, money and effort, all of which will affect the profits generated. Thus, it is important to understand that portfolio management revolves around tradeoffs and informed decision-making.

5.2.1.3 Stage-gate

This study showed both qualitatively and quantitatively that it is essential to have an NPD framework for the execution and delivery of a new product, from which it follows that some form of stage-gate process is necessary. 78% of participants feel that stage-gate could be improved and there are inconsistencies between the business process and the stage-gate review system .

Further, in interviews, 70% of interviewees confirmed that original business assumptions are rarely challenged and there is an upward drift in the estimated cost of goods throughout the lifetime of the program . This was explored through the qualitative analysis process and it was found that there was a gulf between the thoroughness applied when developing the technical requirements of a program versus the business requirements.

The author was surprised by the significant finding that 60% of participants agreed that there is a high level of rigour applied at the stage-gate process while 25% disagreed. What is of real concern is that directors can self-determine the level of rigour applied but that failing to do so adequately will result in unfit demand. This view is shared by Schmidt *et al.,* (2009).

5.2.1.4 Program and Resource Management

Data from this research showed that a high percentage of respondents believe that not only internal program management systems are not effective neither are the resource loading and tracking systems. Surprisingly, this caused a split in opinions during the interview with almost equal numbers supporting centralised command and control and decentralised command and control.

LS used to have a substantial Office of Program Management with a project manager who was in control of the delivery of all projects. But success was hindered by the company using a matrix management structure to determine the provision of resources. This was explained by Kennedy, Ward & Liker who stated that ineffective program management with unequal technical, commercial and operational knowledge and experience will lead to a spiral of failure. Nowadays, the company is managed by a core team of three leaders one for each of technical, commercial and operational aspects and each with equal power and voice.

5.2.1.5 Reworking/Retesting/Revalidating

In the areas covered by this study it has been established as shown in Fig.5.4 that more than 80% of waste within R&D is generated by rework, retesting and revalidation, second only to poor response to customer requirements in the amount of waste it generates. Interview participants assured the author that they had personally witnessed a significant amount of waste caused by rework, retesting, and revalidation, both individually and collectively. They all agreed that unfit demand was a significant cost in term of reputation, lost sales, rework and, especially, with people placed under stress in order to recover the situation. In some cases the damage reached levels that severely shook the firm.

There are a number of unexpected outcomes from this study and one of them is how participants view the role of the supply chain in the product development process bearing in mind that the majority of them claimed that sourcing strategy and capacity planning process is robust. Our analysis showed that the strength of this view originated with commercial respondents but that a hidden source of unfit demand was inaccurate forecasting by commercial departments. Most of the respondents believed that their firm is proactive in integrating suppliers into co-developing technologies . Our explanation is that as R&D budgets contract that creates the need for more supplier-enabled innovation. Lastly, the lack of knowledge about the impact of Development in Progress (DIP) on product development flow was surprising.

5.2.2 Lean Product Developments Theories - Drawbacks

It is very clear from the previous section that respondents viewed rework, retest, and revalidation as a major source of unfit demand. However, the same participants did not have a clue about the impact of DIP on NPD and the restrictions caused by large batches. Only a sixth of the people interviewed were familiar with the practices and tools of Lean Product Development. This is a surprise when it is realized that some of the respondents have more than 20 years of experience in R&D. They are aware of a number of tools such as QFD, TRIZ, JOC, DFM, Value Stream Mapping and so on, but not unfit demand and its sources. The idea of applying lean product development (LPD) in R&D

was not convincing to the majority of respondents because they thought it is a manufacturing paradigm and not related to product development.

The author believes that inconsistences in the theories that underpin LPD are in fact an inhibitor to its adoption. Hence, the development of a more consistent set of theories is needed. Hoppman *et al.*, (2011) stated “The current ambiguity in the understanding of Lean PD represents a major obstacle to progress.”

A number of authors have tried to win support for LPD by simply going back to the Toyota school of thinking. Authors such as Kennedy, Ward and Morgan & Liker have produced sound pieces of work in order to establish the research base for the evolution of LDP. Toyota is the benchmark for the number of new cars introduced, topping the world list, and that is a strong indication of the superiority of its R&D system. However, other firms in other industries are also doing well and performing effectively even under present economic difficulties. Apple is a unique case study for product development because it is simply an innovation machine. However, there are similarities and differences between Apple and Toyota product development. They are similar in as much as they both invest heavily in prototyping and simulation technology. Both companies’ development processes are strongly front end loaded but organisational behavior and company culture have a big influence on the product development process and there are a number of big differences between Apple and Toyota, including:

i. Toyota’s places great emphasis on being close to the customers and developing products by listening to the customers and converting their needs and requirements into reality. On the other hand, Apple does not do market research and relies totally on targeted markets or segments and focus groups (Breillat, 2008).

ii. Supplier integration is not part of the Apple ethos, especially supplier-led innovation. The company has a core group of 20 designers who control design from A-Z. Apple rely heavily on this group of people to deliver products that surprise and delight the customer (Breillat, 2008). Toyota on the other hand place supplier integration into product development from an early stage.

iii. Toyota is good and effective at product variety management using a system that is enabled through component standardisation. Therefore, Toyota has a high level of sku proliferation (Hoppmann *et al*., 2011). By contrast, Apple does the opposite, which makes it difficult to scale up an extensive product line.

The author's view is that both companies are wrong because their approaches are biased towards the product level of the framework and not the internal processes. It is essential in Fit to make value flow in product development and to do so, a deep understanding of Fit (Elimination/monitoring of queues, Reduction in development batch sizes, Cadence–standard work, Visual factory, and Variability pooling) could be used by both to advantage in their R&D.

During the research process, the author came across a number of references where leading thinkers such as Schuh & Lenders *et al.,* proposed moving towards System Thinking in order to achieve better rhythm and harmony in R&D. Schuh and Lenders *et al.,* who value the system approach extended Hansen's & Birkinshaw's method, which was a praiseworthy attempt to drive an end to end Lean PD. However, they are linear in execution and that does not reflect the level of interdependence that exists in the process.

Finally, it can be concluded that current Lean approaches in product development are not widely used due to the inconsistencies in approaches and different interpretations of principles that exist. However, that does not mean that Lean does not deliver. The author would argue that the failure to adopt Lean is due to the limited scale at which it is used within parts of the organisations. A satisfactory Fitness level is therefore not attained.

5.2.3 Current Measures for Unfit Demand

5.2.3.1 Metrics Research Analysis

Survey data shows that there is an even split between respondents on their attitudes towards the existence of a post-launch metric. Most measures used in NPD are management metrics and they fail to take into account important aspects of the process such as providing information on how well the company is innovating or the effectiveness of the product development process. This is obvious in some metrics such as pipeline productivity, time to market, R&D spend as a percentage of sales and product performance in the market place. Only 30% of businesses measure the outcome of a new product post-launch (Cooper & Edgett, 2008).

Moreover, measures such as NPV and IRR are open to question due to the known inaccuracy of the input data and forecasts and projected development expenses (Crowley, 2005). The values of products throughout their lifetimes are continuously influenced by strong forces which don't reflect the effectiveness of the development process. This is reflected in our research, where 60% of respondents felt that they don't have measures to reflect how well they executed the process that get them to product launch.

Additionally, Fit product development performance metrics should reflect important aspects of the Leanness of the process during execution. This is because the new measurement system should identify bottlenecks or waste that affects and compromises product development performance (Haque, & James-Moore, 2004). Leon & Farris (2011) confirmed this when they stated: “Tracking LPD progress in term of uncertainty and risk are greatly determined by activity arrangements and interactions”.

Reinertsen (2009) contributed greatly to NPD analysis by focusing on metrics that reflect the internal dynamics of the R&D process. His way of measurement is similar to taking the pulse of a patient but this time it is not blood but the flow of a product through the development cycle. It is not far from the metrics used in lean manufacturing.

What the field is lacking is a methodology for measuring how to innovate and this is a recognisable gap in the literature, a gap which is a major barrier to the adoption of lean product development within different industries.

5.2.3.2 Launch Quality Metric (LQM)

The LQM by Flower (2012) reflects how effective the product development process is at getting to the point of launching a product. However, this tool is still a lagging metric. According to Flower (2012), a 100% LQM means that the product is delivered on time, meets customer specifications, and has been developed on budget. The author applied the Flower metric to LS as a case study.

$$\mathbf{LQ = L_{ot} \times [Q_s \times Q_y] \times [C_d \times C_p]}$$

Where

Launch on time (L_{ot}) = 12month/15month = 0.8

Compliance to specification (Q_s) = 90%

Compliance to product yield (Q_y) = 98%

Development Cost (C_d) = £2m/£3m = 0.66

Product Cost (C_p) = £14/£14.81= 0.94

LQ= 0.8x[0.90x0.98]x[0.66x0.94] = 0.44 = 44%

Firstly, this metric realistically reflects the difficulties likely to be met in both the development process and at the launch of a product. This is truly beneficial for comparison of data held by top R&D managers. However, it lags product development which is a limitation. It is argued, therefore, that a new metric for performance index is required to optimise processes within R&D. The manner in which a firm innovates throughout the product development cycle needs to be measured, which would make it easier in the future to compare and contrast between projects without subjective assessments. In the following section, a new index, the Fit Flow Index (FFI), is developed to measure flow within R&D.

5.2.3.3 Fit Flow Index (FFI)

FFI can be applied at any time during the development cycle. It provides decision makers with a clear picture of the current situation. Being able to assess performance more accurately makes value flow more smoothly throughout the product development system.

Fit Flow Index =Time x Resource Utilisation x Development in Progress x Quality.

$$\textbf{FFI = T x (R x D x Q)}$$

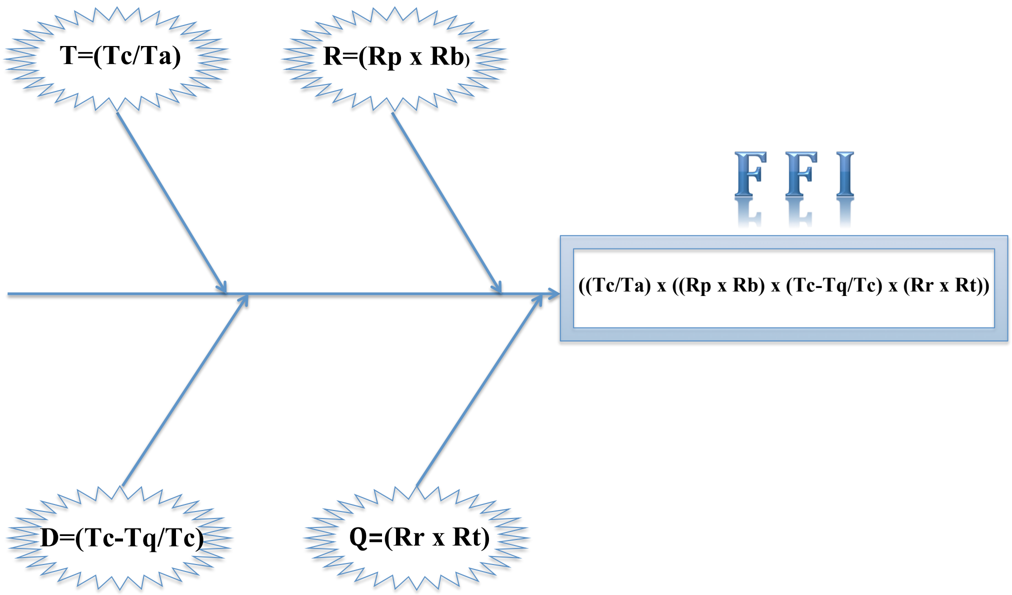

Fig 5.10 Fit Flow Index (FFI)

Where:

Ta: Actual time elapsed at that point,

Tc: Remaining committed time for delivery of the program,

Tq: Queueing time,

Rp: Resource utilisation [(people committed)/(people allocated)],

Rb: Resource utilisation expressed as a percentage [(budget £)/(expenditure £)]

Rr: Rework,

Rt: Retest.

FFI consist of a new combination of important measures which are: Time, Resources Utilisation, Development in Progress, and Quality. Starting with Time (T) which is the ratio of Remaining committed time for delivery of the program (Tc) to Actual time elapsed at that point (Ta). Secondly, Resources Utilisation (R) that can be calculated by multiplying the ration of people committed (Rp) to people allocated and the ration of budget to expenditure (Rb). Thirdly, Development in Progress (D) which is computed by subtracting Queuing time (Tq) from Remaining committed time for delivery of the program(Tc) and the result is divided by Remaining committed time for delivery of the program(Tc). Finally is determining Quality (Q) by multiplying Rework (Rr) and Retest (Rt)

Worked example: Based on current LS development program.

Project X is 7 months into its development cycle. The project plan indicates there is only 6 months work left to complete at this point. The budget spend is running at 110% of the original allocation. The planned headcount required at this point was 16 but currently there are only 14 staff available. There is 2 weeks work queued in front of the characterisation team and 3 weeks queue in front of the clinical testing team. To date there has been no rework required. However, a batch that required retesting took 4 weeks.

FFI = ((Tc/Ta) x ((Rp x Rb) x (Tc-Tq/Tc) x (Rr x Rt))

FFI = (6/7) x ((14/16) x (100/110)) x ((7-0.5)/7) x (1x(1-(1/7)))

FFI= (0.86) x (0.875 x 0.91) x (0.92) x (0.86)

FFI = 0.54

Fit Flow Index considerations – what's good or bad?

The author believes that taking the living pulse of the product development system will enable senior managers to make informed decisions during the review process and to more effectively identify potential problems. If the index is significantly lower than unity, a deeper analysis and a thorough investigation is needed, looking at each input to the equation to identify what is hindering the flow. On the other hand, if the FFI is significantly higher than 1 then either the firm is under-utilising its resources or the lead time should be shortened.

However, if two projects have the same FFI number managers must not assume that they both suffer from the same problem because different sources of variation can combine to produce the same FFI. Each FFI must be should be dealt with on a case-by-case basis and treated individually. This is similar to metrics such OEE where numbers can be deceptive.

Summary

In this chapter the author explored and discussed the idea of increasing the flow in product development by acquiring information about sources of unfit demand. A FFI depending on various factors that affect and hinder processes in R&D environment was developed to measure this flow. Some interesting and surprising results were reached that should improve our understanding of the implementation of Lean product development.

- CHAPTER 6 -
Fit Customer Satisfaction

Preliminaries

The main objective of this final part of results and analysis is to investigate and explore the data collected through questionnaire and interview. In Section 6.1 a representation and discussion of participant's demographical data will be provided. Section 6.2 explores participant's attitude regarding different dimensions of company's services. Section 6.3 explores more thoroughly the five dimensions by utilising descriptive measures, Analysis of Variance (ANOVA), and Test of Independence. The author aims to put the data under stress because the data cannot be verified without this. Additionally, to get a clear picture of the improvement intervention statistical tests which are feasible to the data were applied.

6.1 Survey Results

6.1.1 Respondents' Demographics

The survey for this part of the thesis was designed to measure cutomer's satisfaction towards changes that the company has made to improve the quality of service. In total there is eight questions, the first three asked about participant's gender, location, and age. The rest of the questions measured the following dimensions: speed of service, taste of product, accuracy of order, friendliness, and quantity of waste. The company announced that customer satisfaction has improved dramatically and doubled between 2008-2010 and it still improving ever since. Therefore, the survey is a measurement of Fit Customer Satisfaction (FCS) aiming to measure the pulse of process improvement from customer's standpoint or prospective. This research consists of a new methodology on how to evaluate Fit intervention and the impact it has on customer's experience in the coffee shop. Customers will retain memories about the experience because it is seen, tasted, memorized, and sensed. Therefore, the new improvements will impact and change shopper's psychology and attitude regarding the company either positively or negatively.

The analysis of this part of the thesis will commence with a summery of some basic statistics such as N, Mean, Median, Mode, and SD for all the questions in the survey. The following Table 6.1 will represent data overview:

		Gender	Location	Age	Q 4	Q 5	Q 6	Q 7	Q 8
N	Valid	822	822	822	822	822	822	822	822
	Missing	0	0	0	0	0	0	0	0
Mean		1.59	2.93	3.62	2.65	2.77	2.67	2.83	2.19
Median		2.00	4.00	4.00	2.00	3.00	2.00	3.00	2.00
Mode		2	4	3	2	3	2	2	2
Std. Deviation		.493	1.487	1.029	1.244	.980	1.300	1.311	1.049

Table 6.1 Overall Frequencies

Overall, eight hundred and twenty two (822) completed questionnaires were received, based on an online as well as delivery and collection methods (Saunders *et al*., 2003). Data analysis showed a split between male and female respondents, with 481 male respondents at 58.5 percent and 341 females at 41.5 percent as shown in the following table and chart (Figure 6.1).

	Freq	Percent	Valid Percent	Cumulative Percent
Female	341	41.5	41.5	41.5
Male	481	58.5	58.5	100.0
Total	822	100.0	100.0	

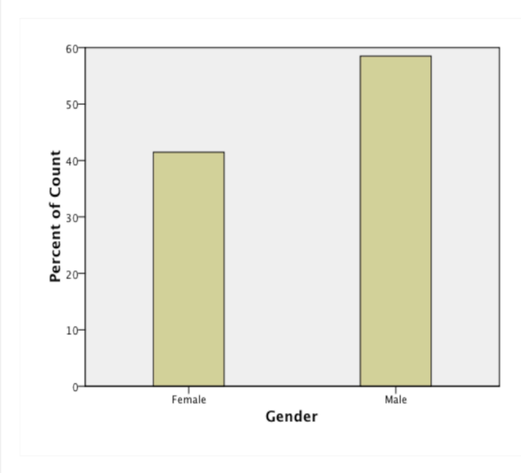

Fig. 6.1 Gender Frequency and bar chart

The Age question graph representation was a normal distribution (because it follows the shape of the normal curve) with the big group of 21-29 at its centre as expected. The majority of respondents belonged to the 21-29 and 30-39 age groups, accounting for 39.1 and 35.5 percent respectively of the total respondents. The remaining less than 25 percent spread across the other four age groups of (20 or younger), (40-49), (50-59) and (over 60), with percentages of 9.3, 11.7, 3.6, and 0.9 percent respectively. The following table and chart (Figure 6.2) shows all the details:

	Freq	Percent	Valid Percent	Cumulative Percent
20 or younger	76	9.3	9.3	9.3
21-29	321	39.1	39.1	48.3
30-39	292	35.5	35.5	83.8
40-49	96	11.7	11.7	95.5
50-59	30	3.6	3.6	99.1
60 or older	7	.9	.9	100.0
Total	822	100.0	100.0	

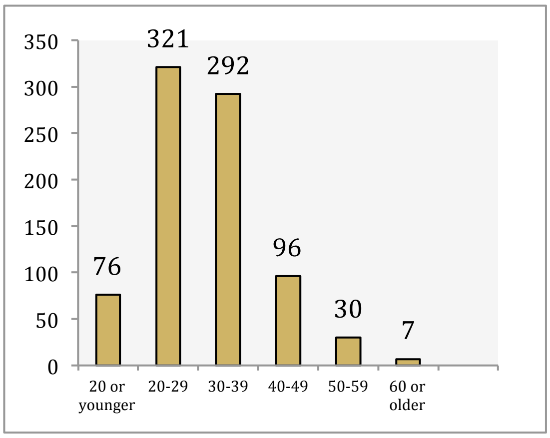

Fig 6.2 Age Frequency and bar chart

In addition, three hundred and thirty four respondents were located geographically in Europe at 40.6 percent The two next largest groups were located in the Middle East and US & Canada, with 221 respondents belonging to the former and 159 respondents belonging to the latter at 26.9 percent and 19.3 percent respectively. The remaining 13.2 percent was divided between the other three locations of Latin America, Asia and Africa, with percentages of 0.7, 11.6, and 0.9 percent respectively, as shown in the following Table 6.2. The overall chart reflects to a certain extent an EU taste with the tallest bar in the chart.

Additionally, the American population represented a fifth of my sample of 822 Starbucksers and in the USA the first and biggest Lean changes happened and are still happening. Their weight and input gave my data more credit, in our opinion. Our only observation regarding this section is the negative image of Starbucks in the Middle East (27 percent) due to the political involvement of Starbucks Corporation in Israel's politics and their big donation to extend the settlements in the Holy Land. This move meant that for all Arabic and Islamic countries, the Starbucks brand had a negative image and consequently

Muslims launched a big marketing campaign to boycott this brand and franchisees' businesses in those countries. We think in this research that Starbucks as a corporation should not get involved in political issues so that it may sustain its market share, as competition is getting harder every day. As a result, we received more than 1200 rejections and empty surveys from that region alone and all for that reason. Sample size was therefore affected dramatically and dropped unfortunately.

	Freq	Percent	Valid Percent	Cumulative Percent
Middle East	221	26.9	26.9	26.9
US & Canada	159	19.3	19.3	46.2
Latin America	6	.7	.7	47.0
Europe	334	40.6	40.6	87.6
Asia	95	11.6	11.6	99.1
Africa	7	0.9	0.9	100.0
Total	822	100.0	100.0	

Table 6.2 Location Frequency

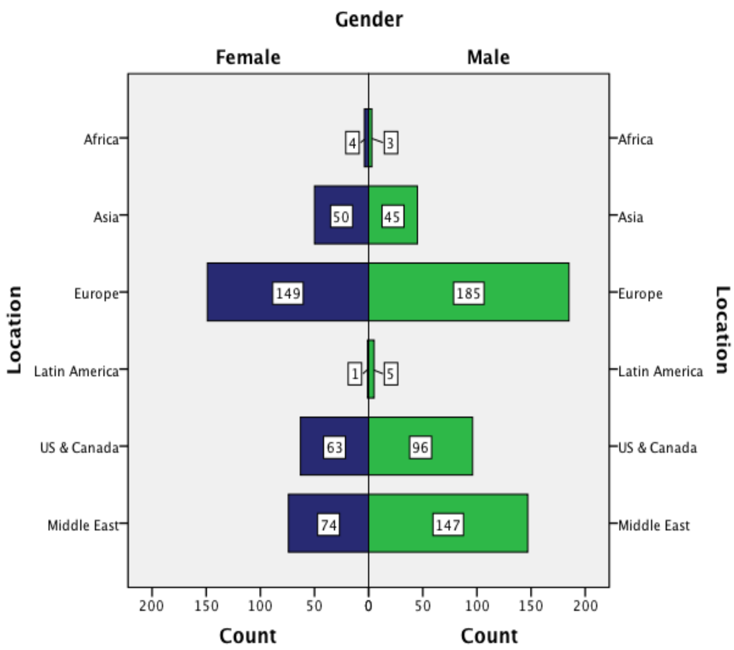

Fig 6.3 Gender vs Location

The graph presented on the left Fig 6.3 suggests that Males had higher Age scores than Females and that this difference is more pronounced among the Latin American and Middle Eastern groups. Among the rest of the groups the difference in scores between males and females is small.

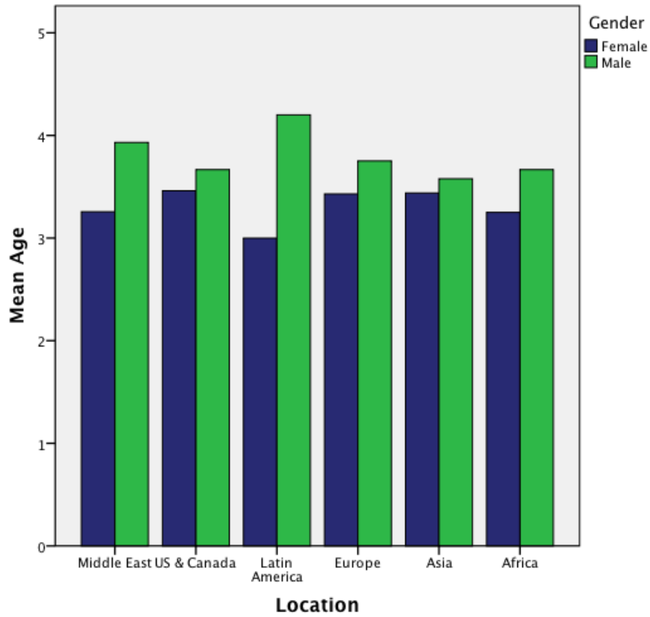

Fig 6.4 Gender vs Location means

6.1.2 Fit Dimensions

6.1.2.1 Hot Drinks

In the first question, respondents were asked “At Starbucks, do you wait for your hot drink to cool down before drinking it?” which was measured on a five-point scale of (1) Always, (2) Sometimes, (3) Rarely, (4) Never, and (5) Do not know. The question was designed to investigate whether the company is offering hot drinks as “warm” drinks at 160F, so that they can save time both in the process of making the drink and in the duration of customer’s stay, meaning that the store becomes able to turnover more customers then before. Additionally, some service agents do not like to heat drinks to high temperatures (170-185F) because their aprons will smell burnt, although heating the milk to this kind of temperature will not affect its taste. This question seeks to give an indication of whether reducing lead time by eliminating VA steps has a negative impact on the perception of the product quality at Starbucks.

6.1.2.1.1 Quantitative Analysis

The first round of measuring the impact of the intervention was completed by all Respondents with a surprising result of 33.1 percent answered ‘Never’. On the other hand, 19.6 percent choose ‘Always’, which is the other extreme on the graph. However, 42 percent picked the middle choices, which are the two groups of ‘Sometimes’ and ‘Rarely’ combined, with 207 respondents of the former and 137 respondents of the latter at 25.2 percent and 53.5 percent respectively.

From a different perspective, 44.8 percent of our sample ticked the two boxes of ‘Always’ and ‘Sometimes’, and 49.8 percent ticked the other two boxes of ‘Rarely’ and ‘Never’. Thus, there is more weight and gravity on the latter side than on the former.

It is clear, therefore, from the numbers that participants are drinking hot drinks that are not as hot as they wish them to be because they are offered them warm and at room temperature, according to the participants. The face to face interviewing gave us a deeper understanding of the answers and the reasons behind them. Moreover, the majority of questionnaires were completed while the customer was having his or her fresh beverage and this made people react much faster because they were living the whole experience. The following table and chart (Fig 6.5) illustrates the above:

	Freq.	Percent	Valid Percent	Cumulativ Percent
Always	161	19.6	19.6	19.6
Sometimes	207	25.2	25.2	44.8
Rarely	137	16.7	16.7	61.4
Never	272	33.1	33.1	94.5
Do not Know	45	5.5	5.5	100.0
Total	822	100.0	100.0	

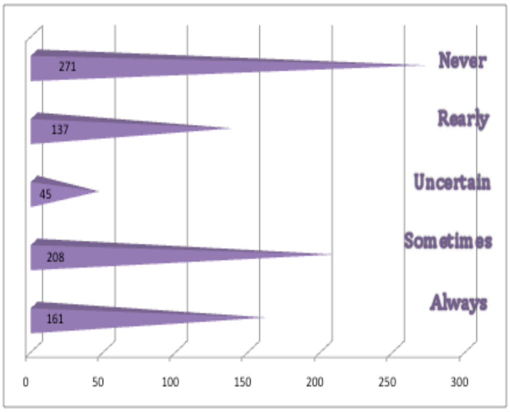

Fig 6.5 Quantitative Analysis (Hot drinks to cool down)

6.1.2.1.2 Qualitative Analysis

Observing Starbucks' processes and having the opportunity to chat with a large number of baristas gave us new information and explanations for certain actions. Regarding hot drinks, a barista in Cardiff-UK- disclosed that they heat the milk between 145-160F and they pour it on different bases that cool the drinks down. Bearing in mind that the UK's Health and Safety regulations allow them to heat the beverage to 190F, this limit is much higher than the current heating point. Unfortunately, 33.1% found that their hot beverage is never hot and its usual for them to have it warm. If so they can ask baristas to make the drink "extra hot". On the other hand, partners justified this range of heating temperature by explaining that milk will loss some of its sweetness if the higher maximum range is used, because milk may burn at 200F. However, at the same time a barista admits to heating milk based on the sound when it has been ordered as a take away or drive through to save time. He went further by mentioning that a small number of his colleagues don't like their apron to smell like burned milk and that therefore they heat hot drinks closer to the minimum standard temperature.

Summary

From an operational point of view, we feel that Starbucks is trimming time from the "time of heating Milk" to reduce the lead-time and so to increase orders/hour for hot drinks. That cut had its negative impact on the product's quality and a large segment of customers became aware of that change and started to get annoyed. Therefore, management should take care of this issue because this number of participants will spread the bad word, which is the worse enemy to any brand. In other words, 1 out 10 happy customers will tell another person about the good service, but one sad consumer will tell ten people about that bad experience.

Additionally, when the whole picture is considered, it is found that cutting lead-time by reducing temperature will reduce the experience time, which will free up more seats in the store in the long run. In other words, having a warm "hot drink' will make the customer start drinking and enjoying his/her drink almost in no time. In this case, store capacity is optimised but with a damaging effect on customers once they know about it and the customer starts questioning Starbucks' ethical practices and unfair treatment. It is important to get value for money.

It could be concluded, therefore, that the idea which argued that lead-time reduction can affect the satisfaction of customers and their retention was supported by this research's results. Value Added activities are not well understood in this case and a deeper comprehension of Quality v Time is needed. The big bar in the figure shown above in Fig 6.5 is so significant that it is a warning to the company to reengineer the processes to meet real customers' expectations. Additionally, technical and taste issues should work in parallel while redesigning the new system to locate some hidden VA and NVA activities.

6.1.2.2 Comparing New with Old Espresso machine

In the second question, respondents were asked “At Starbucks, how does the taste of an espresso made with the new La Marzocca automatic machine compare with that of the old manual machine?” This was measured on a four-point scale of (1) Better, (2) No Difference, (3) Worse, and (4) Do not know. This question relates to Schultz’s letter in 2007, in which he commented upon regretting replacing the old espresso machine with the new automatic machines, because customers missed the romance and theatre of the old machines. Additionally, the new replacement machines deny the customer the ability to watch the drinks being made, which changes the experience. However, the decision to replace the old machines was to reduce processing time through automation of the process.

6.1.2.2.1 Quantitative Analysis

This section of the survey was answered by all participants. As shown in Fig 6.6, the results were surprising because more than a third of respondents (274 respondents at 33.3 percent) found that the taste of espresso produced by the new automatic machine is worse when compared with that of one produced by the old machine. On the other hand, only 95 respondents (11.6percent) replied that espresso tasted better than before and they represent a third of the number of the ‘Worse’ group. However, 228 respondents (27.7percent) believed that there is no difference between the taste of espresso made by the new or old machine. Furthermore, 225 respondents (27.4 percent) went with the neutral choice and ticked ‘Do not Know’. Most of these don’t drink espresso or hot drinks in general.

In the following section, which looks at the whole picture, we will explore the reasons behind customers’ frustration by analysing the qualitative data.

	Freq	Percent	Valid Percent	Cumulative Percent
Better	95	11.6	11.6	11.6
No Difference	228	27.7	27.7	39.3
Worse	274	33.3	33.3	72.6
Do not Know	225	27.4	27.4	100.0
Total	822	100.0	100.0	

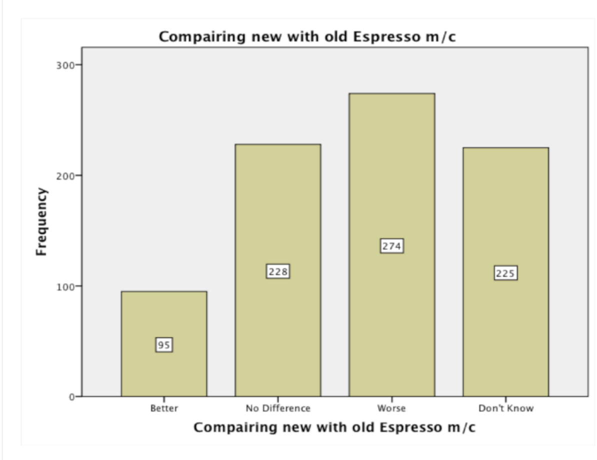

Fig 6.6 Quantitative Analysis (Comparing Manual & Automatic m/c)

6.1.2.2.2 Qualitative Analysis

People across different demographics reacted positively to the semi-structured interview. On the one hand, when participants were asked about the reason behind not liking the taste of espresso, the majority of them said:

" Now it feels like a fast-food restaurant. They need to go back to their roots"

" They only care about money"

"I missed the taste of the perfect espresso shot"(Young man)

"The improvement of speed does not justify the sacrifice"

" For me the taste is more important than chatting to the barista"

" Sometimes getting back to basics is the perfect solution"

"I missed the action and romance that comes with the old machine"

" Part of the whole journey had changed for me once the old La Marzocca was gone"

" I like beans to be freshly ground seconds before brewing a pot of coffee"

“ They are trying to turn us to robots” (Barista in London).

“Pulling the right shot is gone” (Barista in Cardiff)

“ The shot does not come with rich body and cream any more, with the old Italian machine my customers always enjoyed it and adored it” (Barista in Manchester)

“ There is no art anymore in making the espresso, because it is difficult to cool off the digital steam on the new machines” (Barista in London)

“ They need to redesign the old La Marzocca to work better ergonomically and then no need for the new machines” (X Barista)

On the other hand, a few participants found replacing the old machine a positive move from the company and said:

“ The sound of grinding with the old manual machine was so loud and I got headaches from it in the past” (Barista in Norwich)

“Calibrating the new machine will get you a very similar taste to the old ones, however, my DM would not let us do it” (Barista in London)

Summary

It is obvious from the bar chart (Fig 6.6) that a high percentage of respondents are not happy about the changes that Starbucks has made in order to reduce the lead-time. This indication is aligned with Schultz when he admitted in his letter the mistake of replacing the old La Marzoccas. However, this significant difference between ‘Better’ and ‘Worse’ was not expected to be that pronounced, which makes it alarming from an operational perspective. The Kano Model is a very useful tool for understanding customer’s needs by differentiating between different factors and their implementation. According to the model, if a basic factor, as in our case the hot drinks temperature, is fulfilled then the customer will not be delighted but rather be neutral. If this high temperature is absent then a dissatisfied customer will be the result. In other words, basic needs that the customer expects to be fulfilled every time s/he visits the store are not to be played with, otherwise the consequences will be damaging to Starbucks' image and customer retention.

The company should focus on reducing lead-time by removing non-value-adding activities in addition to reducing necessary non-value-adding activities rather than hindering with VA activities. This is the essence of Lean thinking and any diversion from its building concepts will not make any sustainable improvements. Automation will adds value to the process if it solved clear-cut problems and when it cost less than simple solutions, otherwise it will be a waste of resources specially if the quality of the drink is not improved (Bicheno and Holweg, 2009). Therefore, the company needs to consider putting back the old machines and reengineer its processes for better services.

6.1.2.3 Custom-made beverage

In the third question, respondents were asked "At Starbucks, when you order a custom-made beverage, how often do you get what you expect?" which was measured on five-point scale of (1) Always, (2) Sometimes, (3) Rarely, (4) Never, and (5) Do not know. This question examines the impact of having a large variety of products has on the drink's quality and taste. Meeting customer expectations is a core goal of Fit operations, which means that customisation that damages a product's quality should not be a priority and that sticking with standard products may be a better choice.

6.1.2.3.1 Quantitative Analysis

This question asked respondents about the quality of beverage when it is ordered custom-made. The bar chart below (Fig 6.7) illustrates customers' beliefs about the quality of custom-made drinks at Starbucks. 349 respondents (42.5 percent) voted for 'Sometimes', which is the highest voted answer for this question. Additionally, 131 respondents (15.9 percent) thought that they 'Always' get their custom-made beverage the way they like it. However, 25.8 percent (212 respondents) went either with 'Rarely' (130 respondents at 15.8 percent) or 'Never' (82 respondents at 10 percent).The remaining less than 16 percent (130 respondents) couldn't decide and they chose 'Do not Know' because most of them order a standard beverage from the menu. The qualitative analysis for this question will be discussed in the following section to explain the root cause of most answers.

	Freq	Percent	Valid Percent	Cumulativ Percent
Always	131	15.9	15.9	15.9
Sometimes	349	42.5	42.5	58.4
Do not Know	130	15.8	15.8	100.0
Rarely	130	15.8	15.8	74.2
Never	82	10.0	10.0	84.2
Total	822	100.0	100.0	

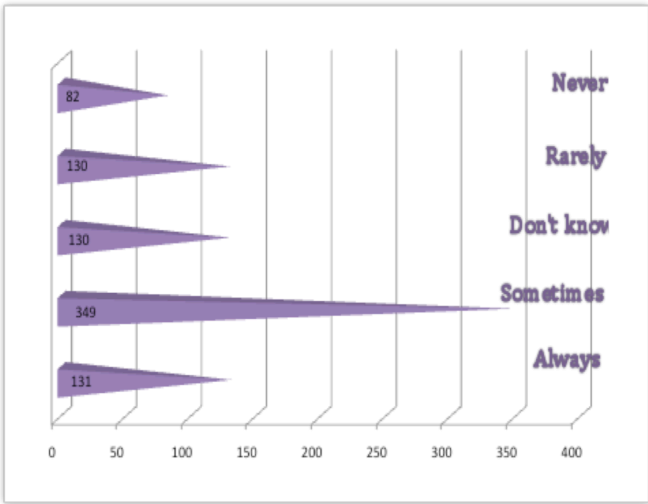

Fig 6.7 Quantitative Analysis (Custom-made beverage)

6.1.2.3.2 Qualitative Analysis

Different opinions were supplied by the respondents that reflected generally satisfied customers. The majority thought that visiting their usual store will increase the chance of having exactly what they wanted. About half of respondents emphasised the importance of location and that a deeper interaction with the barista was important in the long-run, so the barista will know what the customer wants even before ordering the custom-made drink. Respondents with the highest percentage ('Sometimes') expressed themselves by saying for example: " *the shot count is less in the UK compared to the US*"

Additionally, people who believed that Starbucks ('Always') produce their tailored drink up to their standards said that:

"The chain is always consistent in their drink's taste".

" They do not take very long to make what I want exactly"

" Sometimes they surprise me with the drink, that is why I feel that I'm treating myself"

However, over a quarter of respondents ('Rarely & Never') exhibited some frustration towards not having value for money by thinking and saying:

> *" The quality of the drink depends on the size of the beverage"*
>
> *" They used to care about making the drink"*
>
> *" I always have to pay extra for the extra shot so I can drink the beverage, otherwise the extra milk will roughen the taste"*
>
> *" Sometimes I feel like leaving Starbucks because their drink's taste does not suit me any more"*
>
> *" Starbucks became a rare thing to me after I lost my job two years ago, it's a premium brand and I cannot afford their coffee"*

Summary

After an analysis of the results both qualitatively and quantitatively it is believed that overall customer satisfaction regarding tailored drinks is fairly good. Customers' positive response is an advantage that needs to be capitalised upon. In other words, transforming Starbucks to be the place to have your unique and tailored drink with all the choices that you desire, could be the ultimate goal for this business.

Additionally, reducing the lead-time to produce this customised beverage is so essential that it is vital to become able to compete with rivals while maintaining consistency in taste. Therefore, the company should capitalise on this advantage and try to use it as a selling point for its beverages. Customers like to be treated as an individuals and this could be the cornerstone for Starbucks marketing campaign in order to attract and retain more customers.

6.1.2.4 Barista's Badge and Personalisation

In the fourth statement, respondents were asked "At Starbucks, I feel the barista's badge makes the experience more personal" which was measured on a five-point scale of (1) Strongly Agree, (2) Agree, (3) Disagree, (4) Strongly Disagree, and (5) Do not know. Starbucks prioritises personalisation in their services and interactions with customers, including a recent return to the use of quotes on their cups. They trim waste to create more time to interact and chat with customers, justifying the use of Fit to enable them to offer a unique customer experience.

6.1.2.4.1 Quantitative Analysis

Respondents were asked if they agree or disagree with the statement that the barista's badge makes the experience more personal. It is found that 117 respondents (14.2 percent) 'Strongly Agreed' and 283 respondents (34.4 percent) 'Agreed' with the statement. In other words, 48.6 percent found that knowing barista's name did add value to the experience in one way or another. However, 78 respondents (9.5 percent) 'Strongly Disagreed' and 193 respondents (23.5 percent) 'Disagreed' with the idea suggested by the question. Therefore 33 percent of respondents thought that personalising the service by enhancing the interaction between both sides does not add value to them. Additionally, 151 respondents (18.4 percent) were neutral or 'Do not Know', as shown in Fig 6.8.

Almost half of the customers, therefore, believed that knowing Starbucks' representatives name is good and essential to having a good experience. In the following section we will explain in depth the reasoning behind those numbers.

	Freq	**Percent**	**Valid Percent**	**Cumulative Percent**
Strongly Agree	117	14.2	14.2	14.2
Agree	283	34.4	34.4	48.7
Disagree	193	23.5	23.5	72.1
Strongly Disagree	78	9.5	9.5	81.6
Do not Know	151	18.4	18.4	100.0
Total	822	100.0	100.0	

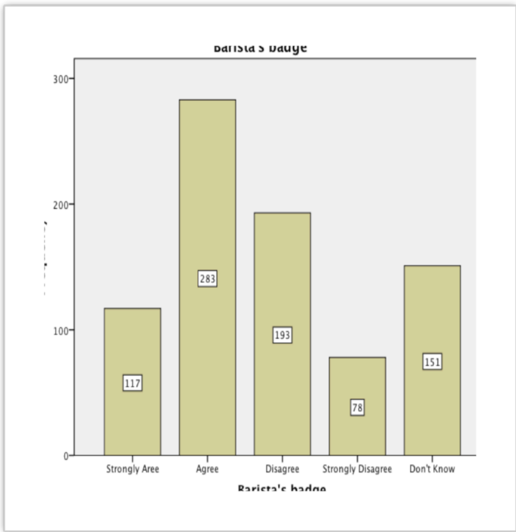

Fig 6.8 Quantitative Analysis (Personalisation)

6.1.2.4.2 Qualitative Analysis

In this question we found a big acceptance that knowing the name of barista will improve the experience somehow. For example, some of them expressed themselves by saying:

> *" It is nice when I know the name of who is serving me, and good that he calls me by my name as well"*
>
> *" The interaction is important for me and the name badge makes it easier to communicate'*
>
> *" Starbucks asks for my name when I order my drink so they don't mix it up with another's order, and they give their names so I can call him by his name"*

Summary

Both qualitative and quantitative results supported the claim that personalising the service will increase customer satisfaction. Starbucks exchange names with customers in an effort to tailor the experience. However, some customers reported that misspelling their names could put them off their drink. In other words, customer's name on the cup improves the experience if it is spelled correctly but if baristas did not get the name right then some customers will feel offended, which will have a negative impact on the experience. At the time of writing this research, Starbucks started again offering unique take-away cups with a variety of inspirational massages written on them.

6.1.2.5 Layout and barista's movement

In the last question, respondents were asked "At Starbucks, I feel the barista moves too much between stations whilst preparing my drink" which was measured on five-point scale of (1) Strongly Agree, (2) Agree, (3) Disagree, (4) Strongly Disagree, and (5) Do not know. This question was inspired by the theory of Lean layout and flow, seeking to examine whether the customer has consciously noticed any changes in the design and arrangement of stations at the back where drinks are made. The excess movement and motion is a measure of waste in the process. Thus, if customers feel that they are paying for some non value-added activity, this will tend to result in reduced satisfaction and a feeling of not getting value for money. TWI tools should have an impact on the flow at the back by increasing worker's efficiency, meaning that Starbucks baristas will not have to work on more than two drinks at the same time to assure that quality is up to standard. The new concept emphasised by the Fit team was to apply One Piece Flow in addition to reducing the batch size.

6.1.2.5 Quantitative Analysis

This question is associated with layout optimisation and behind the counter activities. Participants were asked if they agree or disagree that partners are moving too much in order to make the beverage. All 822 respondents answered the question with just 54 (6.6 percent) who did not notice the changes or did not have a clue about the issue and they ticked 'Do not know'. It is worth mentioning that this question scored the least in negative responses or uncertainty.

The chart and table below (Fig 6.9) illustrates that 50.5 percent of customers (415 respondent) 'Agreed' with the statement and this large segment of customers is represented by the big bar in the chart below. Moreover, another 23.8 percent (196 respondent) 'Strongly Agreed' that it is taking too much effort and movement from the barista to make their drink. Therefore, more than 76 percent of this sample believed that changes and improvements are still not noticeable from their perspective.

Nonetheless, around 19 percent thought that the statement is harsh and they disagreed with the claim. Only 126 respondents (15.3 percent) 'Disagree' and even fewer than 4 percent (31 respondents) 'Strongly Disagree' with the statement. Therefore, it is obvious that numbers are not supportive of the claim that Starbucks is offering a value for money beverages because the customer is not ready to pay for the extra and unnecessary movement the barista makes to produce his/her drink. In other words, efficiency behind the counter is seen as a week point at Starbucks by their customers. The following section we will qualitatively analyse the lay out issue and attempt to understand why customers are making these claims.

	Freq.	Percent	Valid Percent	Cumulativ Percent
Strongly Agree	196	23.8	23.8	23.8
Agree	415	50.5	50.5	74.3
Disagree	126	15.3	15.3	89.7
Strongly Disagree	31	3.8	3.8	93.4
Do not know	54	6.6	6.6	100.0
Total	822	100.0	100.0	

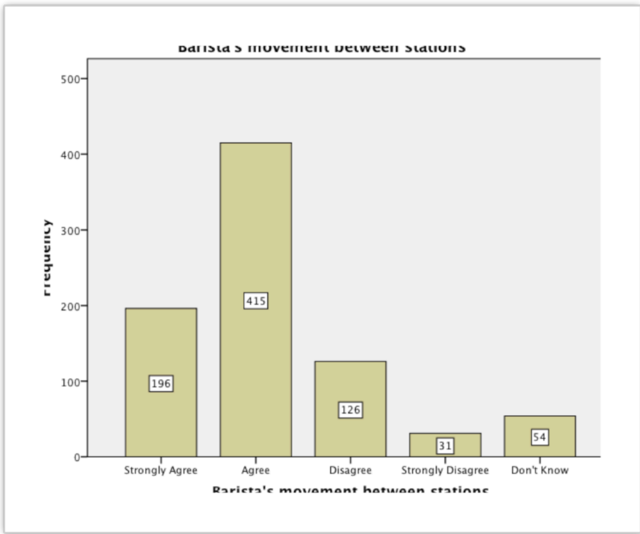

Fig 6.9 Quantitative Analysis (Barista's movement between stations)

6.1.2.5.2 Qualitative Analysis

Table 6.3 contains both ends of the spectrum and how some customers justified their choices by stating:

	Strongly Agree or Agree	Strongly Disagree or Disagree
Male	*" I always complain to the worker that he/she is moving*	*" By the time I arrive at the delivery*

	too much, but they say we have to" *" When I see them moving too much I feel like I am paying more than what the drink deserves"* *" They charge a premium price, each penny should count"* *" I feel that redesigning the working area is important if they need to be more efficient"* *" The machine used to make the drink always blocks my vision and I can't see the action of making the drink which I like"* *" They move too much between different stations to make my drink"*	*point my drinks will be ready"* *" All ingredients of my drink are near the preparation station, so he/she barely moves"*
Female	*" It is annoying especially in peak times to see their excessive movement at the back"* *" I don't like when they turn their back to me to make my drink because I like chatting while he/she makes the drink"* *" When more than four workers are working at the back, it becomes like a beehive"*	*" I get my coffee almost in no time while chatting with the barista"*

Table 6.3 Qualitative Analysis (Layout)

Summary

Both qualitative and quantitative analysis shows that movement behind the counter is an issue at Starbucks. The majority of customers were able to notice the excess movement in order to make their drink and they started questioning the pricing of Starbucks' products. Unnecessary movement and motion are not adding value to the product and it's a huge source of waste, so therefore some customers believe that they are not receiving value for money.

Starbucks should start reconfiguring the layout by using P-Q analysis in order to know which products belongs to the following categories (Runners, Repeaters, or Strangers). While doing this analysis it is vital to keep routings in mind because it is relevant in the process of reengineering the layout. Additionally, Systematic Layout Planning (SLP) can provide and additional advantages to improve shops layout because it connects all different relationships that could be found in the shop in a single triangle matrix. Hence, a better understanding of the current state will raise the probability of having a better future state for each single shop. However, this analysis should be applied separately for each shop and the reason is that each shop is designed differently which makes it wrong to use a universal solution.

6.1.3 ANOVA and Chi-Square

In this section we deployed some tests to examine some hidden statistical significance between different variables. ANOVA is a technique that allows us to look at the individual and joint effect of two independent variables on one dependent variable. We used one-way between-groups ANOVA to compare the preference scores for both genders. We found a significant difference between Males and Females in two dimensions. In the last section a summary of correlations between all dimensions and different variables was given.

Several authors have reported gender differences in taste. According to Cohen & Gitman (1959), men returned a higher incidence of taste errors than women. However, as no previous study has investigated the correlation between gender and hot drinks preferences, we believe that gender differences will impact upon consumer preferences regarding hot drinks and hence beliefs will vary and be significant. Additionally, we believe that differences in gender will affect the consumer attitude towards the barista's name tag.

6.1.3.1 Gender

6.1.3.1.1 Gender and Hot drinks to cool down

6.1.3.1.1.1 Chi Square Test

			Hot drinks to cool down					Total
			Always	Sometimes	Rarely	Never	Do not Know	
Gender	Female	Count	90	101	49	85	16	341
		Expected Count	76.7	95.8	57.7	92.1	18.7	341.0
		% within Gender	26.4%	29.6%	14.4%	24.9%	4.7%	100.0%
		% within Hot drinks to cool down	48.6%	43.7%	35.3%	38.3%	35.6%	41.5%
	Male	Count	95	130	90	137	29	481
		Expected Count	108.3	135.2	81.3	129.9	26.3	481.0
		% within Gender	19.8%	27.0%	18.7%	28.5%	6.0%	100.0%
		% within Hot drinks to cool down	51.4%	56.3%	64.7%	61.7%	64.4%	58.5%
Total		Count	185	231	139	222	45	822
		Expected Count	185.0	231.0	139.0	222.0	45.0	822.0
		% within Gender	22.5%	28.1%	16.9%	27.0%	5.5%	100.0%
		% within Hot drinks to cool down	100%	100%	100%	100 %	100.0%	100.0%

Table 6.4 Gender vs Hot drinks

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.199[a]	4	.046
Likelihood Ratio	8.204	4	.048
Linear-by-Linear Association	6.297	1	.012
N of Valid Cases	822		

0 cells (0.0%) have expected count less than 5. The minimum expected count is 18.67.

Table 6.5 Chi-Square Gender vs Hot Drinks

We can notice from Table 6.5 that the 'Asymp. Sig. (2-sided)' value is less than 0.05 so therefore we know that there is a statistically significant relationship between Gender and Hot drinks preferences. Hence, we will accept the alternate hypothesis and this means that beverages status is dependent on gender.

6.1.3.1.1.2 ANOVA Gender and Hot Drinks

	N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Female	341	2.52	1.250	.068	2.39	2.65	1	5
Male	481	2.74	1.234	.056	2.63	2.85	1	5
Total	822	2.65	1.244	.043	2.56	2.73	1	5

Table 6.6 Gender vs Hot Drinks –Taste-

Descriptive analysis was carried out to confirm the above significance between the two genders. According to Pallant (2010), the following test (Homogeneity of Variances) in Table 6.7 proves that there is a significant difference between the variances of both genders. The test is to make sure that ANOVA offers statistical evidence validating the theory or hypothesis. The results confirmed the significance of the two dimensions as shown in Table 6.8.

Levene Statistic	df1	df2	Sig.
.287	1	820	.592

Table 6.7 Test of Homogeneity of Variances

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.751	1	9.751	6.338	.012
Within Groups	1261.642	820	1.539		
Total	1271.393	821			

Table 6.8 ANOVA Gender vs Hot drinks –Taste-

As seen in Table 6.8, the variance estimate between subjects is 9.75 and within subjects is 1.53 which makes the F value equal to 6.33. Therefore, the population variance between groups is 6 times grater than the population variance within groups that has been accounted for.

There is a significant relationship between gender and preferences towards hot drinks because the Sig. value (0.012) is less than or equal to 0.05 (Table 6.8).

The histogram on the right (Fig 6.10) shows that 137 Male respondents and 85 Female respondents 'Never' waited for their drinks to cool down.

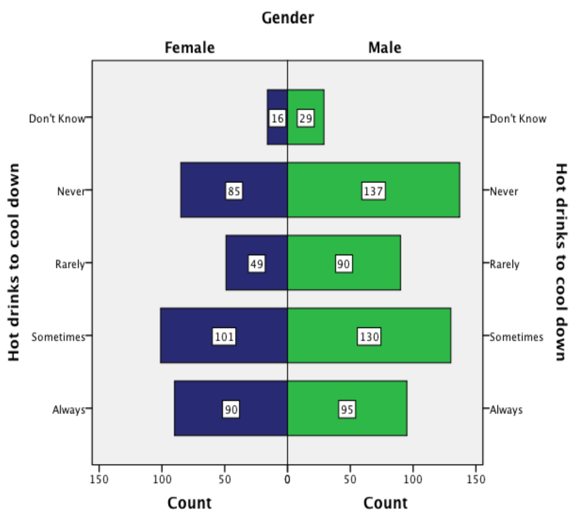

Fig 6.10 Gender v Hot Drinks to cool down

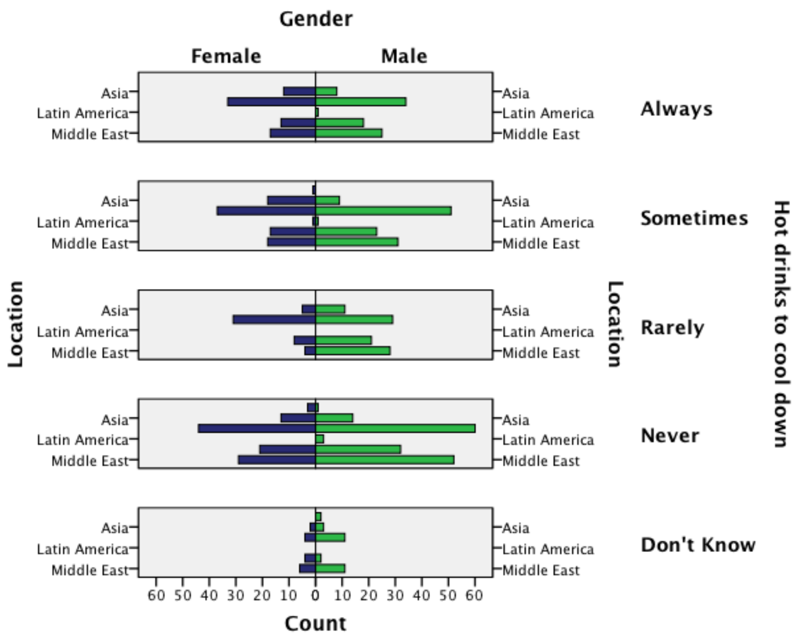

Fig 6.11 Gender v Location (Hot drinks to cool down)

After applying the ANOVA test our conclusion is that there is a significant one-way

ANOVA effect and we reject the No hypothesis.

6.1.3.1.2 Gender and Barista's name badge

6.1.3.1.2.1 Chi Square

			Barista's badge					Total
			Strongly Agree	Agree	Disagree	Strongly Disagree	Do not Know	
Gender	Female	Count	45	112	78	27	79	341
		Expected Count	48.5	117.4	80.1	32.4	62.6	341.0
		% within Gender	13.2%	32.8%	22.9%	7.9%	23.2%	100.0%
		% within Barista's badge	38.5%	39.6%	40.4%	34.6%	52.3%	41.5%
	Male	Count	72	171	115	51	72	481
		Expected Count	68.5	165.6	112.9	45.6	88.4	481.0
		% within Gender	15.0%	35.6%	23.9%	10.6%	15.0%	100.0%
		% within Barista's badge	61.5%	60.4%	59.6%	65.4%	47.7%	58.5%
Total		Count	117	283	193	78	151	822
		Expected Count	117.0	283.0	193.0	78.0	151.0	822.0
		% within Gender	14.2%	34.4%	23.5%	9.5%	18.4%	100.0%
		% within Barista's badge	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 6.9 Gender vs Barista's name badge

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.773[a]	4	.044
Likelihood Ratio	9.685	4	.046
Linear-by-Linear Association	4.630	1	.031
N of Valid Cases	822		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 32.36.

Table 6.10 Chi-Square Tests –Personalisation-

We can see from Table 6.10 that the 'Asymp. Sig. (2-sided)' value is less than 0.05. Therefore we know that there is a statistically significant relationship between Gender and Barista's badge. Hence, we will accept the alternate hypothesis and this means that barista's badge is dependent on gender.

6.1.3.1.2.2 ANOVA Gender & Barista's badge –Personalisation-

	N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Female	341	2.95	1.366	.074	2.80	3.10	1	5
Male	481	2.75	1.265	.058	2.64	2.86	1	5
Total	822	2.83	1.311	.046	2.74	2.92	1	5

Table 6.11 Friendliness

According to Pallant (2010), the following test (Homogeneity of Variances), shown in Table 6.12, proves that there is a significant difference between the variances of both genders. The test was used to make sure that ANOVA provides statistical evidence to validate the theory. The results confirmed the significance of the two dimensions as shown in Table 6.13.

Levene Statistic	df1	df2	Sig.
2.554	1	820	.110

Table 6.12 Test of Homogeneity of Variances (Barista's badge)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.952	1	7.952	4.650	.031
Within Groups	1402.215	820	1.710		
Total	1410.167	821			

Table 6.13 ANOVA –Friendliness-

As seen in Table 6.13, the variance estimate between subjects is 7.95 and within subjects is 1.71 which makes the F value equal to 4.65. Therefore, the population variance between groups is almost 5 times grater than the population variance within groups that has been accounted for.

The table above shows the Sig. value is equal or less than 0.05. Thus there is a statistically significant difference between both genders. This difference is shown in more detail in the chart Fig 6.12 on the right.

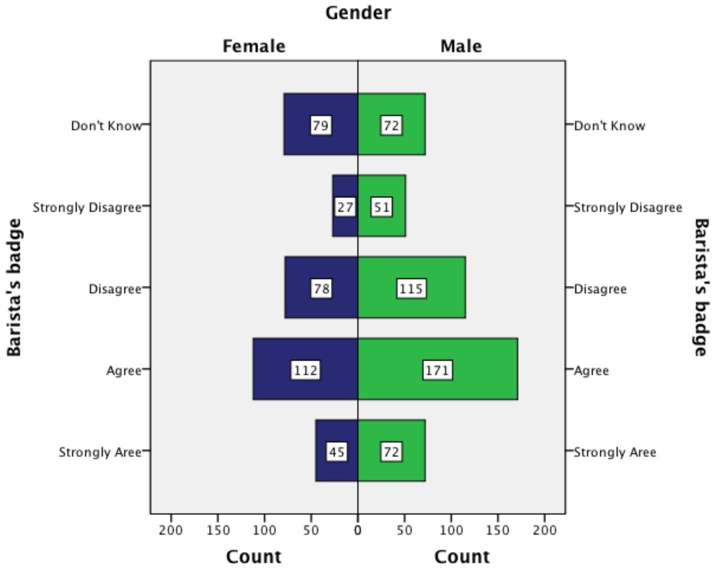

Fig 6.12 Gender v Barista's movement

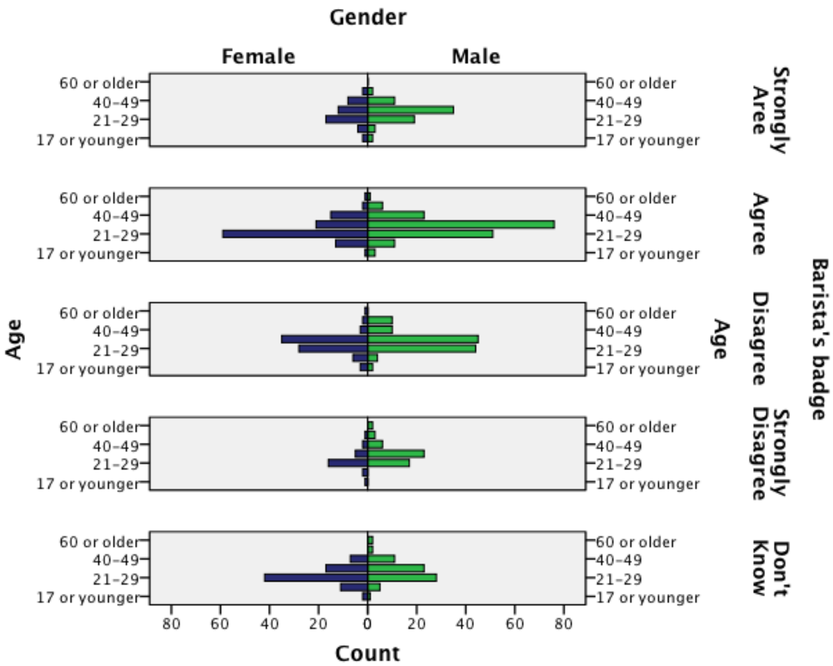

Fig 6.13 Gender v Age (Personalisation)

After applying the ANOVA test our conclusion is that there is a significant one-way ANOVA effect and we reject the No hypothesis.

6.1.3.2 Location

Chi Square (Location and Customisation)

Crosstab

			Custom-made beverage quality					Total
			Always	Sometimes	Rarely	Never	Do not Know	
Location	Middle East	Count	34	90	32	24	41	221
		Expected Count	35.2	93.8	35.0	22.0	35.0	221.0
		% within Location	15.4%	40.7%	14.5%	10.9%	18.6%	100.0%
		% within Custom-made beverage quality	26.0%	25.8%	24.6%	29.3%	31.5%	26.9%
	US & Canada	Count	40	73	19	11	16	159
		Expected Count	25.3	67.5	25.1	15.9	25.1	159.0
		% within Location	25.2%	45.9%	11.9%	6.9%	10.1%	100.0%
		% within Custom-made beverage quality	30.5%	20.9%	14.6%	13.4%	12.3%	19.3%
	Latin America	Count	1	1	1	2	1	6
		Expected Count	1.0	2.5	.9	.6	.9	6.0
		% within Location	16.7%	16.7%	16.7%	33.3%	16.7%	100.0%
		% within Custom-made beverage quality	0.8%	0.3%	0.8%	2.4%	0.8%	0.7%
	Europe	Count	49	143	60	31	51	334
		Expected Count	53.2	141.8	52.8	33.3	52.8	334.0
		% within Location	14.7%	42.8%	18.0%	9.3%	15.3%	100.0%
		% within Custom-made beverage quality	37.4%	41.0%	46.2%	37.8%	39.2%	40.6%
	Asia	Count	7	38	18	13	19	95
		Expected Count	15.1	40.3	15.0	9.5	15.0	95.0
		% within Location	7.4%	40.0%	18.9%	13.7%	20.0%	100.0%
		% within Custom-made beverage quality	5.3%	10.9%	13.8%	15.9%	14.6%	11.6%
	Africa	Count	0	4	0	1	2	7
		Expected Count	1.1	3.0	1.1	.7	1.1	7.0
		% within Location	0.0%	57.1%	0.0%	14.3%	28.6%	100.0%
		% within Custom-made beverage quality	0.0%	1.1%	0.0%	1.2%	1.5%	0.9%
Total		Count	131	349	130	82	130	822
		Expected Count	131.0	349.0	130.0	82.0	130.0	822.0
		% within Location	15.9%	42.5%	15.8%	10.0%	15.8%	100.0%
		% within Custom-made beverage quality	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 6.14 Chi Square (Location and Customisation)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	33.581[a]	20	.029
Likelihood Ratio	34.937	20	.020
Linear-by-Linear Association	2.563	1	.109
N of Valid Cases	822		

a. 10 cells (33.3%) have expected count less than 5. The minimum expected count is .60.

Table 6.15 Chi-Square (Location vs Customisation)

It is clear from Table 6.15 that the 'Asymp. Sig. (2-sided)' value is less than 0.05. We know therefore that there is a statistically significant relationship between Location and Custom-made beverage. Hence, we will accept the alternate hypothesis and this means that custom-made beverage is dependent on location.

6.1.4 Correlations

The following Table 6.16 establishes correlations between different dimensions and variables. All variables are normally distributed and they had a linear relationship and therefore Pearson's r correlation is used. Across the diagonal line values are 1 because if we correlate a variable with itself it will be perfectly positively correlated. Additionally, correlation coefficient is always between +1 and -1 which means positively correlated and negatively correlated respectively therefore they are exactly on a straight line.

It is clear from the Person Correlation Coefficient in the table that most of the correlations are weak. However, when we look at some of the Significant values which are less than 0.05 we can conclude that there is a statistical significant to suggest that the correlation we observed does exist in the population.

		Gender	Age	Hot drinks	Comparing new & old m/c	Custom-made beverage	Barista's badge	Barista's movement
Gender	Pearson Correlation	1	.183**	.061	-.033	.048	-.075*	-.024
	Sig. (2-tailed)		.000	.080	.345	.167	.031	.495
	N	822	822	822	822	822	822	822
Age	Pearson Correlation	.183**	1	-.003	.016	.052	-.051	.026
	Sig. (2-tailed)	.000		.922	.640	.140	.146	.465
	N	822	822	822	822	822	822	822
Hot drinks to cool down	Pearson Correlation	.061	-.003	1	.063	.101**	.077*	.097**
	Sig. (2-tailed)	.080	.922		.072	.004	.027	.005
	N	822	822	822	822	822	822	822
Comparing new with old Espresso m/c	Pearson Correlation	-.033	.016	.063	1	.121**	.126**	.064
	Sig. (2-tailed)	.345	.640	.072		.000	.000	.066
	N	822	822	822	822	822	822	822
Custom-made beverage quality	Pearson Correlation	.048	.052	.101**	.121**	1	.130**	.213**
	Sig. (2-tailed)	.167	.140	.004	.000		.000	.000
	N	822	822	822	822	822	822	822
Barista's badge	Pearson Correlation	-.075*	-.051	.077*	.126**	.130**	1	.193**
	Sig. (2-tailed)	.031	.146	.027	.000	.000		.000

	N	822	822	822	822	822	822	822
Barista's movement between stations	Pearson Correlation	-.024	.026	.097**	.064	.213**	.193**	1
	Sig. (2-tailed)	.495	.465	.005	.066	.000	.000	
	N	822	822	822	822	822	822	822

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Table 6.16 Correlations

6.1.5 Fitness Index

The following Fit Customer Satisfaction (FCS) model was developed to refocus back the whole point and purpose of this research. The company now is measured on different scales which is a reflection of the customers' perspective which makes the customer the cornerstone for current improvements and future ones. This measurement could be used to see if changes within the company are justified or not. The scale is a 10-point scale system where being closer to the positive is what the company must look for if it is to thrive.

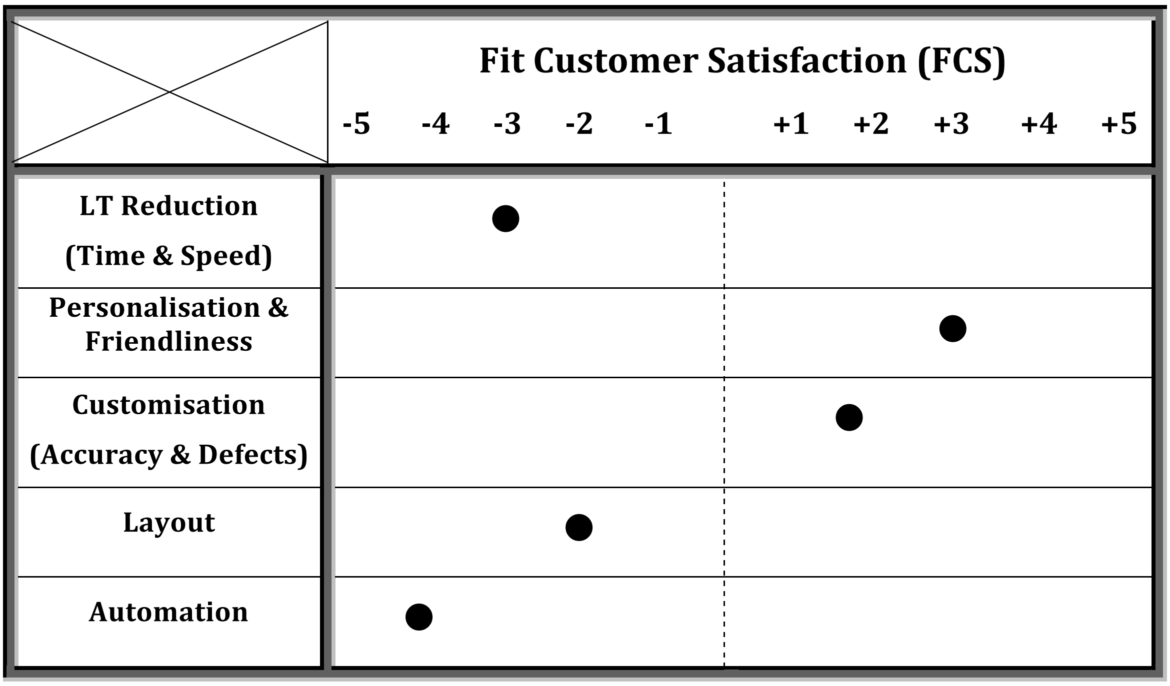

Fig 6.14 FCS

The numerical translation for Fit Customer Satisfaction (FCS) model can be expreced as follows in the Fitness Index in figure 6.15:

Fitness = LT x P x U x L x S x A x R

Where:

LT (Lead-Time Reduction %)= $\frac{\text{Targeted LT}}{\text{Actual LT}}$

P (Performance%) = $\frac{\text{(number of Products / Uptime)}}{\text{Targeted LT}}$

U (Utilization %) = $\frac{\text{Uptime (Total Time}-\text{downtime)}}{\text{Total Time}}$

L (Layout optimization) = $\frac{Total\ Net\ Sales}{Square\ meter\ of\ Selling\ space} / \frac{Total\ pre\ implemintatin\ Net\ Sales}{Old\ Square\ meter\ of\ Selling\ space}$

S (Scrap %) = $\frac{\text{number of rejected Products}}{\text{Total Products}}$

A (Automation %) = $\frac{\text{m/c Time (Total Time – Manual Time)}}{\text{Total Time}}$

R (Resources %) = R_P (planned) x R_A (actual)

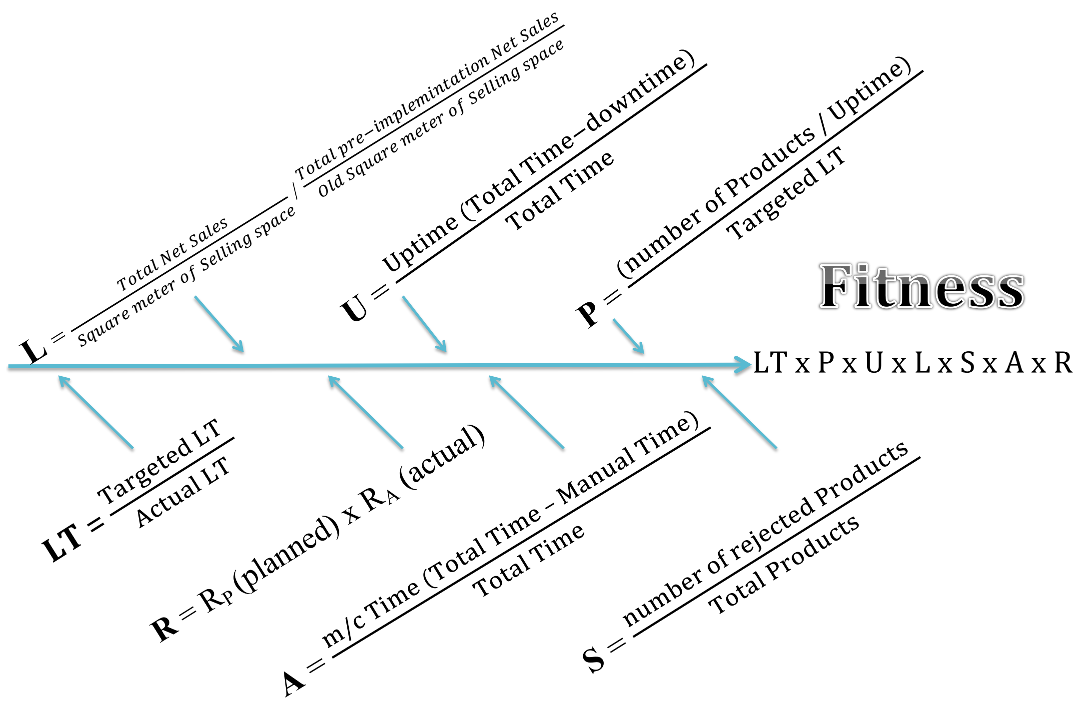

Figure 6.15 Fitness Index

LTPULSAR is a set of acronym for a set of measures in different areas and in a wide variety of contexts to assess how successful the intervention is so far. Fitness Index provides a simple numerical measure of a company's situation that helps it noticing any derailment from the main objective of the intervention. The index starts with Lead Time (LT) which is the time between placing an order and the availability of the drink or food for use.

The Fitness equation takes advantage of this concept by calculating the ration of Targeted LT to Actual LT to recognise if there is any diversion from what the company is aiming to achieve. The second element in the index is Performance percentage (P) which is calculated by dividing number of products served in a single day by uptime of machines in this day, then the result is divided by Targeted lead-time. Thirdly is Utilisation percentage

(U) which can be calculated by subtracting machine Uptime from Total time of operating, then the result is divided by Total time of operating.

The fourth element in the equation is Layout optimization (L) which is the ratio of (Total Net Sales divided by Square meter of selling space) to (pre-implementation Total Net Sales divided by pre-implementation Square meter of selling space). Defective products cost companies money, consume resources, and damage company's image, hence, the percentage of Scrap (S) or defects in the system is incorporated in the index and can be calculated by dividing the amount of rejected products by total amount of products.

Automation can potentially lower costs, reduce variation in quality, and shorten lead-time, therefore, Automation percentage (A) is vital to be measured in the Fitness Index and it can be calculated by dividing Machine time (subtract labor Manual time from Total time) by Total time. Available machine and labor hours limits how much we can improve, therefore it is pivotal to include them in the index by computing percentage of Resources (R) deployed during the intervention by multiplying Actual Resources and Planned Resources.

Fitness Index – what's good or bad?

The outcome of the index is going to be around the value of 1, where values under reflects a bad sign and values above 1 shows the superiority of the system. When the company finds it self in a poor situation, they could refer back to the index to see what is causing most of the damage. Hence, it is an effective diagnostic tool for measuring how healthy is your system at anytime of the intervention to keep managers updated with all the information they need. However, when companies score the same value by the index this don't have mean that they suffer from the same problems, therefore, a through investigation need to take place to understand the real causes.

Summary

To sum, we could say that implementing Lean without measuring how effective the intervention is considered to be a big mistake specially when this toolbox is used to survive and grow. Data analysis appears to support this argument which makes FCS a necessity when applying Lean tools to increase the chances of success. Additionally, the index will notify companies about their current location and situation to help them throughout their continuous improvement journey.

- CHAPTER 7 -
Conclusions and Recommendations

Preliminaries

In the last part of this thesis the author will point out all the major findings and conclusions drawn from the three main contributions that were developed., starting with FDT. Considerations of FFI, and FCS follow.

7.1 Contributions

7.1.1 Fit Product Development

The author established the most effective way of implementing FDT components in different industries and sectors. The shortage of methodologies that link the eleven components of product development was a major motive for researching this topic. The survey in this research established the nature, and the interdependence between, individual components and results showed that:

i. A comprehensive Fit PD framework had been developed by using a matrix that covered the interdependence and correlation between the tools. FPD enhanced utilisation of the eleven components.
ii. A direct comparison can now be undertaken by companies based on empirical data that focused on measuring the usefulness of components, the difficulty of applying them and the time taken to implement them.
iii. Some tools are in clusters, meaning that they are intertwined and have to be implemented in conjunction with each other for better performance.
iv. Upper-level tools (such as Set-based Engineering) are defined and should be implemented in the later stages of the intervention because they require other tools as prerequisites.

v. Lower-level tools (such as Process Standardisation) can be utilised at an early stage of the intervention because they do not have prerequisites.

7.1.2 Fit Flow Index

7.1.2.1 Unfit Modes

i. Certain unfit demand sources such as failure to meet customer requirements, rework/ retesting and ineffective portfolio management are widespread.
ii. Some kinds of unfit demand had a less negative effect on NPD than expected by the author, such as DIP that is caused by the stage gate process.
iii. Managers tend to accept waste in NPD because they produce end products without caring about the means by which they reached that point.

7.1.2.2 Innovation Techniques' Adoption

i. Lean PD is not as widespread as expected despite delivering results. This is due to the inconsistencies in methodologies that focused primarily on waste reduction without dealing with the source.
ii. A systems approach is needed for LPD to be utilised for more efficiency. This is due to the immaturity of the topic.

7.1.2.3 NPD Measurements

i. The current metrics system does not reflect the true innovation of the project, because it measures *what* they innovate rather than *how* they innovate.
ii. The Fit Flow Index was developed to measure flow in NPD during the development cycle, which is a good basis for continuous improvement. Increasing the flow will optimise performance and reduce lead-time.

7.1.3 Fit Customer Satisfaction

7.1.3.1 Lead-Time Reduction

i. Reducing lead-time to increase order/hour by eliminating VA activities can be harmful to businesses.
ii. Reducing lead-time had a negative impact on product's quality which leads to customers feeling that they were not the center of the improvement process.

7.1.3.2 Automation

i. Automation can compromise quality in some cases, this leads to a negative impact on customer satisfaction, which probably will damage the way customers perceive the brand.

7.1.3.3 Customisation v Quality

i. Increasing product varieties and the number of choices more than operational capability might increase the chances of having more defects.

7.1.3.4 Personalisation v Satisfaction

i. Personalising services will increase customer satisfaction if prices are reduced.

7.1.3.5 Sustainability

i. The Fit Customer Satisfaction Index was developed so management can monitor and measure how successful is intervention, in addition to measuring its impact on customers' experience.

7.2 Research Limitations

During this research the author faced a number of challenges and difficulties that can be summarised in the following points:

i. The researcher aimed to gather the opinions of a large number of respondents so that the sample would be more representative of the population but unfortunately we did not have the means to collect this large number of responses. Sampling and design errors might therefore have occurred.

ii. Due to time limitations the author could not get access to all the information needed which could have added more weight and value to this work.

iii. The length of the interview combined with high costs meant that it was difficult to have enough time to discus all issues in depth. This occurred because of budget constraints that meant that there was only limited time for each participant to explore his/her opinions.

7.3 Directions for Further Research

Fit Manufacturing is a fresh research topic with enormous potential for improving current practices. Like every new manufacturing strategy it has to be practised and validated so that it will spread much faster and be applied in different industries. Additionally, moving the research direction towards the service side of the picture will increase the chances of developing a Fit Enterprise framework. This is our ultimate goal. Below are more detailed directions for future research.

7.3.1 FDT

i. This contribution could be extended towards a more micro investigation into the different clusters of the FDT bubble chart and validated by case studies.

ii. Applying the same matrix to different countries and geographical locations will create a more holistic picture of the global dynamics within R&D. In addition, the cultural impact of the use of certain tools might be explored.

iii. Increasing the sample size will expand the list of difficulties experienced by companies nowadays.

7.3.2 FFI

i. Testing the index by using it in more firms across different industries will generate data that will help optimising the index to make it more accurate in reflecting reality. Eventually, the development cycle and the company's innovation will be enhanced by means of this in-depth investigation.

7.3.3 FCS

i. The Fit Customer Satisfaction Index could be adopted in different industries and sectors to evaluate the intervention process at different stages of the process.

ii. The Index can be modified and optimised to make it more accurate in reflecting the future needs of the customer.

iii. Different geographical locations and a different sample would give a more clear and complete picture of customers' needs and how Fit is responding to them.

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Appendix 1

Fit Development Toolbox Survey

To what extent does components in row require component in column?	Strong Project Manager	Specialist Career Path	Workload Levelling	Responsibility-based Planning and Control	Cross-project Knowledge Transfer	Simultaneous Engineering	Supplier Integration	Product Variety Management	Rapid Prototyping, Simulation and Testing	Process Standards	Set-based Engineering
Strong Project Manager	X										
Specialist Career Path		X									
Workload Levelling			X								
Responsibility-based Planning and Control				X							
Cross-project Knowledge Transfer					X						
Simultaneous Engineering						X					
Supplier Integration							X				
Product Variety Management								X			
Rapid Prototyping, Simulation and Testing									X		
Process Standards										X	
Set-based Engineering											X

Appendix 2

Fit Flow Index Survey

Section 1

What company do you work for?

- DCF (Diabetes Care Franchise)
- Franchise within LS
- Non LS

What function do you perform?

- Development Organization
- Operations Development
- Commercial
- Supply Chain

Please describe your job level?

- Director and above
- Manager
- Professional/ individual contributor

Section 2

Please Rate the following Statements	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**	**N/A**
Q1. The company works closely with customers/users to identify customer needs.					
Q2. We as organization constantly meet our customer requirements					
Q3. There is a strong business case development process in place with robust outputs.					
Q4. We are effective at portfolio management					
Q5. There is little unnecessary waste created in the requirements management process.					
Q6. As an organization we don't over-engineer our products- we only deliver features that the customer is willing to pay for.					
Q7. The current stage gate NPD process is effective at creating flow through new product pipeline.					
Q8. There is a high level of governance and rigour applied at the stage gate reviews, Go/No Go decision are made based on data.					

Q9. There are no inconsistences between our business process and the stage gate system.					
Q10. We an effective program management system.					
Q11. Our product characterization and design verification process minimizes any upstream failures at PQ and post launch.					
Q12. Rework, retesting ,revalidation does not create significant level of non value add activity in this company.					
Q13. We control and monitor work queues/ batches sizes in the NPD process.					
Q14. There is an effective resource loading and tracking system in place					
Q15. This organization does not adopt the status quo supply chain model for each new product.					
Q16. A scouring strategy is developed through the NPD process to protect our customers by not going into back order at launch.					
Q17. We consistently meet our cost of goods sold target sets out in the initial business case.					
Q18. The right level of manufacturing capacity is installed at external manufacturing partners sites based on forecasts in the business case.					
Q19. There is a strong reflections of the impact of external factors such as the reg. environment built in to our product development timelines.					
Q20. We are proactive at integrating our suppliers into our process of developing technical					
Q21. There are well defined cost post launch metrics & post reviews for continuous learning.					
Q22. In the organization there is a strong ethos of learning, knowledge conversion, and recycling lessons learned back into programs.					
Q23. A measurement system is in place to determine on how effective a new product lunch is in term of its execution.					
Q24. The creation of flow through identification of value and elimination of waste is integrated into our current NPD system.					

Section 3.

For the following modes of Unfit demand in NPD, please rate them from 1 to 5 in term of the impact that they have on generation of waste.

	1 Least Impact	2	3	4	5 Most Impact	N/A
Poorly defined customer requirements						
Failure to meet requirements once defined						
Portfolio Management						
Over engineered products						
Resource management/ capacity utilization						
Retesting/ rework/ revalidation						
Current stage gate NPD process						
Ineffective program management						
DIP – Development in progress/ queues/ large batch sizes.						
Supply chain design						

Appendix 3

Fit Customer Satisfaction Survey

1. What is your gender?

- Female
- Male

2. In which part of the world do you live?

- Middle East
- US & Canada
- Latin America
- Europe
- Asia
- Africa

3. Which category below includes your age?

- 17 or younger
- 18-20
- 21-29
- 30-39
- 40-49
- 50-59
- 60 or older

4. At Starbucks, do you wait for your hot drink to cool down before drinking it?

- Always
- Sometimes
- Rarely
- Never
- Don't Know

5. At Starbucks,, how does the taste of an espresso made with the new La Marzocca automatic machine compared with that of the old manual machine?

- Better
- No Difference
- Worse
- Don't Know

6. At Starbucks, when you order a custom-made beverage, how often do you get what you expect?

- Always
- Sometimes
- Rarely
- Never
- Don't Know

7. At Starbucks, I feel the barista's badge makes the experience more personal.

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree
- Don't Know

8. At Starbucks, I feel the barista moves too much between stations whilst preparing my drink

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree
- Don't Know

9. If you have any comments, please write them below and thank you for taking the time to fill out this survey. It is much appreciated and the results will be shared once they are collated.
Jameel Kutbi
@DrEngJimmy

Appendix 4

Crosstabs

Gender * Comparing new with old Espresso m/c

Crosstab

			Comparing new with old Espresso m/c				Total
			Better	No Difference	Worse	Don't Know	
Gender	Female	Count	37	93	111	100	341
		Expected Count	39.4	94.6	113.7	93.3	341.0
		% within Gender	10.9%	27.3%	32.6%	29.3%	100.0%
		% within Comparing new with old Espresso m/c	38.9%	40.8%	40.5%	44.4%	41.5%
	Male	Count	58	135	163	125	481
		Expected Count	55.6	133.4	160.3	131.7	481.0
		% within Gender	12.1%	28.1%	33.9%	26.0%	100.0%
		% within Comparing new with old Espresso m/c	61.1%	59.2%	59.5%	55.6%	58.5%
Total		Count	95	228	274	225	822
		Expected Count	95.0	228.0	274.0	225.0	822.0
		% within Gender	11.6%	27.7%	33.3%	27.4%	100.0%
		% within Comparing new with old Espresso m/c	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.216[a]	3	.749
Likelihood Ratio	1.213	3	.750
Linear-by-Linear Association	.892	1	.345
N of Valid Cases	822		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 39.41.

Gender * Custom-made beverage quality

Crosstab

			Custom-made bevarage quality					Total
			Always	Sometimes	Rarely	Never	Don't Know	
Gender	Female	Count	66	139	55	28	53	341
		Expected Count	54.3	144.8	53.9	34.0	53.9	341.0
		% within Gender	19.4%	40.8%	16.1%	8.2%	15.5%	100.0%
		% within Custom-made bevarage quality	50.4%	39.8%	42.3%	34.1%	40.8%	41.5%
	Male	Count	65	210	75	54	77	481
		Expected Count	76.7	204.2	76.1	48.0	76.1	481.0
		% within Gender	13.5%	43.7%	15.6%	11.2%	16.0%	100.0%
		% within Custom-made bevarage quality	49.6%	60.2%	57.7%	65.9%	59.2%	58.5%
Total		Count	131	349	130	82	130	822

	Expected Count	131.0	349.0	130.0	82.0	130.0	822.0
	% within Gender	15.9%	42.5%	15.8%	10.0%	15.8%	100.0%
	% within Custom-made bevarage quality	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.549[a]	4	.162
Likelihood Ratio	6.526	4	.163
Linear-by-Linear Association	1.915	1	.166
N of Valid Cases	822		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 34.02.

Gender * Barista's movement between stations

Crosstab

			Barista's movement between stations					Total
			Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
Gender	Female	Count	83	164	58	9	27	341
		Expected Count	81.3	172.2	52.3	12.9	22.4	341.0
		% within Gender	24.3%	48.1%	17.0%	2.6%	7.9%	100.0%
		% within Barista's movement between stations	42.3%	39.5%	46.0%	29.0%	50.0%	41.5%
	Male	Count	113	251	68	22	27	481
		Expected Count	114.7	242.8	73.7	18.1	31.6	481.0

	% within Gender	23.5%	52.2%	14.1%	4.6%	5.6%	100.0%
	% within Barista's movement between stations	57.7%	60.5%	54.0%	71.0%	50.0%	58.5%
Total	Count	196	415	126	31	54	822
	Expected Count	196.0	415.0	126.0	31.0	54.0	822.0
	% within Gender	23.8%	50.5%	15.3%	3.8%	6.6%	100.0%
	% within Barista's movement between stations	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.388[a]	4	.250
Likelihood Ratio	5.442	4	.245
Linear-by-Linear Association	.466	1	.495
N of Valid Cases	822		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 12.86.

Location * Hot drinks to cool down

Crosstab

			Hot drinks to cool down					Total
			Always	Sometimes	Rarely	Never	Don't Know	
Location	Middle East	Count	48	53	33	70	17	221
		Expected Count	49.7	62.1	37.4	59.7	12.1	221.0

	% within Location	21.7%	24.0%	14.9%	31.7%	7.7%	100.0%
	% within Hot drinks to cool down	25.9%	22.9%	23.7%	31.5%	37.8%	26.9%
US & Canada	Count	32	45	29	47	6	159
	Expected Count	35.8	44.7	26.9	42.9	8.7	159.0
	% within Location	20.1%	28.3%	18.2%	29.6%	3.8%	100.0%
	% within Hot drinks to cool down	17.3%	19.5%	20.9%	21.2%	13.3%	19.3%
Latin America	Count	1	2	0	3	0	6
	Expected Count	1.4	1.7	1.0	1.6	.3	6.0
	% within Location	16.7%	33.3%	0.0%	50.0%	0.0%	100.0%
	% within Hot drinks to cool down	0.5%	0.9%	0.0%	1.4%	0.0%	0.7%
Europe	Count	81	98	61	79	15	334
	Expected Count	75.2	93.9	56.5	90.2	18.3	334.0
	% within Location	24.3%	29.3%	18.3%	23.7%	4.5%	100.0%
	% within Hot drinks to cool down	43.8%	42.4%	43.9%	35.6%	33.3%	40.6%
Asia	Count	22	32	16	20	5	95
	Expected Count	21.4	26.7	16.1	25.7	5.2	95.0
	% within Location	23.2%	33.7%	16.8%	21.1%	5.3%	100.0%
	% within Hot drinks to cool down	11.9%	13.9%	11.5%	9.0%	11.1%	11.6%

		Count	1	1	0	3	2	7
		Expected Count	1.6	2.0	1.2	1.9	.4	7.0
	Africa	% within Location	14.3%	14.3%	0.0%	42.9%	28.6%	100.0%
		% within Hot drinks to cool down	0.5%	0.4%	0.0%	1.4%	4.4%	0.9%
Total		Count	185	231	139	222	45	822
		Expected Count	185.0	231.0	139.0	222.0	45.0	822.0
		% within Location	22.5%	28.1%	16.9%	27.0%	5.5%	100.0%
		% within Hot drinks to cool down	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.781[a]	20	.210
Likelihood Ratio	23.661	20	.258
Linear-by-Linear Association	4.356	1	.037
N of Valid Cases	822		

a. 10 cells (33.3%) have expected count less than 5. The minimum expected count is .33.

Location * Comparing new with old Espresso m/

Crosstab

			Compairing new with old Espresso m/c				Total
			Better	No Difference	Worse	Don't Know	
Location	Middle East	Count	22	62	75	62	221

	Expected Count	25.5	61.3	73.7	60.5	221.0
	% within Location	10.0%	28.1%	33.9%	28.1%	100.0%
	% within Compairing new with old Espresso m/c	23.2%	27.2%	27.4%	27.6%	26.9%
US & Canada	Count	21	47	44	47	159
	Expected Count	18.4	44.1	53.0	43.5	159.0
	% within Location	13.2%	29.6%	27.7%	29.6%	100.0%
	% within Compairing new with old Espresso m/c	22.1%	20.6%	16.1%	20.9%	19.3%
Latin America	Count	0	1	3	2	6
	Expected Count	.7	1.7	2.0	1.6	6.0
	% within Location	0.0%	16.7%	50.0%	33.3%	100.0%
	% within Compairing new with old Espresso m/c	0.0%	0.4%	1.1%	0.9%	0.7%
Europe	Count	40	90	115	89	334
	Expected Count	38.6	92.6	111.3	91.4	334.0
	% within Location	12.0%	26.9%	34.4%	26.6%	100.0%
	% within Compairing new with old Espresso m/c	42.1%	39.5%	42.0%	39.6%	40.6%
Asia	Count	11	26	36	22	95
	Expected Count	11.0	26.4	31.7	26.0	95.0
	% within Location	11.6%	27.4%	37.9%	23.2%	100.0%

		% within Compairing new with old Espresso m/c	11.6%	11.4%	13.1%	9.8%	11.6%
		Count	1	2	1	3	7
		Expected Count	.8	1.9	2.3	1.9	7.0
	Africa	% within Location	14.3%	28.6%	14.3%	42.9%	100.0%
		% within Compairing new with old Espresso m/c	1.1%	0.9%	0.4%	1.3%	0.9%
Total		Count	95	228	274	225	822
		Expected Count	95.0	228.0	274.0	225.0	822.0
		% within Location	11.6%	27.7%	33.3%	27.4%	100.0%
		% within Compairing new with old Espresso m/c	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.416[a]	15	.945
Likelihood Ratio	8.297	15	.911
Linear-by-Linear Association	.210	1	.646
N of Valid Cases	822		

a. 8 cells (33.3%) have expected count less than 5. The minimum expected count is .69.

Location * Barista's badge

Crosstab

			Barista's badge					Total
			Strongly Aree	Agree	Disagree	Strongly Disagree	Don't Know	
Location	Middle East	Count	38	83	44	18	38	221
		Expected Count	31.5	76.1	51.9	21.0	40.6	221.0
		% within Location	17.2%	37.6%	19.9%	8.1%	17.2%	100.0%
		% within Barista's badge	32.5%	29.3%	22.8%	23.1%	25.2%	26.9%
	US & Canada	Count	26	62	34	12	25	159
		Expected Count	22.6	54.7	37.3	15.1	29.2	159.0
		% within Location	16.4%	39.0%	21.4%	7.5%	15.7%	100.0%
		% within Barista's badge	22.2%	21.9%	17.6%	15.4%	16.6%	19.3%
	Latin America	Count	1	2	1	0	2	6
		Expected Count	.9	2.1	1.4	.6	1.1	6.0
		% within Location	16.7%	33.3%	16.7%	0.0%	33.3%	100.0%
		% within Barista's badge	0.9%	0.7%	0.5%	0.0%	1.3%	0.7%
	Europe	Count	40	103	86	41	64	334
		Expected Count	47.5	115.0	78.4	31.7	61.4	334.0
		% within Location	12.0%	30.8%	25.7%	12.3%	19.2%	100.0%
		% within Barista's badge	34.2%	36.4%	44.6%	52.6%	42.4%	40.6%
	Asia	Count	11	31	26	6	21	95
		Expected Count	13.5	32.7	22.3	9.0	17.5	95.0
		% within Location	11.6%	32.6%	27.4%	6.3%	22.1%	100.0%

		% within Barista's badge	9.4%	11.0%	13.5%	7.7%	13.9%	11.6%
	Africa	Count	1	2	2	1	1	7
		Expected Count	1.0	2.4	1.6	.7	1.3	7.0
		% within Location	14.3%	28.6%	28.6%	14.3%	14.3%	100.0%
		% within Barista's badge	0.9%	0.7%	1.0%	1.3%	0.7%	0.9%
Total		Count	117	283	193	78	151	822
		Expected Count	117.0	283.0	193.0	78.0	151.0	822.0
		% within Location	14.2%	34.4%	23.5%	9.5%	18.4%	100.0%
		% within Barista's badge	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.529[a]	20	.618
Likelihood Ratio	17.912	20	.593
Linear-by-Linear Association	6.802	1	.009
N of Valid Cases	822		

a. 10 cells (33.3%) have expected count less than 5. The minimum expected count is .57.

Location * Barista's movement between station

Crosstab

			Barista's movement between stations					Total
			Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
Location	Middle East	Count	48	121	30	7	15	221

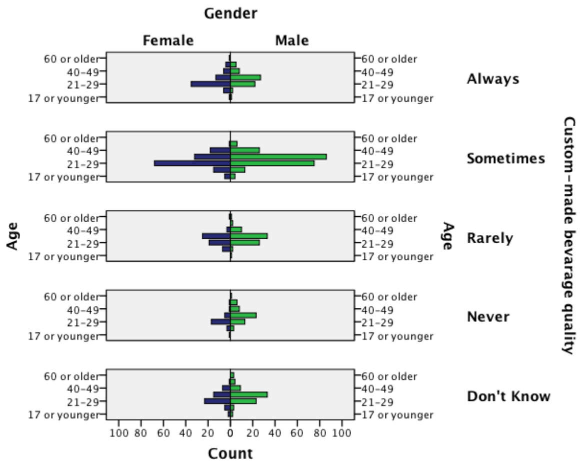
	Expected Count	52.7	111.6	33.9	8.3	14.5	221.0
	% within Location	21.7%	54.8%	13.6%	3.2%	6.8%	100.0%
	% within Barista's movement between stations	24.5%	29.2%	23.8%	22.6%	27.8%	26.9%
US & Canada	Count	41	76	24	5	13	159
	Expected Count	37.9	80.3	24.4	6.0	10.4	159.0
	% within Location	25.8%	47.8%	15.1%	3.1%	8.2%	100.0%
	% within Barista's movement between stations	20.9%	18.3%	19.0%	16.1%	24.1%	19.3%
Latin America	Count	1	3	0	1	1	6
	Expected Count	1.4	3.0	.9	.2	.4	6.0
	% within Location	16.7%	50.0%	0.0%	16.7%	16.7%	100.0%
	% within Barista's movement between stations	0.5%	0.7%	0.0%	3.2%	1.9%	0.7%
Europe	Count	84	164	56	13	17	334
	Expected Count	79.6	168.6	51.2	12.6	21.9	334.0
	% within Location	25.1%	49.1%	16.8%	3.9%	5.1%	100.0%
	% within Barista's movement between stations	42.9%	39.5%	44.4%	41.9%	31.5%	40.6%
Asia	Count	21	50	14	3	7	95
	Expected Count	22.7	48.0	14.6	3.6	6.2	95.0
	% within Location	22.1%	52.6%	14.7%	3.2%	7.4%	100.0%

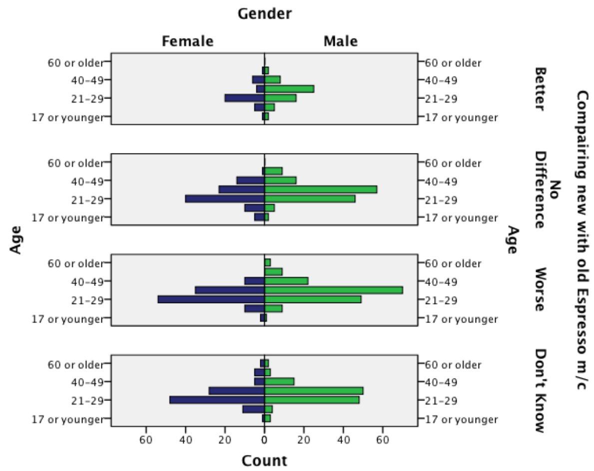
	% within Barista's movement between stations	10.7%	12.0%	11.1%	9.7%	13.0%	11.6%
Africa	Count	1	1	2	2	1	7
	Expected Count	1.7	3.5	1.1	.3	.5	7.0
	% within Location	14.3%	14.3%	28.6%	28.6%	14.3%	100.0%
	% within Barista's movement between stations	0.5%	0.2%	1.6%	6.5%	1.9%	0.9%
Total	Count	196	415	126	31	54	822
	Expected Count	196.0	415.0	126.0	31.0	54.0	822.0
	% within Location	23.8%	50.5%	15.3%	3.8%	6.6%	100.0%
	% within Barista's movement between stations	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

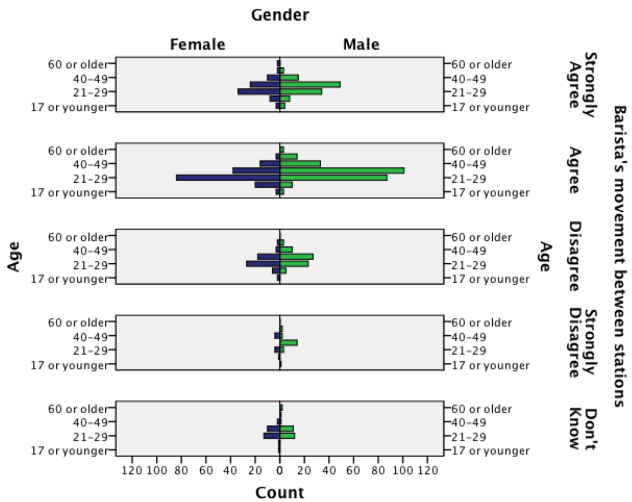
Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	25.084[a]	20	.198
Likelihood Ratio	18.241	20	.572
Linear-by-Linear Association	.045	1	.832
N of Valid Cases	822		

a. 11 cells (36.7%) have expected count less than 5. The minimum expected count is .23.


Gender
Female
Male
Always
Sometimes
Rarely
Never
Don't Know
Custom-made bevarage quality
Age
60 or older
40-49
21-29
17 or younger
100 80 60 40 20 0 20 40 60 80 100
Count


Gender
Female
Male
Better
No Difference
Worse
Don't Know
Compairing new with old Espresso m/c
Age
60 or older
40-49
21-29
17 or younger
60 40 20 0 20 40 60
Count


Gender
Female
Male
Strongly Agree
Agree
Disagree
Strongly Disagree
Don't Know
Barista's movement between stations
Age
60 or older
40-49
21-29
17 or younger
120 100 80 60 40 20 0 20 40 60 80 100 120
Count

Correlations

		Gender	Age	Hot drinks to cool down	Compairing new with old Espresso m/c	Custom-made bevarage quality	Barista's badge	Barista's movement between stations
Gender	Pearson Correlation	1	.183**	.061	-.033	.048	-.075*	-.024
	Sig. (2-tailed)		.000	.080	.345	.167	.031	.495
	N	822	822	822	822	822	822	822
Age	Pearson Correlation	.183**	1	-.003	.016	.052	-.051	.026
	Sig. (2-tailed)	.000		.922	.640	.140	.146	.465
	N	822	822	822	822	822	822	822
Hot drinks to cool down	Pearson Correlation	.061	-.003	1	.063	.101**	.077*	.097**
	Sig. (2-tailed)	.080	.922		.072	.004	.027	.005
	N	822	822	822	822	822	822	822
Compairing new with old Espresso m/c	Pearson Correlation	-.033	.016	.063	1	.121**	.126**	.064
	Sig. (2-tailed)	.345	.640	.072		.000	.000	.066
	N	822	822	822	822	822	822	822
Custom-made bevarage quality	Pearson Correlation	.048	.052	.101**	.121**	1	.130**	.213**
	Sig. (2-tailed)	.167	.140	.004	.000		.000	.000
	N	822	822	822	822	822	822	822
Barista's badge	Pearson Correlation	-.075*	-.051	.077*	.126**	.130**	1	.193**
	Sig. (2-tailed)	.031	.146	.027	.000	.000		.000
	N	822	822	822	822	822	822	822
Barista's movement	Pearson Correlation	-.024	.026	.097**	.064	.213**	.193**	1
	Sig. (2-tailed)	.495	.465	.005	.066	.000	.000	

between stations	N	822	822	822	822	822	822	822

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).