MANUFACTURING SYSTEM OPTIMIZATION:

A STUDY OF UNITY AND EFFICIENCY IN PRODUCTION (UEP)

IN PEUGEOT AUTOMOBILE NIGERIA (PAN)

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NIGERIA

JANUARY, 2015

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NIGERIA

JANUARY, 2015

DECLARATION

I hereby declare that the work in the thesis titled **"MANUFACTURING SYSTEM OPTIMIZATION:A STUDY OF UNITY AND EFFICIENCY IN PRODUCTION (UEP) IN PEUGEOT AUTOMOBILE NIGERIA (PAN)"**was performed by me in the Department of Mechanical Engineering under the supervision of Dr. M. Dauda and Prof. S.Y. Aku. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this workhas been presented for another degree or diploma at any institution.

Rilwan Olaitan Bamigbaye _____ _____

Signature Date

CERTIFICATION

This thesis titled **MANUFACTURING SYSTEM OPTIMIZATION: A STUDY OF UNITY AND EFFICIENCY IN PRODUCTION (UEP) IN PEUGEOT AUTOMOBILE NIGERIA (PAN)** meets the regulations governing the award of the degree of Master of Science of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Dr. M. Dauda	_____	_____
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All glory belongs to **God.**

ABSTRACT

Theaim of this study is to investigate why the implementation of Unity and Efficiency in Production(UEP)is not yielding the expected results in PAN. The overall operations, production and sales are still on the low trend.This survey examined how the adaptation of UEP tools and the level of functions integration relate to the overall implementation success.A well-structured questionnaire distributed andcollected from fourty respondents (at supervisory level) were analyzed to determine the level of understanding of the philosophy, the usage of UEP tools and the scope of the UEP implementation in relation to the success of the implementation.The chi-square test statistics was used to test the research hypotheses generated at 0.05 level of significance. This is to find out if there exists relation between the adaptation of this method and the overall success of the UEP implementation.

The result of the hypotheses tested revealed that all critical aspects were more or less considered (i.e. 4 out of 15 were not taken into account by at least 50% of the respondents). The lowest score (critical value) of 40% is an indication that all aspects considered are relevant/important for this research work. This is also an indication that the findings flow in line with established theories and literatures. The hypotheses also show that majority of the tools have remarkable relationship with UEP implementation success. The overall responses from questionnaireanalyzedclearly show that the UEP concept was not fully integrated into all company operations/functions. This made the overall expectations of using the principles notentirely fulfilled.

The general inferencefrom this survey is that activities in PAN could be enhanced for high level of productivity and efficiency if all findings and recommendationsmade are critically considered by management in the entire value chain.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE PROJECT

Customers have numerous choices when it comes to buying any product. Combined with choices available to the consumer and expectation of shorter order fulfillment lead times, customers have become more fickle in their purchasing decisions and less loyal to their old long-standing business relationships.

In recent years, companies have become increasingly focused on market demand and customers responsiveness. This has led to the implementation and adoption of manufacturing improvement and optimization techniques in the automotive industry. Optimization is necessary for the control of any business process to achieve better product quality, high productivity with low cost.

Optimization is defined as minimization or maximization of cost function with variable input parameters. The word optimization commonly refers to the mathematical handling of parameters in order to maximize or minimize a mathematical function. The global optimization is about finding the best possible solutions for given problems. This makes optimization of various systems an increasingly important activity. Apart from this, manufacturing systems are also optimized using any of the process improvement methods. Improvement methods such as lean, just in time, six sigma and the likes, have contributed immensely to system success and profitability.

In order to optimize the manufacturing process, a company has to have the ability to identify its main bottlenecks in manufacturing process. It needs to be able to set the proper goals, i.e. grouping company's activities into modules and set the control points.

Optimization criteria include: cost of production, quality of final products, lead time, production risk and the likes.

Recently, manufactures are critically evaluating their processes to determine their effectiveness in bringing maximum value to customers with reduced cost. Production management techniques yesterday are being replaced by the most efficient methods that greatly reduce the late delivery of products to customer, reduce production and operating costs which enhances the process quality (Krishnan *et al.,2011).* The following are the inventions for reducing the work in process inventory:

i. In 1890 Sakichi Toyoda invented the philosophy of kaizen.

ii. In 1908 Henry Ford created the moving assembly line.

iii. In 1937 Kiichiro Toyoda built a plant and hanged a sign at the shop floor that read JIT (Just In Time). This was to improve the imbalance he found in his production line.

iv. In 1940 and the early 1950s Taichii Ohno the assembly manager for Toyota developed many improvements that eventually became the Toyota Production System (TPS).

v. In 1995 James Vonock and Jones published "lean thinking". Lean manufacturing started becoming popular in factories around the world.

Competitive pressures forced manufacturers to continuously improve the provision of products and associated services desired by customers. Manufacturers have adopted lean practices such as just-in-time (JIT) and Total Quality Management (TQM) to reduce costs and improve quality.Intense global competition, uncertainties in energy cost and supply, and exponential growth in information technology are shifting industries toward agile, just-in-time processing, high-performance manufacturing, and accelerated introduction of new products. Business performance is increasingly linked to sustainability and environmental, health and safety (EHS) issues. Companies can use smart manufacturing (SM) to help meet objectives associated with these issues and

improve overall economy, safety, and competitiveness. In short, many manufacturing firms are becoming relatively more agile (agile manufacturing).Agile manufacturing differs from lean manufacturing in the sense that lean manufacturing is oriented toward a repetitive manufacturing environment with order characteristics of high-volume/low-mix, and agile manufacturing applies to low-volume/high-mix. Agile manufacturing is seen as the next step after lean in the evolution of production methodology.

The principles of the Unity and Efficiency in Production (UEP) adopted by Peugeot Automobile Nigeria PAN are closely related to the lean process. Despite the huge plant installations and great human capacity, the production and sales trend of Peugeot products has declined considerably after the full implementation of UEP in PAN. It is of great interest, investigating this negative trend and proposing best possible solutions.

1.1.1 Peugeot Automobile Nigeria (PAN)

PAN was incorporated on December 15, 1972 as a limited liability company with an authorized share capital of three million naira (PAN, 1975). The total surface area is 330,000 square meter (82.5 acres). Twenty-seven months after incorporation, the then head of State, General Yakubu Gowon, commissioned the assembly plant on March 14, 1975, though full operations commenced on March 2, 1975. The company layout is as shown in figure 1.2. Production process start with completely knocked down CKD elements in body shop through to paint shop, assembly shop and then to the commercial unit as indicated in the layout.

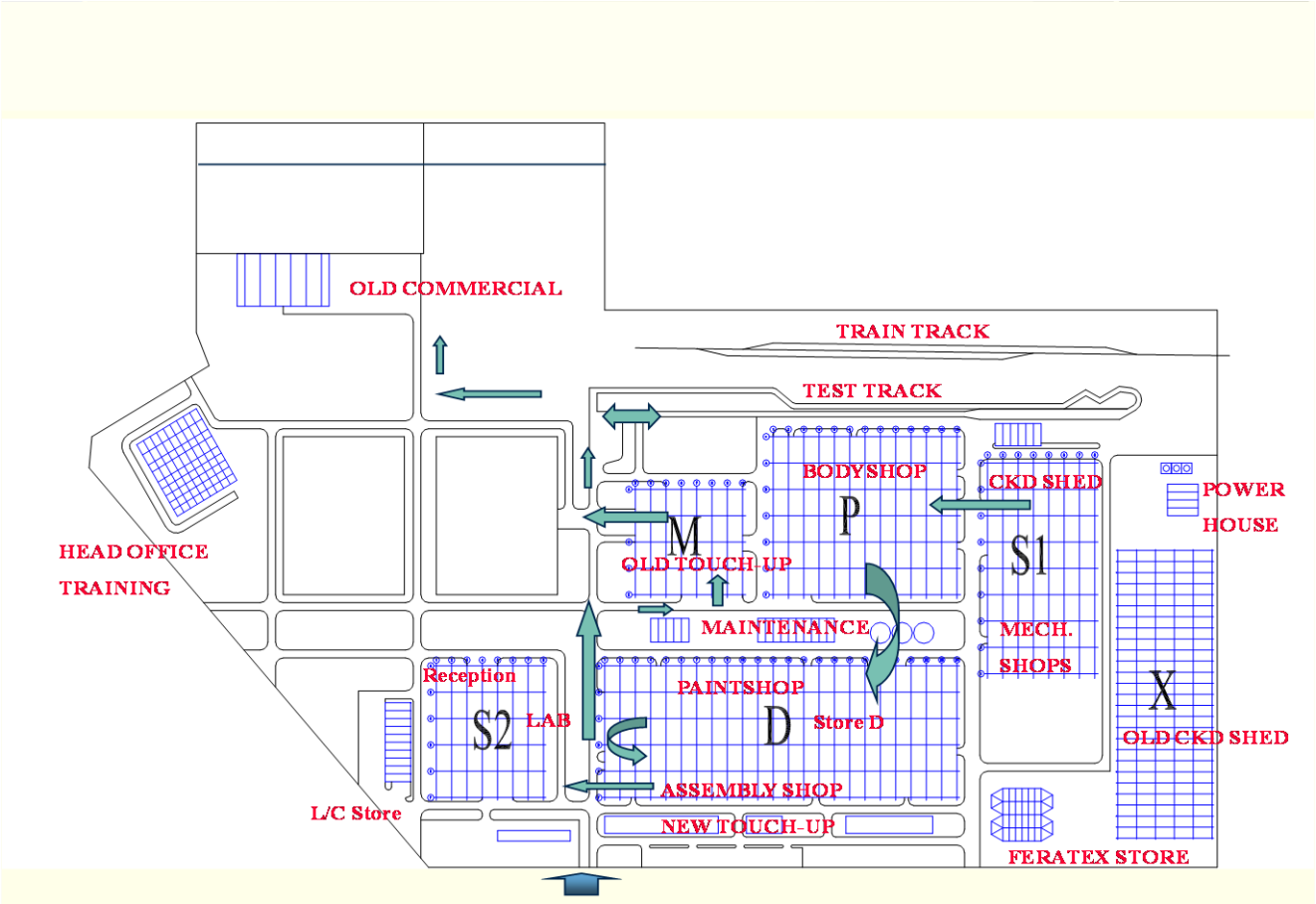


Figure 1.1 Peugeot Automobile Nigeria Layout (PAN, 1975)

The objectives here are to produce and sell passenger cars, provide a platform for the development of middle and lower industries and provide employment, training and development.Between 1975 and 1985 PAN engaged in the production of Peugeot 404 (SAL), 504 **(**GR, GRAC, GL, SR, SW) 505 (GR, SR, ST, EVO). Production of the 504 progressed till 1995 when the 306 (SAL,XN/XR/T) was introduced. Production of Peugeot 406 started in 1999 with SR, then ST, DYNAMIC, COMFORT and PRESTIGE. In 2009 the Peugeot 406 line was replaced by the Peugeot 307 sedan/saloon, called the T6 project.

From record, the annual production/sales volume has drastically reduced from 37,000 in the 1980s to less than 5,000 in 2012. This trend needs to be turned around with the effective use of instituted management tools and resources. Considering global

reorganization of the automobile industry and the direction of the global strategy that took place in the 1990s and the fast growing information and communication industries, automobile production has concurred with similar change. Peugeot Automobile Nigeria Limited is also faced with the challenge of flowing with the tide.

1.1.2 Concept of Unity and Efficiency in Production (UEP)

Unity and Efficiency in Production (UEP) is a dynamic and continuous improvement system that ensures effective, timely, sustainable production and work organization.

UEP is the work management philosophy used in Automobile Peugeot (AP) France for system optimization. Peugeot Automobile Nigeria PAN started its implementation in the year 2003. The aim is to standardize company operational methods in line with the Peugeot- Citroën group worldwide so that vehicles produced in Nigeria will attain the same quality level as those produced in France and other European countries.

Peugeot-Citroën(the second largest car maker in Europe) sold 2.8 million vehicles worldwide in 2013, of which 42% outside Europe. The group also made sales and revenue record of €54 billion in 2013 (PSA, 2014). The success story hinges on the application of UEP concept of work organization. UEP is uniquely a Peugeot work organization system. Hence, some factories within the Peugeot Société Automobile (PSA) group are able to produce 2,000 vehicles a day. Today, UEP is the only recognized management improvement tool available within the PSA group. PAN without exception has to embrace the new concept of management work organization if it must continue to survive and play the leading role in the auto market throughout Africa and Nigeria in particular.

Management's obligation is to use efficiently, the available resources at its disposal to achieve efficient result. Before the year 2003, the production process in PAN did not

have a specified tool to motivate staff towards achieving defect free cars on the production line.The need for change in functional organization became paramount in the prevailing circumstances. The industrial management structure that has a long chain of command, viz: Management – Superintendent – Supervisor – Foreman, Team head, and Workers was re-structured to meet UEP requirements that allowed PAN to conform to the standard of the other Peugeot Société Automobile PSA group. The UEP team shown in figure 1.3 now forms the new structure. The chain of command is now reduced drastically.

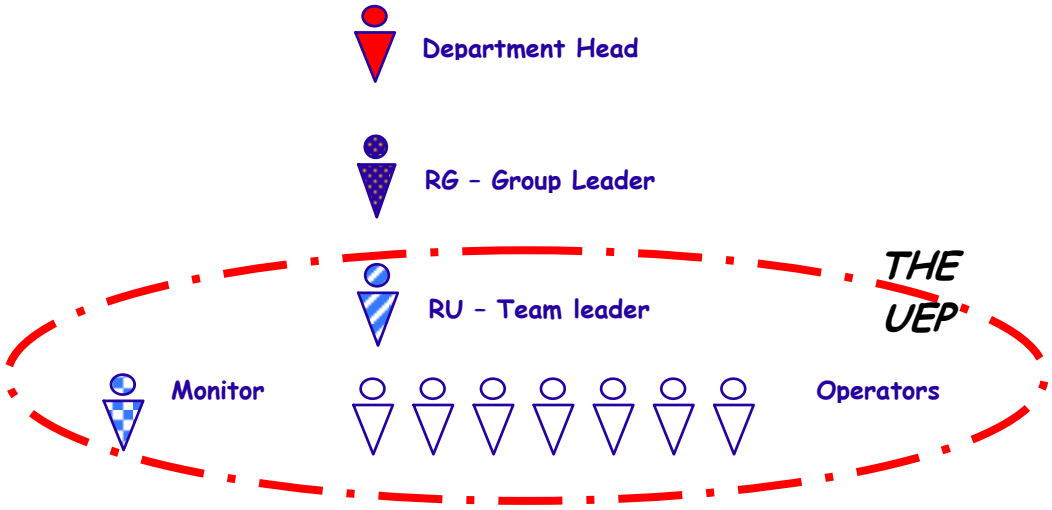


Figure 1.2 Unity and Efficiency in Production-UEP TEAM
(Peugeot Automobile Nigeria, 2003).

UEP is based on three principles: product quality, continuous improvement and social cohesion. The UEP tools include: walk the floor, operational meeting, monthly communication briefing, five progressive cleaning actions "5S", idea schemes, regular analysis of the UEP problems (its performance indicators and the list of actions), continuous improvement (quality training, recognition, health and safety, ergonomic assessment and risk assessment).

The UEP is a dynamic organization which continuously develops. The process of continuous improvement is marked by 5 stages which measure its development and ensure its sustainability. These steps are indicated in figure 1.4.

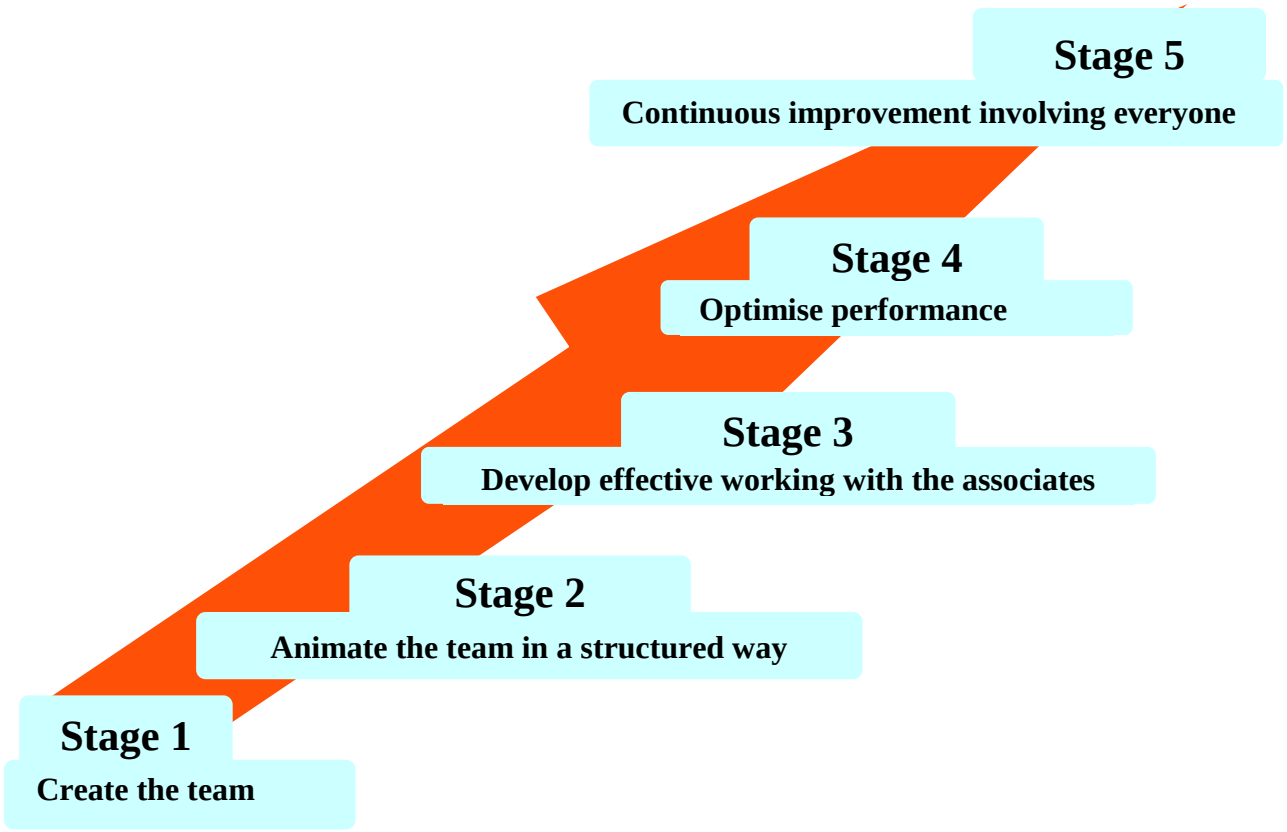


Figure 1.3 Stages of development of the UEP
(Peugeot Automobile Nigeria, 2003).

Figure 1.4 shows that UEP process has five developmental stages. The reference guide explains that the attainment of each stage is highly celebrated and rewarded.

1.1.3 Peugeot Quality System Indicators

Indicators are available to have a global view of the entire system if whatever is established is working as defined. They include Aspect Quality Indicator (IQA)/Functional Quality Indicator (IQF), Procedures application, 5M's (Man, Method, Machine, Material, and Environment), Reactivity, Destructive test, Supplier's

efficiency, and Warranty claims. Frequent assessment of these indicators allows for improvements to be made in the process and product.

Reactivity: These are defined procedures and processes of solving process or product related problems using quality tools, such as non-conformity serial checks, progress agreement, action plan form etc.

Quality level targets for finished cars are set yearly by PAN management in consonance with PSA referential. This is done through an audit carried out by the quality department using the defects grading system. Defects left on the finished cars at the point of delivery for commercialization are used as reference for measure of quality level.

Table 1.1 Finished vehicles quality level targets for year 2006 (PAN, 2006)

Description → ↓	406	
	Aspect Quality Indicator IQA	*Function Quality Indicator IQF*
Global (disapproval points) →	120	30
SPAB (Av def/car) →	0.8	0.2

Table 1.2 Finished vehicles quality level targets for year 2007 (PAN, 2007)

Description → ↓	406	
	Aspect Quality Indicator IQA	*Function Quality Indicator IQF*
Global (disapproval points) →	110	25
SPAB (Av def/car) →	0.68	0.10

SPAB = Group of major defects (see note below). Average defect per car (Av def/car)

These quality indicators measure the functionality and appearance levels of the cars produced.

Defect grading is of two categories:

1. Major defects (SPAB): Defects under this group attract weighted points ranging from 10 to 120 disapproval points.
2. Minor defects (CD): Defect under this group attracts weighted points ranging from 3 to 6 disapproval points.

The less the number of major defects the better the quality level of the car.

SPAB = Group of major defects.

S = Safety related defect, P = Potential break down defect, A = Unacceptable defect, B = could worry the average customer.

Customer Protection through progressive commercialization in the process:

Finished vehicles from each production shop are evaluated to ensure that set quality targets are respected and that no product passes to the next process with a major defect before final delivery to Commercial. This is to protect the internal and external customer.

Assurance of incoming materials from Suppliers: On reception of direct and indirect materials in PAN, the Quality inspection team carries out mandatory conformance checks and accepts only good parts/materials and chemical products into the stores for production use. There is a written inspection/acceptation process for each part/material and chemical. Testing jigs, templates, and laboratory equipment are also used.

Three inspection/acceptation methods are employed.

i. 100% unitary inspection or re-enforced inspection.
ii. Audit based on selected sampling plan.

iii. Monitoring of the quality performance of fitted parts in PAN and After Sales (Warranty).

There is regular communication with suppliers on the quality level of supplied items via technical reports, quality alarms, and claims. Rejects are isolated and sent back to suppliers through a defined process. In conformity with quality system, individual supplier's performance indicator is available to measure the quality level of incoming materials.

1.2 STATEMENT OF PROBLEM

Organizations of all sizes are trying to stay competitive and profitable for long periods. Most companies have a major opportunity to improve quality, reduce; cost, customer lead-time and cycle time through the application of one improvement method or the other.Despite the full implementation of new work management tool; Unity and Efficiency in Production UEP, the Peugeot Automobile Nigeria:

1. Still runs below full capacity. A system with multiple production lines that produced over two hundred and fourty (240) cars per day in 1970s now produces less than twenty (20) cars per day.
2. Could not strategically integrate all tools and functions of UEP to all work categories. This neglect subsequently encouraged increased production lead time and low customer patronage.
3. Requires managerial consideration of all critical factors that promote organizational transformation and business optimization.
4. Needs to identify approaches to redirect each non-value added activity into a value added activity in order to reduce waste and improve efficiency of production.

1.3 AIM AND OBJECTIVES OF STUDY

The aim of this study is to investigate why the implementation of the work management philosophy, "UEP" is not yielding the expected results in PAN.

The specific objectives of the study are:

1. To analyze participants' understanding of UEP philosophy.
2. To analyze employee and function involvement in UEP transformation.
3. To identify the critical success factors for sustainable implementation of UEP.
4. To examine how important the UEP philosophy and management behaviour are related implementation issues (for effective system optimization).
5. Analyze quality data before and after UEP implementation.

1.4 RESEARCH SIGNIFICANCE AND JUSTIFICATION

This study seeks to review the UEP implementation process by identifying problems and associated bottlenecks and making recommendation based on analyzed data for the decision making process in order to enhance productivity and customer satisfaction.

Various production/manufacturing process improvement methods have been applied successfully. Most of these have also been distinctly documented and exposed to various criticisms and further research. Unity and Efficiency in Production UEP, is a unique process that is peculiar to Peugeot Automobile worldwide. Embarking on this research study is considered to be useful and relevant because of the following:

1. Use of statistical tools and hypothesis for process analysis, management and control instead of using only the conventional process charts and other documentations/animation (encouragement of long term cost reduction efforts).
2. Proper documentation and further researches for the benefit of continuous improvement and globalization of the application of the process.

3. Use of Peugeot Automobile Nigeria as a case study to clearly understand the concept of implementation that led to eventual success of the process.

A common mistake made by companies when implementing process improvement is to allow the chosen model to dictate the process design. A model that needs to be interpreted base on the business environment and technical needs of the project is not a standard that must be implemented exactly as documented. The correct approach is to balance the recommendations of the model against the business value that the new processes will add.

1.5 SCOPE OF STUDY

The reflections in the fieldwork and the discussion sections have already shown the limitations of the research. The conclusions drawn in this survey are more based on indications than on statistically significant results. The opinions of the respondents could not always be supported by statistics. Even where it was possible, the results should be looked at more closely and considered to be more of a general indication rather than a statistical proof, that certain aspects are critical to successful UEP implementation.

However, as most of the findings of the literature review were reflected by opinions in the survey, it can still be said that the applicability of the theory to the samples could be confirmed.

The research was limited to the resources available, the body of knowledge on the topic of UEP manufacturing technology and the time available to complete the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 REVIEW OF PAST WORK

The UEP work management process used in Peugeot worldwide still has its roots in the lean manufacturing. Basically most of the UEP tools are similar to those of lean manufacturing. The introduction of standardized production systems in the automotive industry today shows a clear trend that companies primarily model their production systems on the Toyota Production System (TPS). The TPS has evolved as the dominant reference model. This process towards institutionalizing the TPS is rooted in the lean manufacturing system.

Lean manufacturing is more than a set of lean tools that can optimizemanufacturing efficiencies; it is a process and mindset that needs to be integrated into daily manufacturing systems to achieve sustainability.

In optimizing a manufacturing system, quality, cost and time oriented criteria are applied. Manufacturers also want to adjust their activities to the best fit in the whole supply chain and this can be a combination of more than just one criterion. Literatures on the implementation of organizational change such as lean manufacturing are quite relevant to UEP review. Hence, a discussion on UEP tools is worth considering in this review.

2.2 TOOLS OF UEP MANUFACTURING

2.2.1 5-S Quality Concept

Besides all kinds of quality improvement techniques developed, one of the most famous is the 5-S concept developed by the Japanese. Osada (1991) developed the original concept of 5-S in the early 1980s. 5S is the acronym for five Japanese words. They are:-

(a) *Seiri:* Sorting out - "When in doubt, throw it out"

(b) *Seiton*: Systematic arrangement - everything has a place, everything in its place

(c) *Seiso*: Shine and span scrub - clean it up

(d) *Seiketsu*: Standardizing- Stabilize - Standardized cleaning and housekeeping

(e) *Shinseki*: Self-discipline Sustain - Make it a way of life

Osada refers to the 5-Ss as the five keys to a total quality environment. The French and Japanese have been widely practicing the 5-S technique and believe it can help in all aspects of life. By practicing 5-S at the workplace, does not only produce quality, but also help to ensure the safety of the workplace. The underlying concept behind 5-S is to look for waste and then eliminate it. Waste could be in the form of scrap, defects, excess raw material, unneeded items, old broken tools and obsolete jigs and fixtures. Taken together, 5S means good housekeeping and better workplace organization.

5-S has link with Total Quality Management (TQM). TQM is a management philosophy, diffused all over the world, with the objective of improving the operative and business performance of the organization, by offering a systemic approach to continually improve the operative activities to continually fulfill customers' requirements (Agus, 2005; Powell,1995). TQM attempts to embed quality in every aspect of the organization. It is concerned with technical aspects of quality as well as the involvement of people in quality, such as customers, company employees, and suppliers. The specific concepts that make up TQM philosophy are as indicated in table 2.1.

Table 2.1 Concepts of the TQM Philosophy (Agus, 2005)

Concept	Main ideas
Customer focus	Goal is to identify and meet customer needs.
Continuous improvement	A philosophy of never-ending improvement.
Employee empowerment	Employees are expected to seek out, identify, and correct quality problems.
Use of quality tools	Ongoing employee training in the use of quality tools.
Product design	Products need to be designed to meet customer expectations.
Process management	Quality should be built into the process; sources ofquality problems
	should be identified and corrected.
Managing supplierquality	Quality concepts must extend to a company's suppliers.

2.2.2 The seven wastes and lead time reduction.

The basic idea to reach the ideal is the principle of using Kaizen or continuous improvement to reduce waste. According to Shingo (1989) waste is any activity that does not contribute to operations and therewith does not add value, such as walking to get parts, unpacking supplied parts or waiting for lots to be finished. Value-adding activities transform materials, changing form or quality; they turn raw materials into parts or products (i.e. assembly, welding, stamping, heat-treating or painting). Figure 2.1 shows the seven wastes according to Ohno (1988).

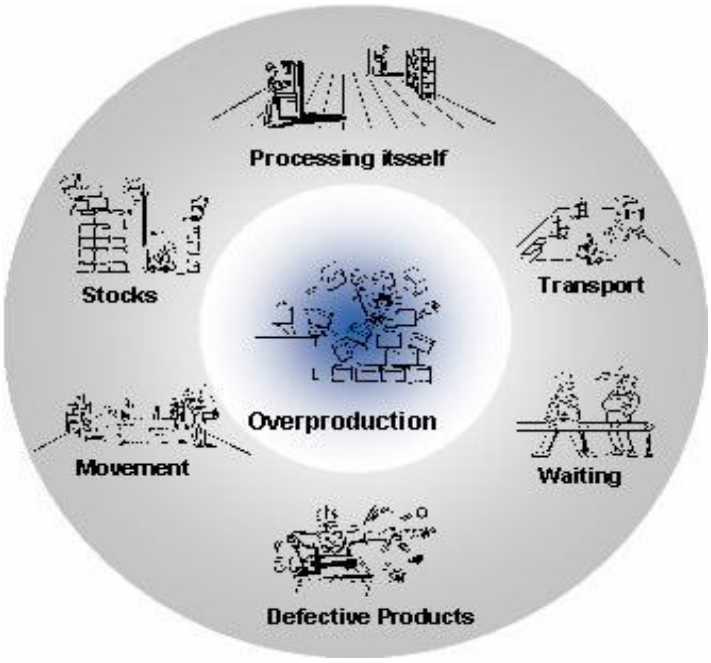


Figure 2.1 The seven wastes (Ohno, 1988)

Lareau (2003) additionally has identified four groups of office waste, such as people waste (i.e. lack of goal alignment, waiting and motion), process waste (i.e. control in the sense of only monitoring, variability, lack of standardization and errors), information waste (missing, irrelevant and inaccurate information) and asset waste (office inventory, buildings and offices that are not fully used and transport of information).

According to Womack and Jones (1990) the focus of continuous improvement lies on the time line from the point where the customer gives the company an order, to the moment at which the money is collected. The time line is reduced by eliminating the non-value added waste.

Summarizing, it would be interesting to find out why organizations are trying to copy the TPS and applying lean thinking in their own environments. Wheatley (2005) has discussed these reasons and provided a chart shown in figure 2.2.



Figure 2.2 Top 5 business factors for lean adoption (Wheatley, 2005)

Wheatley (2005) draws a conclusion from 200 respondents. This will be one of the bases of discussion in this review.

The basic lean philosophy leads to the following critical factors that organizations have to understand in order to successfully implement TPS principles (see table 2.2).

Table 2.2 Critical success factors resulting from the TPS philosophy (Womack, 2003)

Basic TPS and lean ideas	**Understanding the TPS focus** - The TPS focus lies on improving quality and on-time delivery by lead-time reduction. Cost savings based on productivity improvement follow automatically.
	Understanding the lean philosophy concerning productivity improvements - The idea is to identify excess manpower and use it effectively in the continuous improvement process. Therefore the lean philosophy has nothing to do with headcount reduction.
	Understanding the need to eliminate waste - Waste has to be reduced in operations and offices.
	Understanding the meaning of the basic TPS tools - The basic tools just-in-time and autonomation help to implement the lean thought process in operations but they seem to lack adaptability the rest of organisation, i.e. in marketing or finance.
	Understanding that the TPS is a fundamental management philosophy and not a set of tools to improve production - The TPS is not a set of tools but a fundamental manufacturing and management philosophy, in which human development builds the central point.
	Understanding the focus on people first - The key element in the development of lean production is the role of teams and the individual.

Thiscritical success factors for TPS philosophy will be further analyzed in this review as it relates to UEP transformation.

2.2.3 Walk the floor

The "Walk the Floor" procedure is an official round that allows the team leader to examine his/her department by observing the technical, organizational and human key issues and checking that everything is going smoothly by:

1. Gathering comments, remarks and irregularities from the UEP team.
2. Acting and making quick decisions according to the problem.
3. Following the progress of the undertaken actions and decisions.

The "Walk the Floor" procedure takes place a few times a day every day.

Why walk the floor?

To walk the floor on a regular basis allows the team leader to:

1. Be aware of what is going on in his/her department regarding the key positions or the ones that have been a problem in the past.
2. Listen to his/her operators.
3. Control the operators' work and make sure that it complies with the guidelines.
4. Anticipate problems and find a solution before they become problems.
5. Prepare a list of observations that can be passed onto the group leader during the operational meeting, or onto other team leaders.

The time spent walking the floor must lead to a reduction in the number of irregularities since most issues will be dealt with rapidly.

The procedure is made official in order to:

1. Make sure that everything is checked.
2. Have a written report that facilitates communication between the team leaders and the various shifts.
3. Plan the operational meeting with the team leaders (PAN, 2003).

2.2.4 Operational meetings

The Operational Meeting is a formal discussion that takes place once a day between the group and the team leaders. It allows them to see how the line of business performs and to decide on what they should do at short notice.

What happens during the meeting?

6 steps must be followed to:

1. Identify discrepancies between the objectives and the progress by looking at the operational indicators from the previous day.
2. Identify irregularities seen during "Walk the Floor" sessions that could not be solvedby the team leader alone.

3. Decide on short term remedies concerning the first two points, to assign them to a leader and to set a deadline.
4. Identify priorities and/or identify opportunities for the same day.
5. Report on the short term actions agreed upon during previous meetings.
6. Add to the list of progress actions some fundamental actions that can be discussed during the meeting between the group leader and team leader.

Note: The Operational Meeting does not solve the problems, it speeds up the solution procedures.

Prerequisites for the setup of an Operational Meeting

In order to keep the meeting short and efficient, it is necessary to decide on a standard and to formalize it. This must be done by the group leader in agreement with his/her team leaders.

1. To set up the "Walk the Floor" sessions by the team leader, the operational meeting assumes that the "Walk the Floor" sessions have been previously planned.

2. To decide on the indicators to look atsome point during the meeting, the group leader and the team leader will have to examine the indicators that represent the sectoractivity. Therefore, it is necessary to choose (or design) the indicators that will beexamined. These indicators will be as follows:

1. They must represent the mission of the sector (examples: daily production, rate of defects in a manufacturing area, delays in deliveries, etc.).
2. They must be published daily before the meeting so that everyone can plan the meeting.
3. They must include an objective that allows to judge whether or not the mission for a specific area has been fulfilled during the day.

4. They must represent the activity for each UEP.
5. They must not be too numerous in order to keep the meeting focused on the main points.

2.2.5 Total Productive Maintenance (TPM)

Machine breakdown is one of the most important issues that concern the people on the shop floor. The reliability of the equipment on the shop floor is very important since if one machine breaks down the entire production line could go down. An important tool that is necessary to account for sudden machine breakdowns is Total Productive Maintenance. In almost any lean environment setting a TPM program is very important.

There are three main components of TPM program which are preventive maintenance, corrective maintenance and maintenance prevention. Preventive maintenance has to do with regular planned maintenance on all equipment rather than random checkups. The worker has to carry out regular equipment maintenance to detect any anomalies as they occur. By doing so sudden machine breakdown can be prevented, which leads to improvement in the throughput of each machine.

Corrective maintenance deals with decisions such as whether to fix or buy new equipment. If a machine is always down and its components are always breaking down then it is better to replace those parts with new ones. As a result, the machine will last longer and its uptime will be higher. Maintenance prevention has to do with buying the right machine. If a machine is hard to maintain (e.g. hard to lubricate or bolts are hard to tighten) workers will be reluctant to maintain it on a regular basis, which will result in a huge amount of lost money invested for that machine.

TPM evolved from TQM, which evolved as a direct result of Deming's influence on Japanese industry. Deming began his work in Japan shortly after World War II. As a

statistician, Deming initially began to show the Japanese how to use statistical analysis in manufacturing and how to use the resulting data to control quality during manufacturing. The initial statistical procedures and the resulting quality control concepts fueled by the Japanese work ethic soon became a way of life for Japanese industry. This new manufacturing concept eventually became known as Total Quality Management or TQM.

2.2.6 Continuous Improvement (KAIZEN)

Continuous improvement is another fundamental principle in a lean manufacturing. Kaizen, which is the Japanese word for a continuous effort for perfection has become popular in the West as paramount concept behind good management. In manufacturing settings improvements can take place in many forms such as reduction of inventory and reduction of defective parts. One of the most effective tools of Kaizen is 5-S, which is the basis for an effective lean company. 5-S is not only a means to increase profitability but also allows companies to reveal potential strengths and capabilities that were hidden before.

2.2.7 Just – In – Time (JIT)

Closely associated with the lean manufacturing is the principle of just-in-time. It is a management idea that attempts to eliminate sources of manufacturing waste by producing the right part in the right place at the right time. Inventories and material flow systems are typically classified as either push (traditional) or pull (just-in-time) systems. Customers demand is the driving force for the both systems. However, the major difference is in how each system handles customer demand. JIT is a tool that enables the internal process of the company to adapt to sudden changes in the demand pattern

by producing the right product at the right time and the right quantities. Moreover, JIT is a critical tool to manage the external activities of a company such as purchasing and distribution.

According to Ohno (1988) just-in-time means that, in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and only in the amount needed. The goal is an implementation of a flow production with zero work-in-progress (inventory). When trying to work just-in-time, people experienced that conventional operations management methods did not work well. A problem early in the process always resulted in a defective product later in the process. Parts were produced without regard to the later process steps, which resulted in huge and wasteful inventories (Shingo, 1989).

2.2.8 Standardized Work

A very important principle of waste elimination is the standardization of worker actions. Standardized work basically ensures that each job is organized and is carried out in the most effective manner. No matter who is doing the job, the same level of quality should be achieved. Peugeot uses work post documentation (production process). At Toyota, every worker follows the same processing steps all the time. This includes the time needed to finish a job, the order of steps to follow for each job. By doing this one ensures that line balancing is achieved, unwarranted work-in-process inventory is minimized and non-value added activities are reduced. A tool that is used to standardize work is called “takt time” (as expressed in equation 2.1). Takt time refers to how often a part should be produced in a product family based on the actual customer demand. The target is to produce at a pace not higher than the takt time.

$$\text{Takt time} = \frac{\text{Available work time per day}}{\text{Customer demand per day}} \quad \text{.....2.1}$$

2.2.9 Kanban

A system that creates a product that is then sold after it is produced is called a pushsystem. If there is no mechanism to keep work-in-progress below some level that is consistent with product demand, production output can become excessive, which can lead to many problems, including product storage.

In pullsystems, products are created at a pace that matches customer demand. Kanbans are used to buffer variations in customer or next process step demands. A most familiar form of Kanban is the American-style supermarket where each product has a short-term buffer, replenished at the rate of customer demand. The Japanese word Kanban refers to the pulling of a product through a production process. The intent of Kanban is to signal a preceding process that the next process needs parts or material.

A bottleneck is a system constraint. In a pull system, the bottleneck should be used to regulate the pace for the entire production line. Buffers in high-volume manufacturing serve to balance the line. It's important that such operations receive the necessary supplies in a timely basis and that poorly sequenced work does not interfere with the process completion. Pull systems address what the external and internal customers need when they want it.

Rules to consider when operating an effective Kanban:

1. No withdrawal of parts is to occur without a Kanban where subsequent processes are to withdraw only what is needed.
2. Defective parts are not to be used for later processes
3. Preceding processes are to produce only the exact quantity of parts withdrawn by successive processes.
4. Variability in the demand process should be minimized.

If production requirements drop off, the process must be stopped. An increase in production requirements is addressed through overtime and process improvement activities. Kanban can dramatically improve a process that produces few defects within workstations.

However, if there are workstations that have high defect rates (i.e., a hidden factory), the system can become "starved" for parts. This problem could be avoided by integrating Kanban with an Integrated Enterprise Excellence (IEE)measurement and improvement system. Kanban can be the relay signal between supplier and customer. Kanban signals can be generated by lights, colored balls down a tube, or a computer network.

A food market can know when to stock by keeping track of product-volume sold through a barcode system. A stock person responds to a product pull by replenishing the prescribed number using first-in, first-out product restocking. The supplier knows the volume of product to supply because of the Kanban system.

Kanban "label" data can include: Kanban number, supplier name, line site address: location of line where the component will be processed, shipping area address: shipping location for finished assemblies, part store address: factory location for temporary storage of components before assembly line use, part description, quantity in Kanban package, bar code and part number.

2.2.10 Theory of Constraints (ToC)

Theory of Constraints (ToC) is an overall management philosophy introduced by Goldratt (1986). The title comes from the contention that any manageable system is limited in achieving more of its goal by a very small number of constraints, and that there is always at least one constraint. The ToC process seeks to identify the constraint

and restructure the rest of the organization around it, through the use of the five focusing steps:

1. **Identify** the constraint (the resource/policy that prevents the organization from obtaining more of the goal)
2. Decide how to **exploit** the constraint (make sure the constraint's time is not wasted doing things that it should not do)
3. **Subordinate** all other processes to the above decision (align the whole system/organization to support the decision made above)
4. **Elevate** the constraint (if required/possible, permanently increase capacity of the constraint; "buy more")
5. If, as a result of these steps, the constraint has moved, return to Step 1. Don't let inertia become the constraint.

A constraint is anything that prevents the system from achieving more of its goal. Typically, a constraint could relate to:

1 **Equipment:** The way equipment is currently used limits the ability of the system to produce more salable goods / services.

2 **People:** Lack of skilled people limits the system.

3 **Policy:** A written or unwritten policy prevents the system from making more.

2.2.11 Six Sigma (6σ)

Six sigma is a business management strategy, initially implemented by Motorola, which today enjoys widespread application in many sectors of industry. Six sigma seeks to improve the quality of process outputs by identifying and removing the causes of

defects (errors) and variation in manufacturing and business processes. It uses a set of quality management methods, including statistical methods, and creates a special infrastructure of people within the organization ("Black Belts" etc.) who are experts in these methods. Each six sigma project carried out within an organization follows a defined sequence of steps and has quantified financial targets (cost reduction or profit increase).

The particulars of the methodology were first formulated by Bill Smith at Motorola in 1986. Six sigma was heavily inspired by six preceding decades of quality improvement methodologies such as quality control, TQM, and Zero Defects, based on the work of pioneers such as Shewhart, Deming, Juran, Ishikawa, Taguchi and others.

One of the key innovations of six sigma is the professionalizing of quality management functions. Prior to six sigma, quality management in practice was largely relegated to the production floor and to statisticians in a separate quality department. six sigma borrows martial arts ranking terminology to define a hierarchy (and career path) that cuts across all business functions and a promotion path straight into the executive suite (Pande et al.,2001).

2.3 IMPLEMENTATION OF THE UEP PHILOSOPHY AND THE UEP TRANSFORMATION PROCESS

The basic tenet of UEP is that people are the most important asset and for that reason management must have a shop floor focus in order to identify non-value adding tasks.
As UEP transformation is a profound change in business culture (Womack *et al*., 1990), implementation processes fail due to various reasons and it has to be said, that both Ohno (1988) and Shingo (1989) do rarely mention the change process itself.

In order to shed light on the additional critical success factors of successful UEP implementation, the Henley transformational framework was used to classify the relevant criteria mentioned by various researchers. In the following part of the literature review this model was used as a frame of reference. Table 2.3 gives an overview about the stages of a transformation process.

Table 2.3 The Henley Transformational Framework (Herbolzheimer, 2003)

Mobilise for change	- Meet stakeholder expectations, reputation and sustainability - Lead the change: communicate the vision, motivate, energise, overcome barriers to change and determine change agents - What culture?
Translate strategy into objectives and initiatives	- Determine the nature and scale of change, critical gaps - Define strategic goals, concrete objectives and initiatives - Establish performance parameters
Design the change process	- Design choices and change architecture - Set implementation agenda and milestones
Align the organisation	- Organisational structure - Internal organisation (systems, policies and procedures; rewards and incentives) - Skills, capabilities and resources (financial, people, infrastructure)
Organisational learning	- Build the learning organisation - Manage innovation/knowledge and training

In the following part of the UEP survey these stages will be used as a guide to analyse the additional critical success factors for sustainable UEP implementation.

2.3.1 Mobilize for UEP change

2.3.1.1 Stakeholder expectations

Successful UEP implementation is approached from a strategic perspective and companies seek to reach certain goals with UEP initiatives. As creating a UEP workplace requires changing the corporate culture, a robust change management strategy is needed (Parks, 2002). Such abrupt policy changes require a top-down

approach to decision making (Kobayashi, 1995). Mader (2005) emphasizes the need for strong top management leadership in the implementation process. Carefully selected kaizen events should support the organization's strategy and vision.

Only seeing UEP as a quick fix, may give some employees the impression that UEP might not work in certain environments, i.e. in low volume operations. Spear (2004) says that at Toyota managers act as enablers and in that sense coach co-workers in solving problems instead of just fixing them. Strong leadership is essential for the success of this initiative.

Together with the Chief executive officer CEO driving the UEP changes, top-down operating through empowered teams is critical to success. This is done through continuous improvement. Benders and Morita (2004) call the continuous improvement system the backbone of Toyota production system TPS. The role of leaders and supervisors is to motivate, coach, train and facilitate the work of those adding value rather than to tell them what to do. People are kept enthused by continuously being allowed to change their processes in Kaizen events (Vasilash, 2000) and to personalize the changes where appropriate. For example by locating their equipment or positioning their machines on their own. In his opinion, employees should be free to allocate time to improvement.

If an organization reinvests in early improvement the positive feedback creates even bigger improvement. Carter (2004) suggests a no-layoff policy in order to overcome operators' fears that productivity gains may cost them their jobs. Operating through empowered teams means that the UEP organization is less hierarchical than traditional businesses.

2.3.1.2 Lead the change

Convis (2001) says that in the TPS management has no other role than motivating and engaging a large number of people to work together toward a common goal. Therefore the organization should not be shaped through the power of will, but rather through example, through coaching, through helping others to achieve their goals.

Womack and Jones (2003) on the other hand, underline the need for strong will at top management during the transformation process. Joe Day, US based Freudenberg CEO, for example, spent 35% of his time during the first two years of their lean rollouts (Vasilash, 1996). Womack and Jones (2003) add that leaders should create a crisis in order to force the organization to adopt lean thinking and that should be part of the strategy. It is interesting to see, that the other authors do not underline this point; however, the above mentioned Porsche and Toyota examples clearly show that their success was based on crises. Therefore UEP thinking should first be applied in a troubled business unit or facility. This should be supported by the senior management demonstrating impatience during UEP performance reports. The question arises, how can companies drive the UEP transformation if there is no crisis? Whereas Womack and Jones (2003) additionally suggest removing managers who do not accept new ideas like UEP, Henderson and Larco (2000) prefer confrontations and a few heart-to-heart talks to convince concrete heads among the management team. Paris (2000) on the other hand suggests ignoring those who chose to focus on their day-to-day assignments and not to punish them.

2.3.1.3 UEP culture

In the UEP philosophy the value of the produced goods from a customer's point of view is the starting point for improvements (Womack and Jones, 2003). Therefore, the whole organization has to concentrate on the place where the value is created: the shop floor.

This philosophy turns the UEP enterprise upside down – departments and managers exist to support production, not the other way round (Henderson and Larco, 2000). Strong leadership is essential to communicate this idea. Convis (2001) adds that senior managers have to be willing to be involved in day-to-day improvements in operations. This needs the basic tenet that people in the UEP are the most important asset and not the UEP tools. Tempel and Holländer (2001) add that top management presence and availability on the shop floor is one of the most critical points during the UEP rollout. Therefore a UEP culture is characterized by emphasis on people first, trust, strong customer orientation and the joint shop floor.

2.3.2 Translate strategy into objectives and UEP initiatives

2.3.2.1 Determine the nature of change

Concerning the nature of change Keating *et al*. (1999) point out that successful improvement programs must grow organically. Generally they distinguish between two sources of commitment to improvement programs: managerial push and employee pull. Push ranges from mandatory participation in training and Kaizen events to financial incentives. On the other hand, pull arises when employees fully understand the benefits of UEP and improvement potential for themselves independent from management's support. However, the initial stimulation may be guided by management push, which is clearly the implementation strategy of Womack and Jones (2003) and Henderson and Larco (2000). These points clearly show the difficulty in leading this process: a strong top down approach may make employees feel being forced to change whereas a bottom up, organically grown approach may not lead to the expected results.

2.3.2.2 Define UEP initiatives

The TPS founder Ohno (1988) and Shingo (1989) concentrated on the production engineering point of view and both described in depth the tools and techniques. According to Womack and Jones (2003), the most important tool is the value stream map (VSM), which they call the second principle of lean.

A VSM is a simple diagram (see figure 2.3) showing every step involved in the material and information flows needed to bring a product from order to delivery and is therewith indispensable as a technique for visually managing process improvements. Mapping a process gives a clean picture of wastes that inhibit flow (Tapping *et al.*, 2002).

Due to a high level of icon standardization a VSM provides a common language for all personnel as bottlenecks and inventory are located and problem areas as well as wastes are identified (**red** Kaizen focuses in figure 2.3). As all relevant process data (number of machines and operators, machine cycle time, changeover time, scrap and rework and machine availability etc.) are additionally presented in data boxes, a Kaizen team gains insight into how the operation is truly running that day.

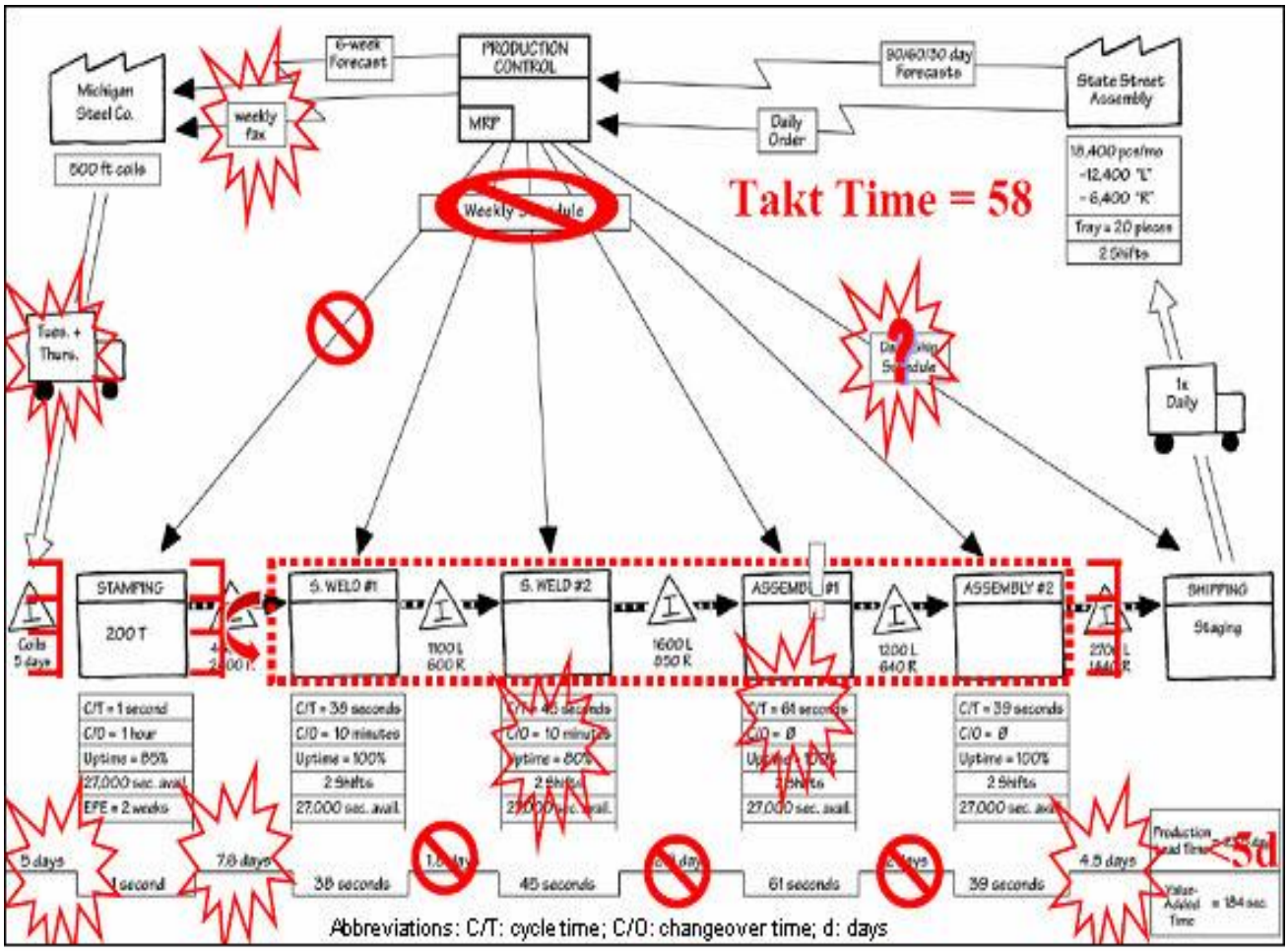


Figure 2.3 Value Stream Map - VSM. (Rother and Shook, 2000)

After mapping the current state, a future state, which identifies the opportunities to design a more efficient and waste-free value stream, is created. Unfortunately Rother and Shook (2000) do not deliver in depth comments on how to choose a value stream for improvement. Overall value streams can be difficult to tackle due to their complexity and therefore prioritizing and targeting a relevant area of concern may be difficult for Kaizen teams. Tapping and Shuker (2003) have additionally developed a VSM concept to plan, map and sustain lean improvements in administrative areas.

2.3.2.3 Establish UEP performance parameters

Before and after Kaizen improvements the results of the UEP implementation have to be tracked. Henderson and Larco (2000) suggest the following performance measures

beside the financial metrics: inventory turns, customer product returns measured in PPM (parts per million) and OTD (on-time delivery) to customer want date. Performance targets on these metrics should be set aggressively and raised as they are neared and an audit mechanism should be built to ensure that the UEP program proceeds on track (Tilson, 2001). Womack and Jones (2003) suggest using policy deployment (see figure 2.4). It summarizes the goals, the projects for that year and the targets for these projects.

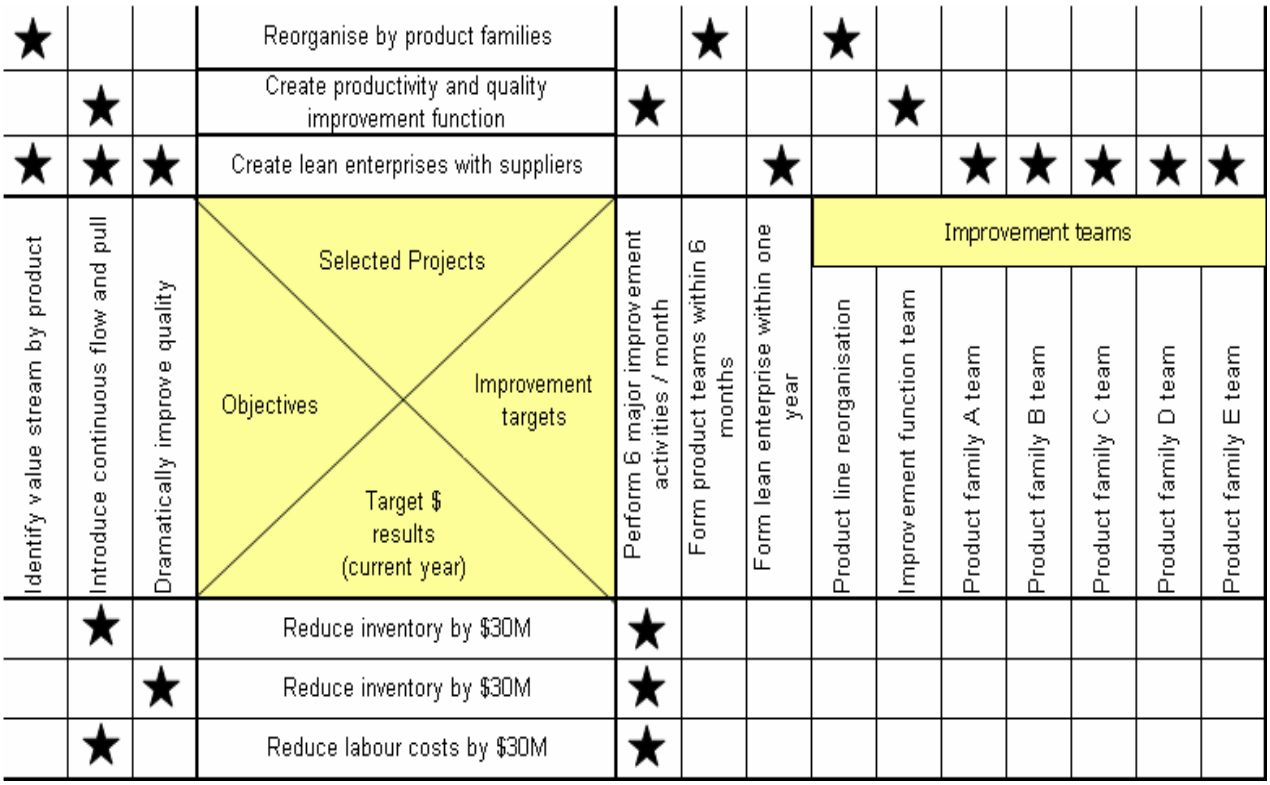


Figure 2.4 Lean Policy Deployment Matrix (Womack and Jones, 2003)

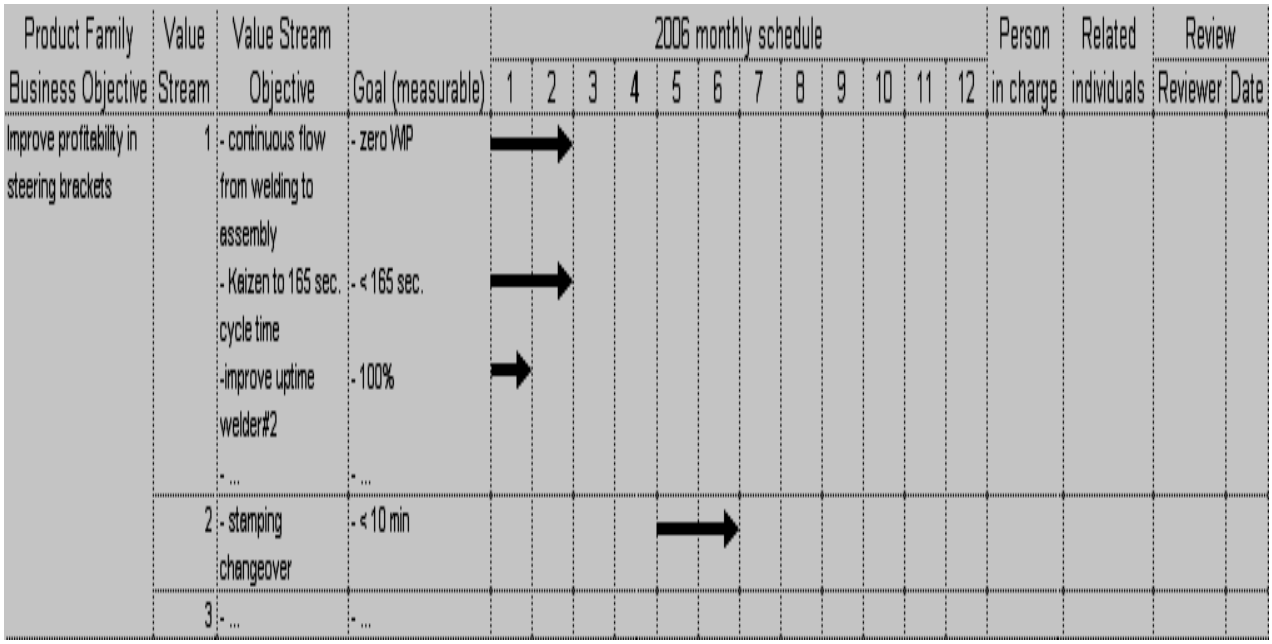
2.3.3 Design the UEP change process

2.3.3.1 Setting a Kaizen (continuous improvement) agenda

Rother and Shook (2000) recommend that a value stream plan should be designed hand in hand with the value stream map: it contains step by step implementation plans on

how to reach the future state value stream, including measurable targets, milestones and completion dates (see table 2.4).

Table 2.4 Yearly value-stream plan (Rother and Shook, 2000)



Product Family Business Objective	Value Stream	Value Stream Objective	Goal (measurable)	2006 monthly schedule 1	2	3	4	5	6	7	8	9	10	11	12	Person in charge	Related individuals	Review Reviewer	Date
Improve profitability in steering brackets	1	- continuous flow from welding to assembly	- zero WIP	→															
		- Kaizen to 165 sec. cycle time	- < 165 sec.	→															
		-improve uptime welder#2	- 100%	→															
		- ...	- ...																
	2	- stamping changeover	- < 10 min					→											
	3	- ...	- ...																

However, this approach only delivers an implementation strategy for the operational level and lacks applicability if an organization has to start at point zero. Ohno (1988) and Shingo (1989) do not deliver an overall approach a company could follow to become lean and Henderson and Larco (2000) only list the above mentioned tools (VSM, 5S, flow production, Kanban). Partly they add bullet points of key factors to success (management vision, strong leadership, UEP expert training, setting performance targets and managementimpatience during the UEP rollout) but do not really design an agenda for the implementation. Also Kobayashi (1995) only delivers the so called 20 keys to workplace improvement which are more a to-do list than a logical sequence.

2.3.4 Align the organization

2.3.4.1 Organizational structure

As a UEP factory shop floor does not make a UEP enterprise Womack and Jones (2003) propose reorganizing the company by value stream, which means rethinking the functional departments. Ohno (1988) does not go that far but clearly explains the function of internal customers and suppliers within the organization.

However, also all supportive departments have active roles in the UEP rollout.

2.3.4.2 Integration of engineering

As total lead time reduction is the overall goal, the introduction of new products (product, process development, and industrialization) has to be done in a very short period of time. Additionally, in order to produce zero defects it has to be ensured upfront that a product can be manufactured efficiently. Therefore engineers have to build mistake-proofing devices into the products and processes wherever possible and critical process parameters must be well understood. Tools for lead time reduction are simultaneous engineering, tools for quality assurance design for manufacturability and design for assembly (Voss, 1995).

2.3.4.3 Integration of quality

In Peugeot production, quality personnel need to be highly skilled problem solvers. They take the lead in analyzing defective parts that are rejected by customers and set up systems that help to ensure quality, i.e. decide on which parts require incoming inspection. They have to implement self-diagnostic test into processes to trigger immediate problem solving (Spear, 2002).

2.3.4.4 Integration of finance

Most cost accounting processes involve standard costing systems. Industrial engineers and controllers, who usually create the standards include non-value adding tasks like

rework, walking or long setup times into work order documents and therewith into calculation and may feel comfortable when a cell is working at 110% of standard. Maskell and Baggaley (2003) underline, that traditional standard costing systems actively motivate non-lean behaviours. Their key measures are machine utilization and the amount of overhead absorbed by production and it does not take long for supervisors and operators to find out that the best way to show good results is to batch quantities and to build inventory.

2.3.4.5 Integration of Human Resource HR

The HR function has to support the cultural change aspects of the UEP transformation. As teams become empowered, managers have to work much more participative than in traditional organizations. Traditional individual piece work incentive schemes usually educate workers to produce inventory; or sometimes, worse, bonuses are even paid for defective parts (Henderson and Larco, 2000). Therefore it is a critical HR task to develop systems where the team is paid for high productivity. As changing customer demand may lead to quicker manning capacity adaptation, a system that guarantees flexible personnel allocation has to be set up. As UEP requires fewer input resources, as mass production and business growth will not always absorb the entire workforce, companies may be forced to handle redundancies. HR has to set the policies, i.e. rightsizing up front. However, looking at the Japanese plants in the US, job security is much higher than in the US car companies (Rothwell, 1994).

2.3.4.6 Integration of sales and marketing

First of all sales and marketing have to produce a good forecast as production uses this to calculate Takt time. Very often, operations cannot react on time to changing customer demands as personnel have to be trained or additional machine capacity has to be built or machines are waiting because of longer lead times of suppliers that were not

informed early enough. Additionally, they have to sell the UEP advantages, such as shorter lead time or cheaper prices due to less inventory or higher productivity (Henderson and Larco, 2000).

2.3.4.7 Integration of purchasing

The purchasing department takes a lead in developing suppliers, i.e. integrating them into the own value chain with Kanban systems. Therefore purchasing staff need to be experts in UEP manufacturing, especially in VSM and Kanban. As not all suppliers respond to UEP initiatives, a UEP company ends up with fewer suppliers. However, as these may become long term partners, there will be benefits (Kobayashi, 1995). Simon and Schuster (1994) point out that even the Japanese have difficulties in introducing their suppliers due to the recession and due to legal restrictions against excessively frequent deliveries of parts which result in traffic jams.

2.3.4.8 Internal organization: reward and incentive system

Paper (1999) adds that employees should have a reward structure that compensates team effort over individual effort. Keating *et al.* (1999) on the other hand deny additional compensation as they are mostly pushed by management in order to motivate the workforce to start with UEP instead of being incremental in nature. So the question arises whether the organization should compensate UEP success stories or not.

2.3.4.9 Skills, capabilities and resources

UEP change agents need to be 100% dedicated to UEP implementation. Companies very often struggle to invest on dedicated personnel towards continuous improvement.

2.3.5 Organizational learning

2.3.5.1 Build the learning organization

Womack and Jones (2003) fifth principle of lean is called perfection. Once completed, the whole continuous improvement process starts again from the beginning. Therefore, some executives implemented Six Sigma programs (see figure 2.5) within their companies (Breyfolge, 1999). This initiative requires the use of more advanced statistical tools.

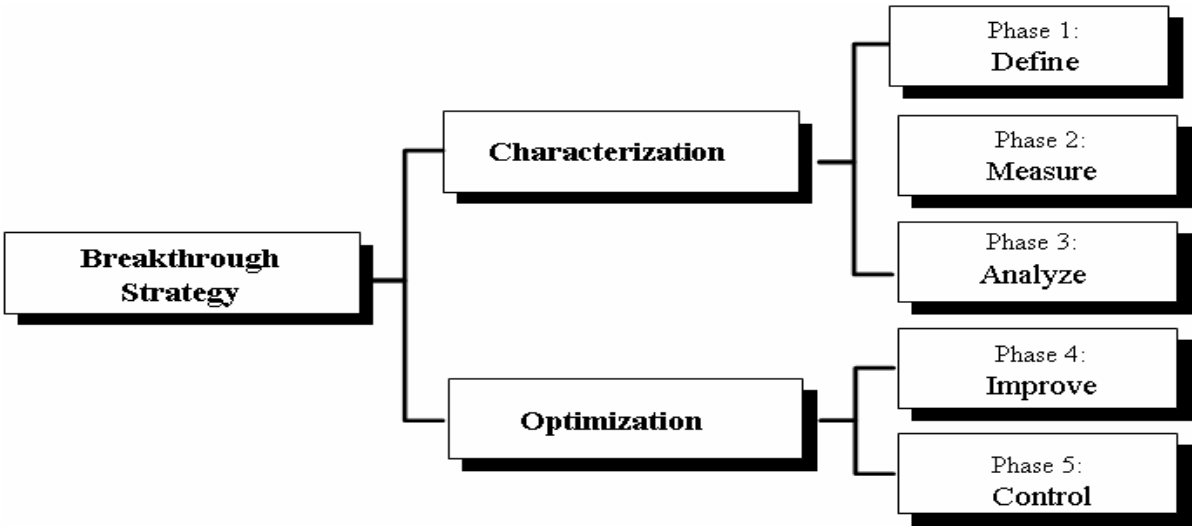


Figure 2.5 Six sigma methodology (Breyfolge, 1999)

2.3.5.2 Manage innovation/knowledge and training

Training capacity includes qualified instructors, a specific set of tools and techniques, which have been developed for the needs of the company with customized materials. Organizations may not be able to directly use all above mentioned tools, as they may not be able to be applied in certain environments. Drickhamer (2004) suggests the linking of training to direct application of learned tools and techniques in the trainee's organization in order to adopt the UEP tools.

Table 2.5 summarizes critical success factors during the lean/UEP transformation process and links them to the Convis (2001) TPS model.

Table 2.5 Critical factors for successful UEP implementation during the transformation process (Covis, 2001)

Henley Transformation Framework	Success Factor	Convis TPS Framework Category
Mobilise for change	**Stakeholder expectations**	
	- getting managers on board	**Management**
	- involving operators through empowered kaizen teams	**Philosophy**
	Lead the change	
	- strong top management leadership	**Management**
	- establishing a sense of urgency: find a lever by seizing the crises, or by creating one	**Management**
	- remove obstacles, i.e. managers who simply can not accept lean ideas	**Management**
	What culture?	
	- forming a powerful guiding coalition with managers acting as enablers	**Management**
	- building trust	**Philosophy**
	- customer first focus	**Philosophy**
Translate strategy into objectives and initiatives	**Determine the nature of change**	
	- convert from top-down leadership to bottom-up initiatives	**Philosophy**
	Define initiatives	
	- mapping the value streams	**Tools and Techniques**
	- applying standard tools and techniques: 5S, production smoothing, SMED, One Piece Flow, Takt time, Kanban	**Tools and Techniques**
	- convincing suppliers and customers to become lean	**Tools and Techniques**
	- planning for and creating short-term Kaizen wins	**Management**
	Establish performance parameters	
	- utilising policy deployment	**Tools and Techniques**
Design the change process	**Set implementation agenda**	
	- setting a kaizen agenda	**Tools and Techniques**
Align the organisation	**Organisational structure**	
	- reorganising the firm by product family and value stream	**Philosophy**
	- making the change stick: spread lean throughout the organization (engineering, quality, finance, HR, sales and marketing, purchasing)	**Philosophy**
	- internal customer - supplier relationships	**Tools and Techniques**
	Internal organisation	
	- reward and incentive system	**Tools and Techniques**
	Skills, capabilities and resources	
	- teaching lean thinking and lean skills to everyone	**Philosophy**
	- expert training and support: finding good change agents	**Management**
Organisational learning	**Build the learning organisation**	
	- striving for perfection	**Philosophy**
	Manage innovation/knowledge and training	
	- creating a lean promotion office	**Tools and Techniques**

2.4 RELEVANT THEORIES AND EQUATIONS FOR ANALYSIS

2.4.1 Sample statistics

In general case a sample size **"n"** would be described by the values $x_1, x_2,.....,x_n$of the random variables X_1, $X_2,.....,X_n$.In case of sampling with replacement X_1, $X_2,.....,X_n$would be independent, identically distributed random variables having probability distribution f(x). Their joint distribution will then be

$$\mathbf{P(X_1=x_1, X_2=x_2,.....,X_n=x_n) = f(x_1)\, f(x_2).....f(x_n)} \qquad \mathbf{(2.2)}$$

For sampling distribution we can compute a mean, variance, moment, standard deviation (also called standard error) etc. (Murray, 1987)

2.4.1.1 Sample mean

$$\mathbf{\bar{X} = (X_1 + X_2 +.....+ X_n) / n} \qquad \mathbf{(2.3)}$$

If $x_1, x_2,.....x_n$denotes value obtained in a particular sample of sizen then the mean for the sample is denoted by

$$\mathbf{\bar{x} = (x_1 + x_2 +.....x_n) / n} \qquad \mathbf{(2.4)}$$

From proven theorem, the expected value of the sample mean is the population mean.

$$\mathbf{E}\,\bar{X} = \boldsymbol{\mu} \qquad \text{where } \boldsymbol{\mu} \text{ is the mean of the population.} \qquad \mathbf{(2.5)}$$

2.4.1.2 Variance and standard deviation

The variance of a set of values, which we denote by $\boldsymbol{\sigma^2}$, is defined as

$$\boldsymbol{\sigma^2} = \frac{\sum f(\mathrm{X}-\bar{X})^2}{\mathrm{n}} \qquad \mathbf{(2.6)}$$

where$\boldsymbol{\sigma^2}$ is the variance of the population, and f is the frequency with which data value x occurs. Note that $\sum f = n$.

An alternative, yet equivalent formula, which is often easier to use is

$$\boldsymbol{\sigma^2} = \frac{\sum f(\mathrm{X})^2}{\mathrm{n}} - (\bar{X})^2 \text{where } \bar{X} = \frac{\sum f(\mathrm{X})}{\mathrm{n}} \text{(the mean)} \qquad \mathbf{(2.7)}$$

In summary, we have:

Standard deviation of a population,σ, of *N* data items is defined by the following formula. $\sigma = \sqrt{\frac{\sum(X-\mu)^2}{N}}$ where μ is the population mean. **(2.8)**

For a **sample** of *n* data items the **standard deviation**, *s*, is defined by,

$$S = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}}$$ where $\bar{X}$is the sample mean. **(2.9)**

Suppose that the population from which samples are taken has the **probability distribution** with mean $\bar{X}$and variance σ^2 that is not necessarily a normal distribution. Then the **standardized variable** associated with $\bar{X}$is given by:

$$Z = \frac{(X-\bar{X})}{\sigma / \sqrt{n}} \qquad \textbf{(2.10)}$$

Sample Variance

$$S^2 = \left\{(X_1 - \bar{X})^2 + (X_2 - \bar{X})^2 + \ldots\ldots\ldots\ldots + (X_n - \bar{X})^2\right\}/(n-1) \qquad \textbf{(2.11)}$$

2.4.1.3 Coefficient of Variation

Without an understanding of the relative size of the standard deviation compared to the original data, the standard deviation is somewhat meaningless for use with the comparison of data sets. To address this problem the **coefficient of variation** is used.

The coefficient of variation, *CV*, gives the standard deviation as a percentage of the mean of the data set.

$CV = \frac{s}{\bar{x}} \times 100\%$ for a sample $\qquad$ $CV = \frac{\sigma}{\mu} \times 100\%$ for a population **(2.12)**

The closer the CV is to 0, the greater the uniformity of data. The closer the CV is to 1, the greater the variability of the data.

2.4.1.4 Standardizing a Normal Random Variable

Suppose the random variable X is normally distributed with mean $\bar{X}$ and standard deviation**σ**, then the random variable

$$Z = \frac{X-\bar{X}}{S} \text{ (sample)} \qquad Z = \frac{X-\mu}{\sigma} \text{(population)} \qquad \textbf{(2.13)}$$

A variable is said to be standardized if it has been adjusted (or transformed) such that its mean equals 0 and its standard deviation equals 1 ($\mu = 0$ and $\sigma = 1$) as indicated in figure 2.6. The random variable Z is said to have the standard normal distribution. The Z-score represents the number of standard deviations that a data value is away from the mean. After finding the area under normal curve using Z-value and standard normal distribution of table in appendix 1, answers can easily be interpreted.

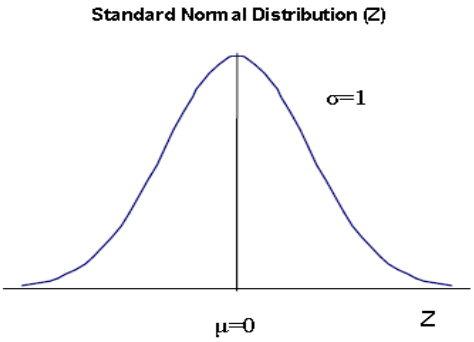


Figure 2.6 Standard Normal Distribution Curve Z (Pagano, 1990)

2.4.2 Test of Hypotheses and Significance

2.4.2.1 Hypotheses test

A Procedure which enables us to decide whether to accept or reject hypotheses or to determine whether observed samples differ significantly from expected results are called test of hypotheses, test of significance or rule of decision.

Significance testing is used to help make a judgment about a claim by addressing the question, Can the observed difference be attributed to chance? We break up significance testing into three (or four) steps:

Step A: Null and alternative hypotheses

The first step of hypothesis testing is to convert the research question into null and alternate hypotheses. We start with the null hypothesis (H_0). The null hypothesis is a claim of "no difference." The opposing hypothesis is the alternate hypothesis (H_1). The alternate hypothesis is a claim of "a difference in the population," and is the hypothesis the researcher often hopes to bolster. It is important to keep in mind that the null and alternate hypotheses reference population values, and *not* observed statistics.

Step B: Test statistic

We calculate a **test statistic** from the data. There are different types of test statistics. If sample **Z** statistic will compare the observed sample mean to an expected population mean $\boldsymbol{\mu_0}$. Large test statistics indicate data is far from expected, providing evidence against the null hypothesis and in favour of the alternate hypothesis.

Step C: *p* Value and conclusion

The test statistic is converted to a conditional probability called a *P*-value. The *P*- value answers the question "If the null hypothesis were true, what is the probability of observing the current data or data that is more extreme?"

Small *p* values provide evidence against the null hypothesis because they say the observed data are unlikely when the null hypothesis is true. We apply the following conventions:

i. When *p* value > .10 → the observed difference is "not significant"

ii. When *p* value ≤ .10 → the observed difference is "marginally significant"

iii. When *p* value ≤ .05 → the observed difference is "significant"

iv. When *p* value ≤ .01 → the observed difference is "highly significant"

Use of "significant" in this context means "the observed difference is not likely due to chance." It does *not* mean of "important" or "meaningful."

Step D: Decision (optional)

Alpha (α) is a probability threshold for a decision. If $P \leq \alpha$, we will reject the null hypothesis. Otherwise it will be retained for want of evidence.

2.4.2.2 Chi-square test χ^2

The steps in using the chi-square test may be summarized as follows:

1. Write the observed frequencies or values in column ***O***
2. Figure the expected frequencies or values and write them in column ***E***.
3. Use the formula to find the chi-square value
4. Find the degree of freedom DF (*N*-1) - the number in the group minus one restriction
5. Find the table value (consult the Chi Square Table – appendix 2) or use formula.
6. If your chi-square value is *equal to or greater than* the table value, reject the null hypothesis: differences in your data are not due to chance alone (Neuhauser, 2009).

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

$O_i \equiv$ observed values for each group

$E_i \equiv$ expected values for each group **(2.14)**

To return one-tailed probability of chi-square distribution from function arguments we have: p-value p = CHIDIST(X^2, DF) **(2.15)**

5% critical value = CHIINV (0.05, DF) **(2.16)**

2.4.3 Quality Control Chart

It is necessary to note that in quality control where one must often quickly decide whether observed changes are due simply to chance fluctuations or to actual changes in process because of deterioration of machine parts, mistakes of employees, etc. Control Charts provide a useful and simple method for dealing with such problems.

2.4.4 Measurement of Performance.

Key Performance Indicators (KPI) are the main parameters necessary to evaluate performance in manufacturing (equivalent to Kaplan's and Norton's "Balanced Scorecard"). In production/manufacturing operations, performance is determined by:

1. **Constraints** on decisions and outcomes that should not be violated, e.g., safety/reliability limits, capacity limits, quality specifications, government regulations.
2. A **Performance Index** which is a single, overall, composite metric of all KPIsimpacts (relevant when constraints are satisfied); an actual or proxy for variable profitimpact.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 RESEARCH DESIGN

Based on the theoretical discussion in the literature review the research objectives enumerated that sustainable and successful UEP implementation is based on various factors from strategic, structural and cultural perspective. Data gathered from the sample was used to verify if PAN applies UEP ideas in the original sense. Theory was tested against data, which is a deductive approach, in order to confirm or reject the applicability of the theory to the population.

Therefore a quantitative method was used. The survey strategy is usually associated with the deductive approach. Using this method allow for the collection of a large amount of data, which was analyzed.

3.2 SAMPLING TECHNIQUE AND SOURCE

As described above, a survey-based research was used to make interferences from the sample to the population. In order to answer the research question, probability sampling was performed.

- **Identifying a suitable sampling frame**

The population consists of all departments, including the production line. The sampling frame consists ofsupervisory staff from office down to the shop floor. Therefore it can be said, that the sampling frame is relevant to the research topic. A sample taken out of this sampling frame is representative of the whole population

- **Deciding on a suitable sample size**

A very important role in sample size selection plays the confidence and the level of certainty that the characteristics of the data collected are representative of the total

population. If 50 responses are needed, it is expected that roughly 100 people will be asked to fill in the questionnaires.

- **Selecting the most appropriate sampling technique and the sample**

The quality of the sample is as important as its size. As the data could not be collected from the unknown entire population, statistical inferences had to be made from the sample and as a suitable sampling frame is available, a probability sample is needed. In order to make sure that all categories of relevant staff/respondents were represented in the sample, stratified random sampling was used. The survey was conducted using printed questionnaires. 40 out of 80 critical responses were made within two weeks' time frame.

3.3 QUESTIONNAIRE DESIGN

A questionnaire with standardized questions was designed (see appendix 3). Since the respondents were geographically dispersed within the company, a self-administered handy questionnaire that includes a combination of open and closed questions wereused.In order to create a flow of questions that would be able to answer the research question, a set of questions was developed to record opinions as well as behaviour. Therefore, the research objectives were subdivided into more investigative questions in order to gather data.

3.4 EMPIRICAL FIELDWORK (DATA COLLECTION)

3.4.1 Questions testing the basic understanding of the UEP philosophy

The first section of the questionnaire (see appendix 3) was used to collect data in order to analyse the understanding of the UEP philosophy with descriptive statistics.

3.4.2 Questions to analyse the usage of UEP tools and techniques

The second section seeks after the usage and application of UEP tools and the third section was designed to assess the level and scope of UEP implementation. As the goal was to analyse behaviour, category questions were used in order to understand the integration of supportive functions into the UEP rollout. The questions were created on the basis of the objectives of the study.

3.4.3 Questions analyzing the scope of UEP implementation

The purpose of the third section was to analyse the scope of the **UEP** implementation. The questions need to find out if functions besides operations are strategically integrated into the company's **UEP** rollouts.

3.4.4 Questions testing the importance of critical management factors

In the fourth section, based on theories of Henderson and Larco (2000), Tilson (2001) and Womack and Jones (2003), scale questions were used to collect opinion data. The list of questions was also used to collect data on behaviour.In order to make sure that if an important item does not apply to a respondent and hinders non-response due to uncertainty, a category of **"other"** was added.

3.5 PROCEDURE FOR ADMINISTRATION OF INSTRUMENT AND DATA COLLECTION

Upon distribution of questionnaires to staff through the Human Resources Department, a two week grace was given for the submission. The instrument was administered on the respondents by the researcher with the help of a research assistant. The respondents were assured of confidentiality, that their responses would be used for research purposes only.A reminder was made a week after the distribution. As the majority of participants that were expected to make responses are at the supervisory level, it was expected that the two weeks will be long enough for required data to be collected. Majority of staff at

this level have satisfactory knowledge and training on the UEP tools and their applications. At the end of all collations,40 (out of 80) questionnaires distributed were received for analysis.

3.6 PROCEDURE FOR SCORING

The questionnaire consists of items based on respondent's level of fulfillment (Question testing the overall expectations of using UEP principles). A five point Likert scale was considered for this analysis (Likert, 1932).

Not at all fulfilled	=	1 point
Hardly fulfilled	=	2 points
Partially fulfilled	=	3 points
Largely fulfilled	=	4 points
Fully fulfilled	=	5 points

Another portion of the questionnaire also consist items based on Yes or No responses (Questions testing the importance of critical management factor). These were rated two and one (2, 1) respectively. Also, items patterned after the four point Likert scale format were scored as follows:

Not important	=	1 point
Little important	=	2 points
Important	=	3 points
Very important	=	4 points

3.7 DATA ANALYSIS AND HYPOTHESIS

For the data analysis, frequency counts and percentages were used to analyze data provided by the respondents. The chi-square test statistics was used to find out if there exist relation between the adaptation of this method and the overall success of the UEP implementation. The 2x2 contingency tables (cross tabulation) is a useful tool in this analysis. The computation of the expected values for all cells in a 2x2 contingency table is expressed in the form:

The general formula for each cell's expected frequency is: ,

$$Eij = (Ti \times Tj)/N$$where:

- Eij is the expected frequency for the cell in the ith row and the jth column.
- Ti is the total number of counts in the ith row.
- Tj is the total number of counts in the jth column.
- N is the total number of counts in the table.

3.8 VALIDITY AND RELIABILITY

The reliability and validity of the data collected largely depended on the design of the questions, the structure of the questionnaire and the rigour of the pilot testing (Saunders *et al*., 2003).

The questionnaire was piloted with 10 testers (respondents were individuals chosen from the sample frame as well as senior colleagues of the researcher, who have long experience in transforming organizations into UEP enterprises), who were also asked to comment on the clarity of the instructions. The goal was to find out how long it took to complete it, and to test if questions were unclear, ambiguous or uneasy to answer. The test showed that completing the questionnaire in 10 minutes was easily possible. Moreover, preliminary analysis using the test data was done in order to make sure that the data collected would allow the investigative questions to be answered.

The findings from the fieldwork were discussed within the context of the set objectives. The questions answered are:

1. Do the survey findings fit with or contradict existing theory or evidence?
2. Do the findings shed light on the existing body of knowledge?
3. What are the critical success factors for sustainable UEP implementation?
4. What are the challenges and problems associated with the UEP implementation and what are the probable solutions proposed?

Together with these discussion recommendations were made for future business optimization and practices.

CHAPTER FOUR

RESULTS

4.1 QUESTIONNARE DATA ANALYSIS

4.1.1 Questions testing the basic understanding of the UEP philosophy

Question 1: When did your organization start efforts to introduce UEP principles?

As shown in the introduction, UEP was introduced in Peugeot Automobile Nigeria in 2003. The question was aimed at discovering if staff can recall when the new work management effort started.

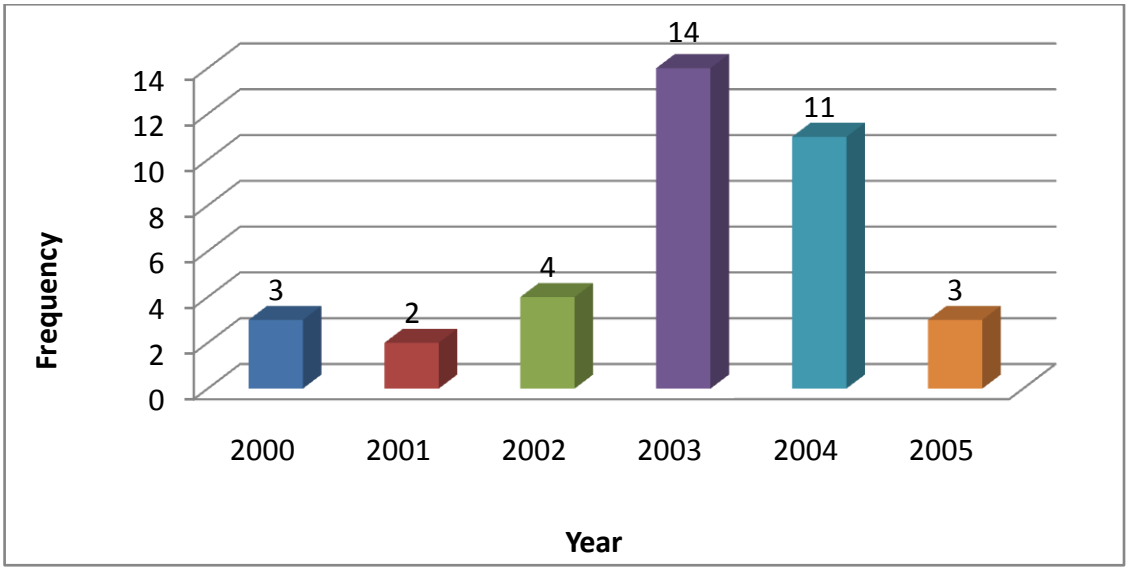


Figure 4.1 Starting year of UEP implementation in PAN

Looking at figure 4.1, from data analyzed and interview made, it was discovered that the process started in the production line in 2003 while other few work functions started using it from 2004.

Question 2: What do you associate with the UEP philosophy?

Considering figure 4.2 below, all respondents do not believe that UEP philosophy is a method to reduce headcount (0%). Of course UEP tools can be used to analyse redundancies, but its basic philosophy is to use these resources for further improvement

and growth. 28% see the UEP as a way to create new work and business. 43% of respondent believe that UEP is a system to reorganize the firm by product family and value stream. This value stream extends all the way from suppliers right through to customers and include all steps in between such as planning, distribution and logistics.

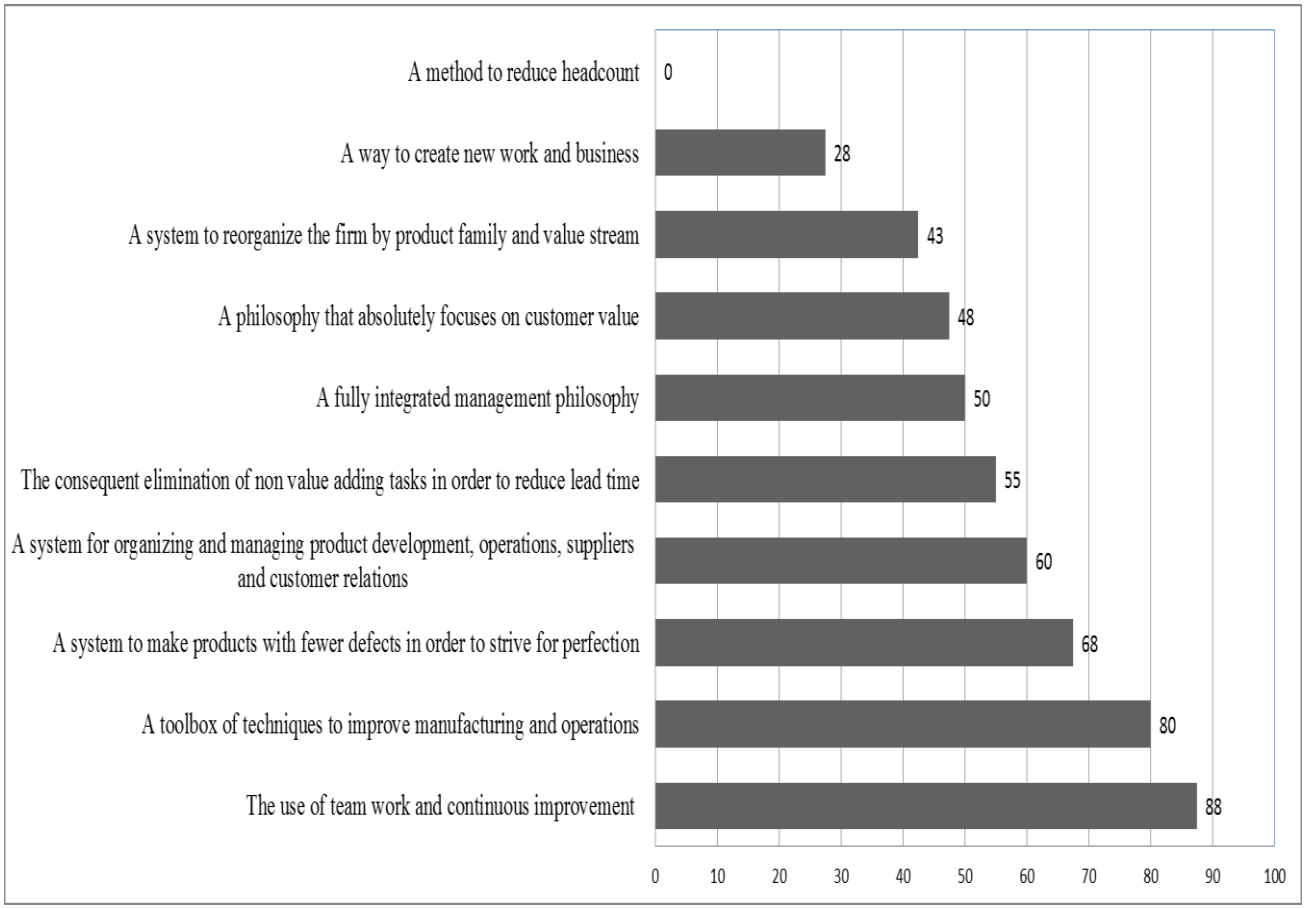


Figure 4.2 Associations with UEP manufacturing

48% of respondents see UEP as a philosophy that absolutely focuses on customer value and 50% see UEP as a fully integrated management philosophy which as the theory has shown is a presumption for success and sustainability.

55% have confidence that UEP philosophy leads to the elimination of non-value adding tasks in order to reduce lead time while 60% believe that it is the system for organizing and managing product development, operations, suppliers and customer relations. 68% of respondent indicated that UEP is a system to make products with fewer defects in

order to strive for perfection while 80% believe that it is a toolbox of techniques to improve manufacturing and operations. Ultimately, 88% of respondent confirm the fact that UEP promotes team work and continuous improvement.

It will be interesting to see how well these respondents were able to put this understanding into practice by analyzing if their expectations on implementing UEP were fulfilled or not.

Question 3: Why did your company decide using UEP principles?

From analysis in figure 4.3, the main reason for implementing UEP practices is "Continued pressure to improve operational performance" and the percentage is quite close to that of Wheatley as indicated in the literature review.

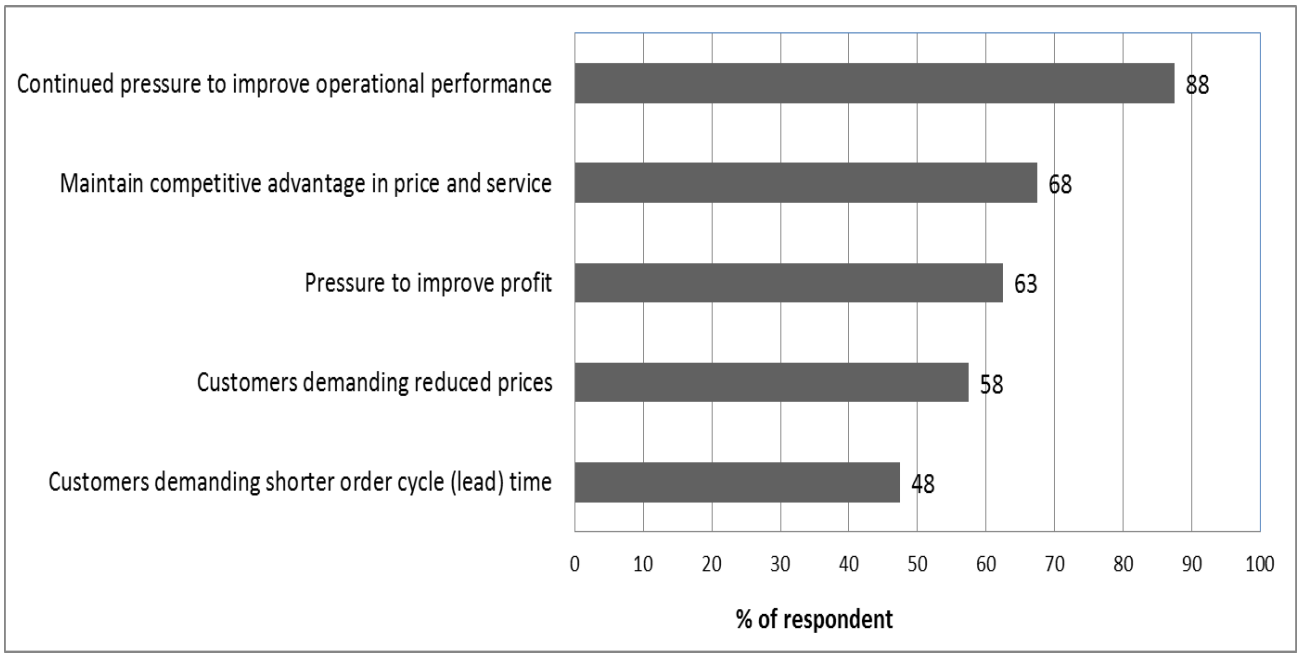


Figure 4.3 Reasons for using UEP principles in PAN

Together with the dispersion of the other factors (all roughly between 48% and 88%) it can be concluded that the sampling frame is suitable enough to draw reasonable conclusions. 58% of the respondent in the sample indicated that their customers are driving their UEP efforts by demanding reduced prices.

According to the literature review this is the other way around, companies should always ask themselves how much the customer is willing to pay and that automatically reduce waste in order to offer a competitive price.

Question 4: Overall expectations using UEP principles.

The fact that below 10% of the survey participants (see figure 4.4) are entirely fulfilled with their UEP implementation shows that the UEP is not easy to apply.

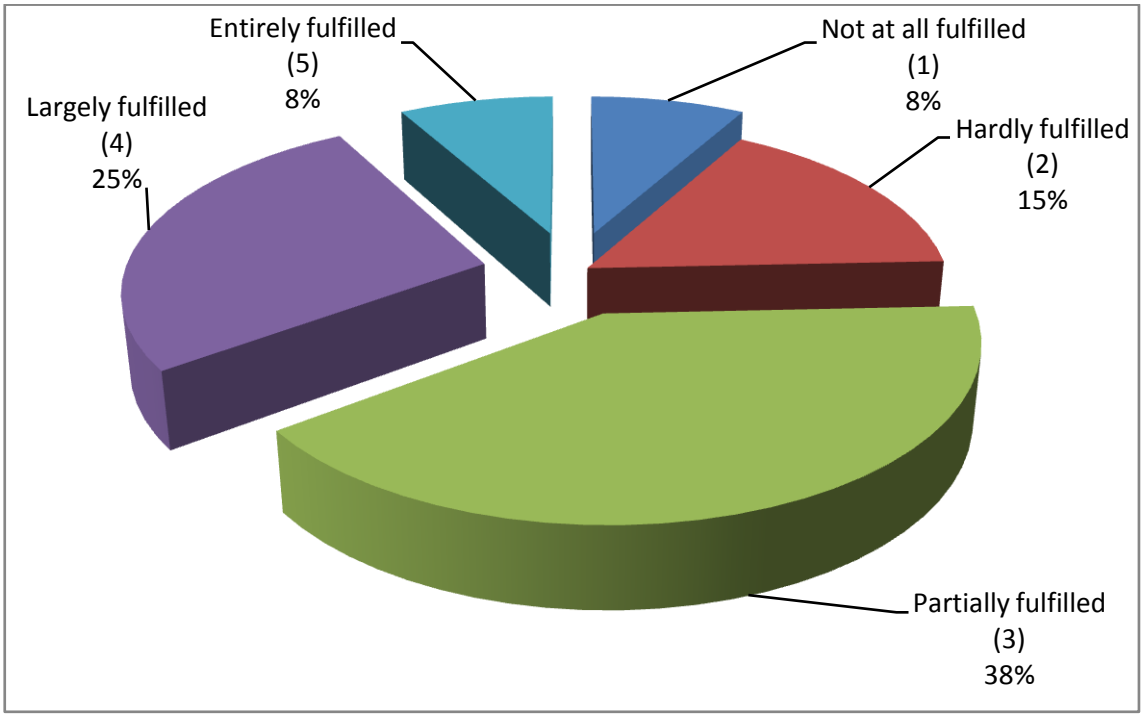


Figure 4.4 Expectations on using UEP principles in PAN

However when looking at the whole dispersion of the data it can be said that the variation follows the normal distribution (see figure 4.5) which again is an indicator that the sample is representative for the whole population as one would expect this distribution type.

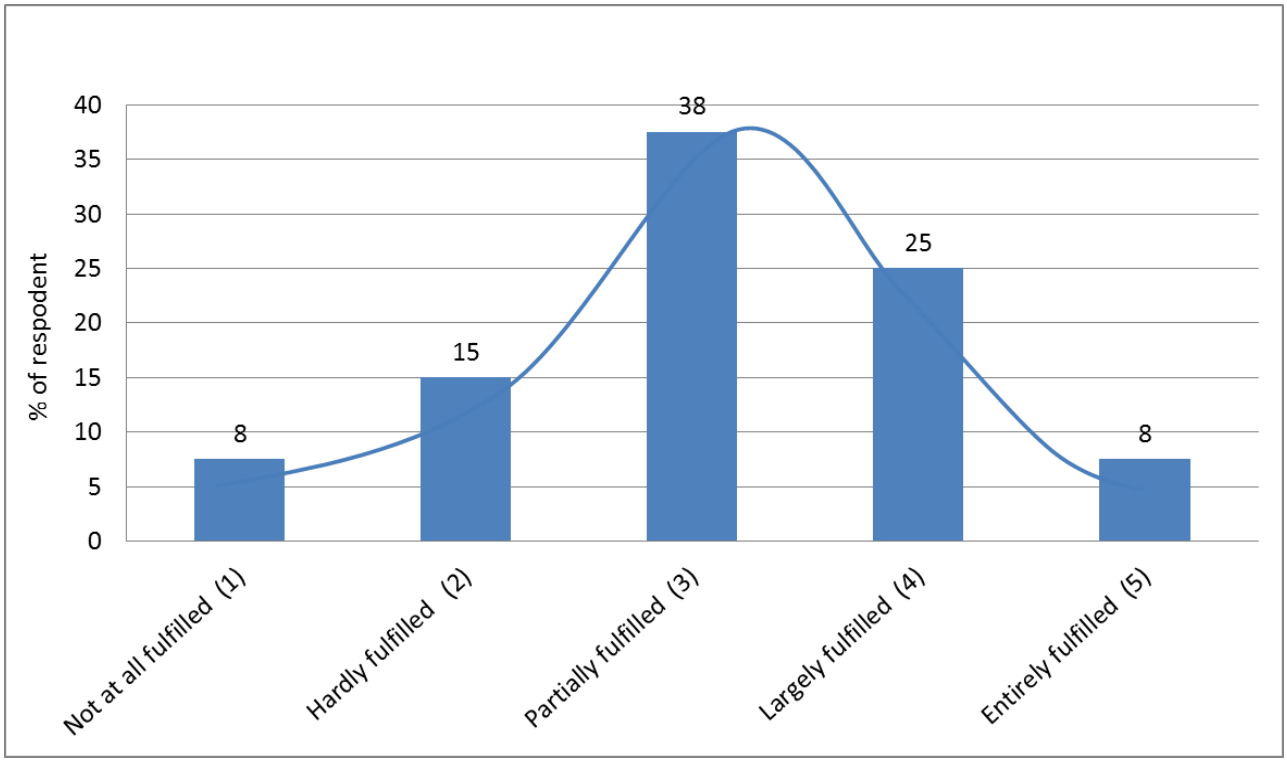


Figure 4.5 Distribution of expectations

4.1.2 Questions to analyse the usage of UEP tools and techniques

Question 5: The specific UEP tools your organization is using in order to become a UEP enterprise.

Question 5 needed to analyse the application of the UEP toolbox among the respondents asking which tools are used and where they are utilized.

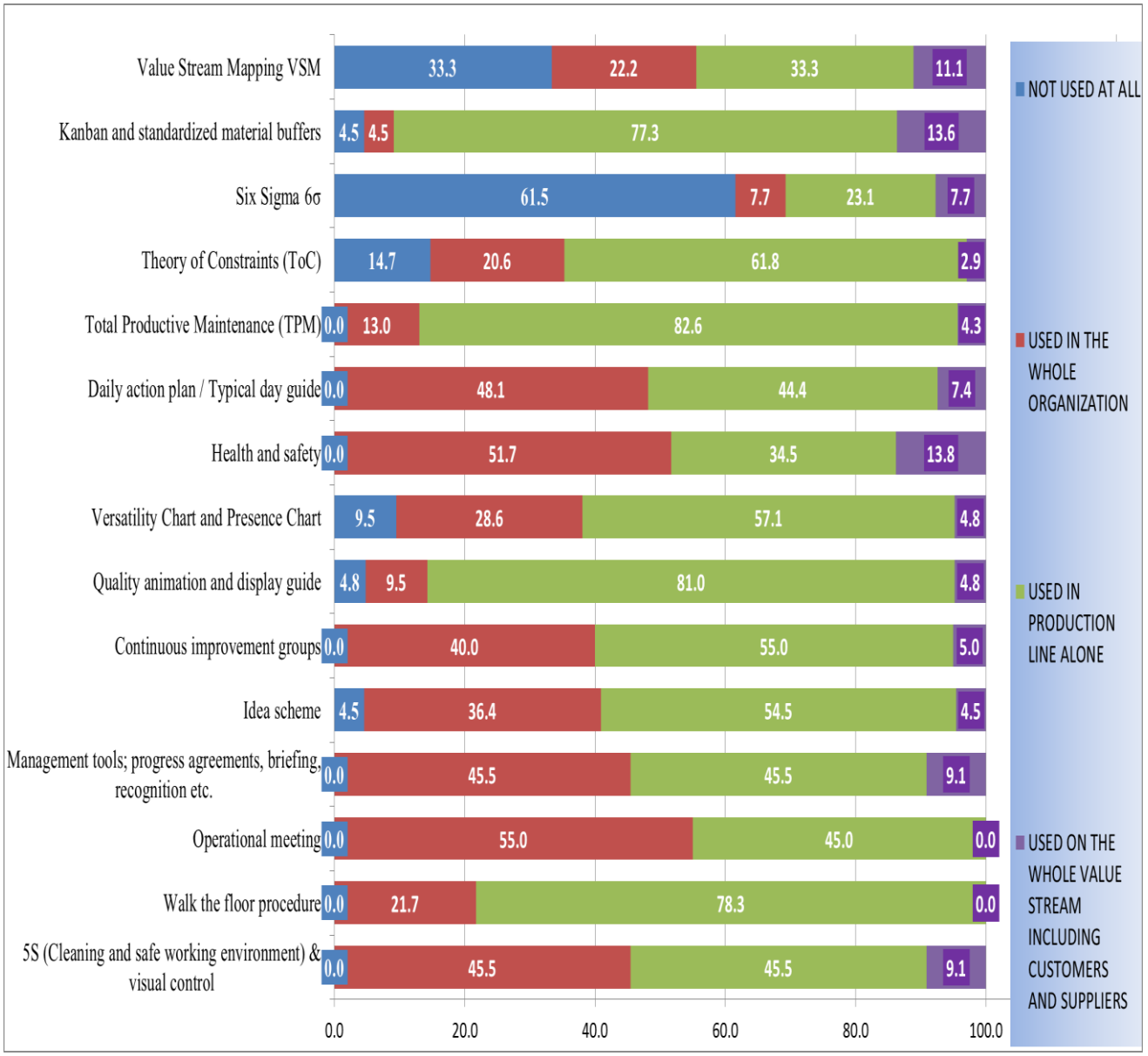


Figure 4.6 UEP tools used in PAN

From findings (figure 4.6), the top three tools which are not used at all are six sigma (62%), Value Stream Mapping VSM (33%) and Theory of Constraints ToC - bottleneck identification and elimination (15%). There is no point contesting this since the recorded data clearly shows that these tools are neither used at all nor used in the whole value stream.

The Literature review revealed that all tools listed in the chart are useful to the success of UEP implementation. In order to deduce that those that are not applied might not

necessarily hinder the progress, Chi-square was used to find out if there is a relation between the adaptation of this method and the overall success of the UEP implementation. Therefore the survey data was grouped as indicated in table 4.1.

Table 4.1: Contingency table – Relation between use of Theory of Constraints ToC and UEP implementation success

	THEORY OF CONSTRAINTS(ToC)	
Expectations on UEP implementation	Not used at all	Local use, use in the whole factory and value chain
Expectations not & hardly fulfilled	5	1
Expectations largely & entirely fulfilled	7	21

Hypotheses to be tested are described below.

If the test statistic are very low (usually p = 0.05 or lower), then there is a statistically significant relationship (Saunders *et al*., 2003).

H_o: There is no relation between the adaptation of ToC and successful UEP implementation.

H_1: There is a relation between the adaptation of ToC and successful UEP implementation.

Chi-Square Test: not used at all; local use, use in factory and value chain

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

		Not used at all	Local use, use in the whole factory and value chain	Total
I		5	1	6
		2.12	3.88	
	X^2 = (O-E)^2/E	3.92	2.14	
II		7	21	28
		9.88	18.12	
	X^2 = (O-E)^2/E	0.84	0.46	
Total		12	22	34
	Chi-squqre X^2 =	7.36	(i.e, 3.92+2.14+0.84+0.46)	
	Degree of freedom =	1	from (#rows - 1)(#columns - 1)	
	p-value =	0.0067	i.e, CHIDIST(X^2, degree of freedom)	

Figure 4.7: χ^2 Test – Relation between the adaptation of ToC and successful UEP implementation.

From analysis in figure 4.7, the p-value of 0.0067 indicates that there is enough evidence to reject $H_{o.}$ This means that there is a relation between the adaptation of ToC and successes with UEP implementation efforts.

More so, the calculated chi-square value for the set of data analyzed (7.36) is greater than that of 5% critical value on chi-square table (3.84). So we reject the null hypothesis. There is a significant difference between the data sets that cannot be due to chance alone. If the number calculated is less than the number found on the table, then we can probably say that any differences are due to chance alone.

This analysis implies that six sigma also follow the same trend. It was noted that six sigma requires the use of more advanced statistical tools. It is quite understandable why the system could not be fully adopted as part of the UEP tool in PAN.

4.1.3 Questions analyzing the scope of UEP implementation

Question 6: Which of the following functions is strategically integrated in your company's UEP rollout?

Figure 4.8 show the percentage distribution of the responses analyzed considering the scope of UEP implementation in PAN. Summing up the categories "fully" and "largely integrated" it can be seen that the function production is the area where UEP is broadly deployed (85%).

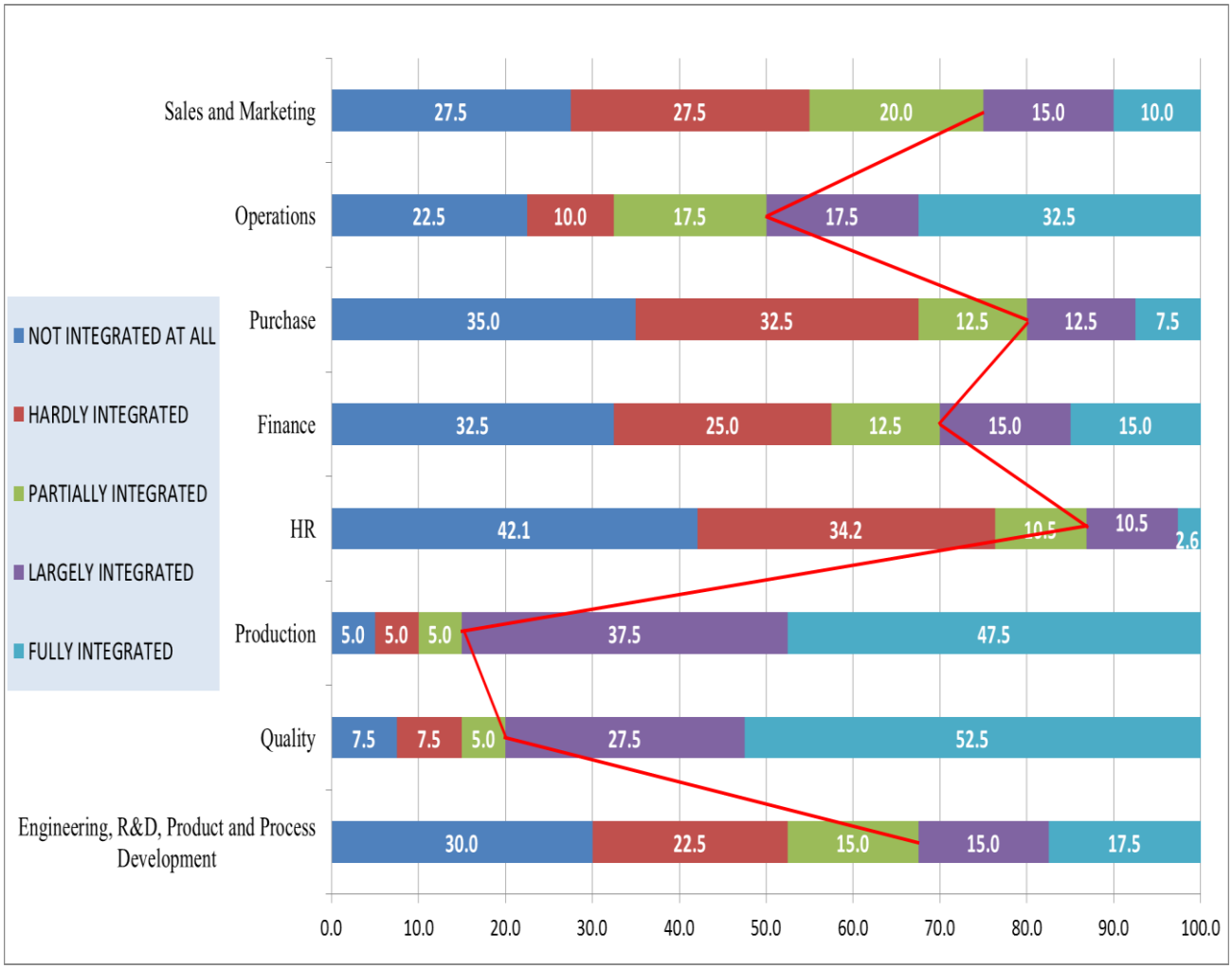


Figure 4.8: Scope of UEP implementation in PAN

The literature review has shown that UEP methods include a lot of quality tools. Therefore it is not surprising that the second biggest function that is largely integrated (as represented by the **red** terminal line) is quality (28%), next to production (38%).

To further analyze this, a contingency table (i.e. table 4.2) deduced from grouped survey data, was used to find out if there is a relation between theintegration of HRor purchase and successful UEP implementation.

Table 4.2: Contingency tables – relation between HR & Purchase integration and UEP implementation success

	HR		PURCHASE	
Expectations on UEP implementation	not/hardly integrated	fully/largely integrated	not/hardly integrated	fully/largely integrated
Expectations not & hardly fulfilled	16	1	14	3
Expectations largely & entirely fulfilled	13	4	13	5

H_o : There is no relation between the adaptation of HR or purchase and successful UEP Implementation.

H_1 : There is a relation between the adaptation of HR or purchase and successful UEP Implementation.

From analysis in figure 4.9, the p-value is 0.15 and the calculated chi-square value (2.11) is less than that of the 5% critical value (3.84). Therefore, the null hypothesis is accepted. The observed difference is not significant since there is no evidence that supports the alternative hypothesis.

The analysis for HR did not deliver a usable p-valueas the chi-square approximation was invalid due a lack of enough data.Most survey participants answeredeither that their expectations were partially fulfilled or that the functions werepartially integrated and these data sets could not be integrated into theanalysis.

Chi-Square Test: not/hardly integrated; fully/largely integrated

Expected counts are printed below observed counts

Chi-Square contributions are printed below expected counts

		not/hardly integrated	fully/largely integrated	Total
I		16	1	17
		14.50	2.50	
	X^2 = (O-E)^2/E	0.16	0.90	
II		13	4	17
		14.50	2.50	
	X^2 = (O-E)^2/E	0.16	0.90	
Total		29	5	34

Chi-squqre X^2 =	2.11	(i.e, 0.16+0.90+0.16+0.90)
Degree of freedom =	1	from (#rows - 1)(#columns - 1)
p-value =	0.1463	i.e, CHIDIST(X^2, degree of freedom)

Figure 4.9: χ_2 Test – Relation between the adaptation of HR and successful UEP implementation.

Based on the literature review a relation between these aspects would also be expected for purchase. However, the limited sample size and the limited number of respondents answering these options do not allow statistically correct conclusions for the population.

4.1.4 Questions testing the importance of critical management factors

Question 7: Which of the following aspects is or was considered during your organizational UEP rollout and which one in your opinion (on a scale from 1 to 4) is critical for successful UEP transformation?

To summarize, more than 50% of all respondents did take the mentioned points into account (with exception of the last four aspects, see table 4.3).

The data was grouped (<50%, 50% to 70%, and > 70% of respondents took aspect into account) for further analysis.

In total there were 5 aspects out of 15 which were taken into account by 70% (and above) of the participants. These 5 points deal with employee involvement (#1, #3 and #5), communication (#2), and top management behavior (#4). When analyzing the concepts that were only used by less than 60%, it is surprising to note that only 55% related converting from top-down leadership to bottom-up initiatives to the success of UEP rollout. 48% respondent related top management presence and availability on the shop floor (and offices) to the success of UEP rollout. 45% related availability of crises that motivates the organization to change to the success of UEP rollout. In order to find out whether this is critical or not, the data needed to be analyzed in more depth by comparing successful and less successful survey participants.

Table 4.3 Aspects considered in the group of "expectations on UEP implementation largely & entirely fulfilled" and in the group of "expectations not at all & hardly fulfilled"

SN	OPTION (SUCCESS FACTORS)	**YES** (% OF "EXPECTATIONS LARGELY"AND "ENTIRELY FULFILLED")		**NO** (% OF "EXPECTATIONS NOT AT ALL" AND "HARDLY FULFILLED")	
		TOTAL FREQUENCY	%	TOTAL FREQUENCY	%
1	Employee pull (employee fully understand the benefits on UEP and improvement on themselves independent of management's support	33	82.5	7	17.5
2	Communication of the transformation process, goals etc	32	80.0	8	20.0
3	Getting shop floor commitment and employee trust	31	77.5	9	22.5
4	Board and top management actively driving and supporting change	30	75.0	10	25.0
5	Finding a good change agent	29	72.5	11	27.5
6	Managerial push (mandatory participation in workshop and training)	28	70.0	12	30.0
7	Leaders (Group, Team) motivate, train, facilitate the work of those adding value rather than tell them what to do	27	67.5	13	32.5
8	Striving for perfection/excellence	25	62.5	15	37.5
9	Implementing reward and incentive system for successful transformation (after stage validation)	24	60.0	16	40.0
10	Resources freed up by productivity gains and reinvested into the search for still greater improvement	24	60.0	16	40.0
11	Converting from top-down leadership to bottom-up initiatives	22	55.0	18	45.0
12	Top management presence and availability on the shop floor (and offices)	19	47.5	21	52.5
13	Availability of a crises that motivates the organization to change	18	45.0	22	55.0
14	Elimination of Managers who would not cooperate in order to get commitment to UEP	14	35.0	26	65.0
15	Integrating suppliers and customers into the UEP transformation	14	35.0	26	65.0

The data was then grouped based on the fulfillment of expectations on the UEP implementation as afterwards further conclusions on the research question were drawn by comparing aspects considered in the group where expectations were fulfilled with the group where expectations were not fulfilled (see table 4.3).

When asking what were the aspects and concepts which 60% or more of the participants who were satisfied with their UEP implementation considered that the top factors are

the communication of the process and goals as well as the speed of the process. It can be seen that cultural and leadership aspects seem to play a far more important role than the UEP tools. Remarkably, 16% of those whose expectations were not fulfilled had direct links with resources freed up by productivity gains and reinvested into the search for still greater improvement. It can also be seen that in the second part of the question, the participants were asked to rank theseaspects concerning importance on a scale from 1 (not important) to 4 (very important) for successful UEP implementation. See table 4.4.

Table 4.4 Critical management factors for successful UEP implementation in PAN

SN	ASPECTS	CRITICAL VALUE % (SCALE 1-4)
1	Getting shop floor commitment and employee trust	62
2	Communication of the transformation process, goals etc	61
3	Employee pull (employee fully understand the benefits on UEP and improvement on themselves independent of management's support	56
4	Leaders (Group, Team) motivate, train, facilitate the work of those adding value rather than tell them what to do	56
5	Striving for perfection/excellence	54
6	Managerial push (mandatory participation in workshop and training)	53
7	Converting from top-down leadership to bottom-up initiatives	53
8	Board and top management actively driving and supporting change	52
9	Finding a good change agent	52
10	Implementing reward and incentive system for successful transformation (after stage validation)	52
11	Resources freed up by productivity gains and reinvested into the search for still greater improvement	47
12	Top management presence and availability on the shop floor (and offices)	45
13	Integrating suppliers and customers into the UEP transformation	43
14	Availability of a crises that motivates the organization to change	42
15	Elimination of Managers who would not cooperate in order to get commitment to UEP	40

Using the highest ranked factor as an example, a score was used to build priorities and a ranking (i.e. eleven participants answered "4", six answered "3", none answered "2", and none answered "1" – score : 11x4 + 6x3 + 0x2 + 0x1 = 62. The resulting data was used to rank the aspects and the datasets were grouped in data above 54% of the top score and below 54%. The fact that even the lowest score is 40% shows that all aspects

are generally relevant for the research topic, therefore it can be concluded that the reality proves the significance of the factors that the literature review has shown.

The dispersion of top five (5) management factors can also be graphically displayed as shown in figure 4.10.

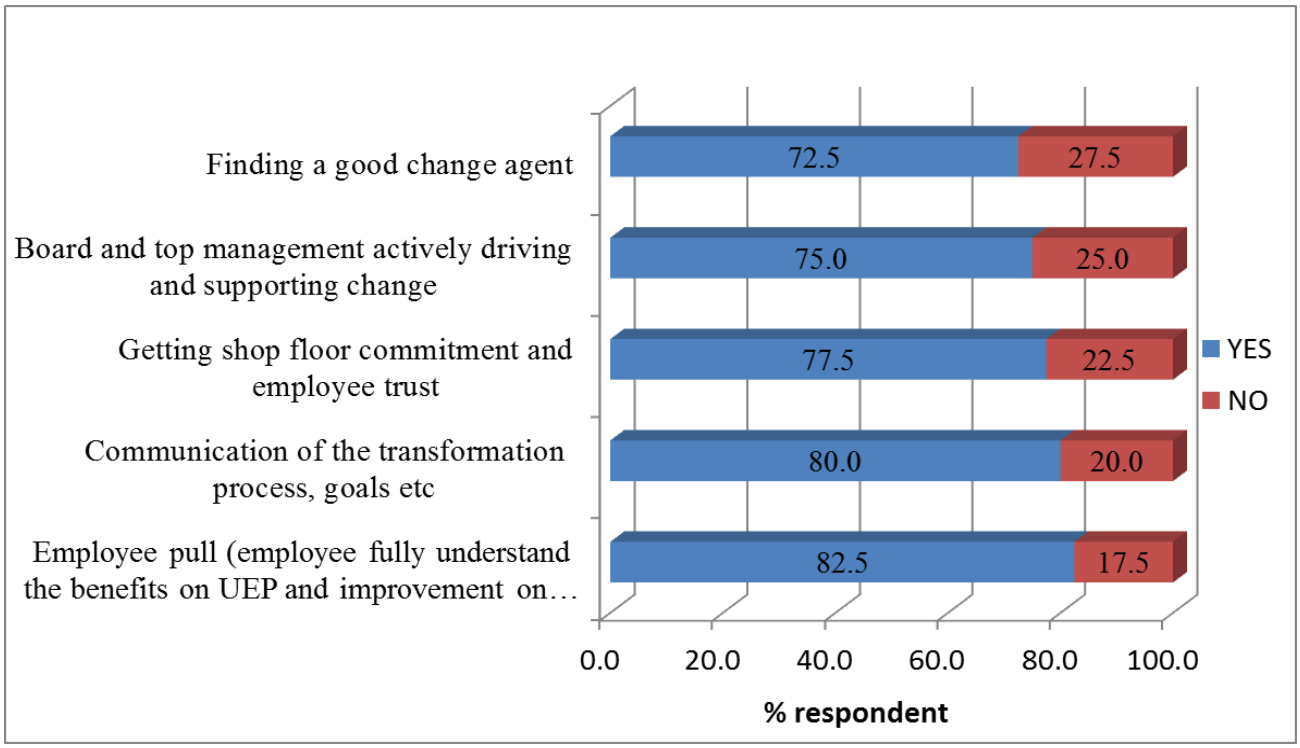


Figure 4.10: Dispersion of top 5 management factors

Again the majority of survey participants have ranked leadership aspects, employee involvement and communication of the process high.

Considering table 4.4 above, the aspects that respondents ranked highest (top three) was statistically verified. The first hypothesis to be verified or rejected was built.

H_o: Getting shop floor commitment and employee trust are not critical for successful UEP implementation.

H_1: Getting shop floor commitment and employee trust are critical for successful UEP implementation.

Table 4.5: Contingency tables – relation between shop floor commitment, employee trust and expectations on using UEP principles

Expectations on UEP implementation	Shop floor trust considered	Shop floor trust not considered
Expectations not & hardly fulfilled	3	2
Expectations largely & entirely fulfilled	24	7

The contingency table 4.5 deduced from grouped survey data, was used to find out if there is a relation between the shop floor trust and successful UEP implementation.

Chi-Square Test: shop floor trust considered; shop floor trust not considered

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

		Shop floor trust considered	Shop floor trust not considered	Total
I		3	2	5
		3.75	1.25	
	X^2 = (O-E)^2/E	0.15	0.45	
II		24	7	31
		23.25	7.75	
	X^2 = (O-E)^2/E	0.02	0.07	
Total		27	9	36
	Chi-squqre X^2 =	0.70		
	Degree of freedom =	1	from (#rows - 1)(#columns - 1)	
	p-value =	0.4039	i.e, CHIDIST(X^2, degree of freedom)	

Figure 4.11: χ^2 Test – Relation between shop floor commitment & employee trust and expectations on using UEP principles

From data analyzed in figure 4.11, the p-value is 0.40 and the chi-square value is less than the critical value. The observed difference is significant. Hence, p-value of 40% does not allow rejecting H_o.

H_o: Employee pull is not critical for successful UEP implementation.

H_1: Employee pull is critical for successful UEP implementation.

Table 4.6: Contingency tables – Relation between employee pull and expectations on using UEP principles

Expectations on UEP implementation	Employee pull considered	Employee pull not considered
Expectations not & hardly fulfilled	4	2
Expectations largely & entirely fulfilled	25	6

The contingency table 4.6 deduced from grouped survey data, was used to find out if there is a relation between the employee pull and successful UEP implementation.

Chi-Square Test: Employee pull considered; employee pull not considered

Expected counts are printed below observed counts

Chi-Square contributions are printed below expected counts

		Employee pull considered	Employee pull not considered	Total
I		4	2	6
		4.70	1.30	
	X^2 = (O-E)^2/E	0.11	0.38	
II		25	6	31
		24.30	6.70	
	X^2 = (O-E)^2/E	0.02	0.07	
Total		29	8	37
	Chi-squqre X^2 =	0.58		
	Degree of freedom =	1	from (#rows - 1)(#columns - 1)	
	p-value =	0.4465	i.e, CHIDIST(X^2, degree of freedom)	

Figure 4.12: χ^2 Test – Relation between employee pull and expectations on using UEP principles

From data analyzed in figure 4.12, the p-value is 0.45 and the chi-square value is less than the critical value. Hence, p-value of 45% does not allow rejecting $H_{o.}$

H_o: Communication of the transformation process, goals is not critical for successful UEP implementation.

H_1: Communication of the transformation process, goals is critical for successful UEP implementation.

Table 4.7: Contingency tables – Relation between communication of transformation process and expectations on using UEP principles

Expectations on UEP implementation	Communication considered	Communication not considered
Expectations not & hardly fulfilled	2	3
Expectations largely & entirely fulfilled	25	6

The contingency table 4.7 deduced from grouped survey data, was used to find out if there is a relation between the communication and successful UEP implementation.

Chi-Square Test: Communication considered; communication not considered

Expected counts are printed below observed counts

Chi-Square contributions are printed below expected counts

		Communication considered	Communication not considered	Total
I		2	3	5
		3.75	1.25	
	$X^2 = (O-E)^2/E$	0.82	2.45	
II		25	6	31
		23.25	7.75	
	$X^2 = (O-E)^2/E$	0.13	0.40	
Total		27	9	36
	Chi-squqre X^2 =	3.79		
	Degree of freedom =	1	from (#rows - 1)(#columns - 1)	
	p-value =	0.05145	i.e, CHIDIST(X^2, degree of freedom)	

Figure 4.13: χ_2 Test – Relation between Communication of the transformation process, goals etc. and expectations on using UEP principles

From data analyzed in figure 4.13, the p-value is 0.05 and the chi-square value is a quite close to that of the critical value (3.84). The p-value of this chi-square test isexactly at the selected significance level of 5%. This would mean that thishypothesis would need further research with more data as the risk of drawingwrong conclusions is too high.

Based on the data given by the respondents one could argue that communication of the transformation process during the UEP transformation is quite significant.

This fact is also confirmed when looking at aspect number one (gettingshop floor commitment and employee trust). Survey participants have theopinion that it is critical for success but this cannot be verified with the analysis in figure 4.11.

From the survey data one canconclude that having shop floor commitment & employee trust or not does not make a difference for success. The literature review shows that this is one aspect that is very vital to successful implementation. It is probable that the small

sample size (especially thesize of the group of participants that were not fulfilled) causedthis p-value. This can only be clarified by further research, especially witha stronger focus on organizations which were not satisfied with their UEP efforts.

4.2 DEFECT ANALYSIS FOR PRODUCED/TESTED CARS

The introduction of UEP in 2003 was a very critical management decision which faced series of challenges. The major one being resistance to change. Table 4.8 shows the aspect and functional quality indicators for produced cars just before and after UEP full implementation. These are average values recorded per year. This analysis is just to show how the introduction of UEP philosophy improved quality of finished cars.

Table 4.8 Peugeot quality indicators (PAN, 2013)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
MODEL	406	406	406	406	406	406	406	307	307	307	307
IQA AVERAGE	130.7	124	135	155	149	111	97	196	117	108	109
Majpr def.Avg.	1.4	0.64	0.68	0.61	0.5	0.33	0.13	1.91	0.09	0.17	0.83
IQF AVERAGE	36.01	28	31.21	27	31	22.4	18.4	36.9	15	15	20
Majpr def.Avg.	0.33	0.15	0.09	0.11	0.09	0.07	0.07	0.2	0.03	0.02	0

The essence of statistical quality control SQC in a manufacturing process is to apply statistical techniques to measure and evaluate the quality of a product, service or process. Defect sources are easily located and eliminated. A good scenario is to analyse how many paint defects there are in the finish of a car? Have we improved our painting process by installing new sprayers? Using the Aspect Quality Indicator IQA and Function Quality Indicator IQF data shown in table 4.8 for this analysis gives:

Table 4.9 Calculating the Standard deviation (PAN, 2013)

Calculating the Standard deviation									
UEP	SN	YEAR	IQA (O)	EXPECTED VALUE (E)	(O-E)^2		IQF (O)	EXPECTED VALUE (E)	(O-E)^2
BEFORE	1	2002	130.70	110.00	428.49		36.01	25.00	121.22
	2	2003	124.00	110.00	196.00		28.00	25.00	9.00
DURING	3	2004	135.00	110.00	625.00		31.21	25.00	38.56
	4	2005	155.00	110.00	2025.00		27.00	25.00	4.00
	5	2006	149.00	110.00	1521.00		31.00	25.00	36.00
	6	2007	111.00	110.00	1.00		22.40	25.00	6.76
	7	2008	97.00	110.00	169.00		18.40	25.00	43.56
	8	2009	196.00	110.00	7396.00		36.90	25.00	141.61
	9	2010	117.00	110.00	49.00		15.00	25.00	100.00
AFTER	10	2011	108.00	110.00	4.00		15.00	25.00	100.00
	11	2012	109.00	110.00	1.00		20.00	25.00	25.00
		Variance S^2 = SUM(O-E)^2/(n-1)			1241.549			S^2 =	62.57142
		n = Sample size (number of data points)			11				11
		Standard deviation		S =	35.23562118			S =	7.9102099
				S =	35%			S =	8%
		Coefficient of variation (CV) = S/E =			0.320323829		Coefficient of variation (CV) = S/E =		0.31641

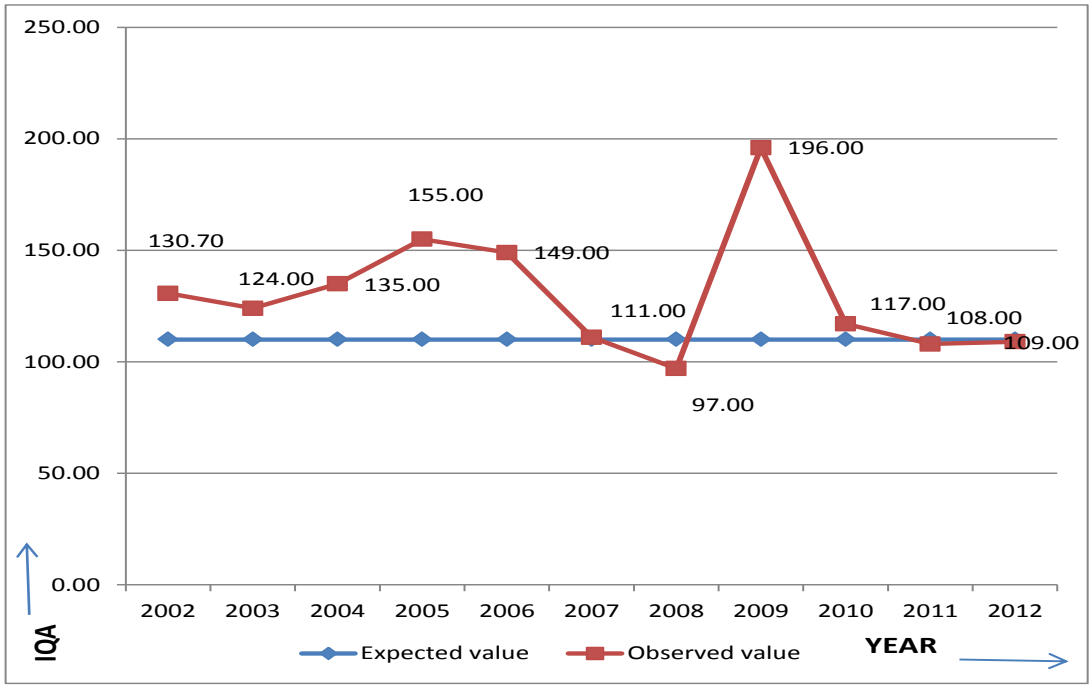


Figure 4.14 (a) Quality chart for IQA

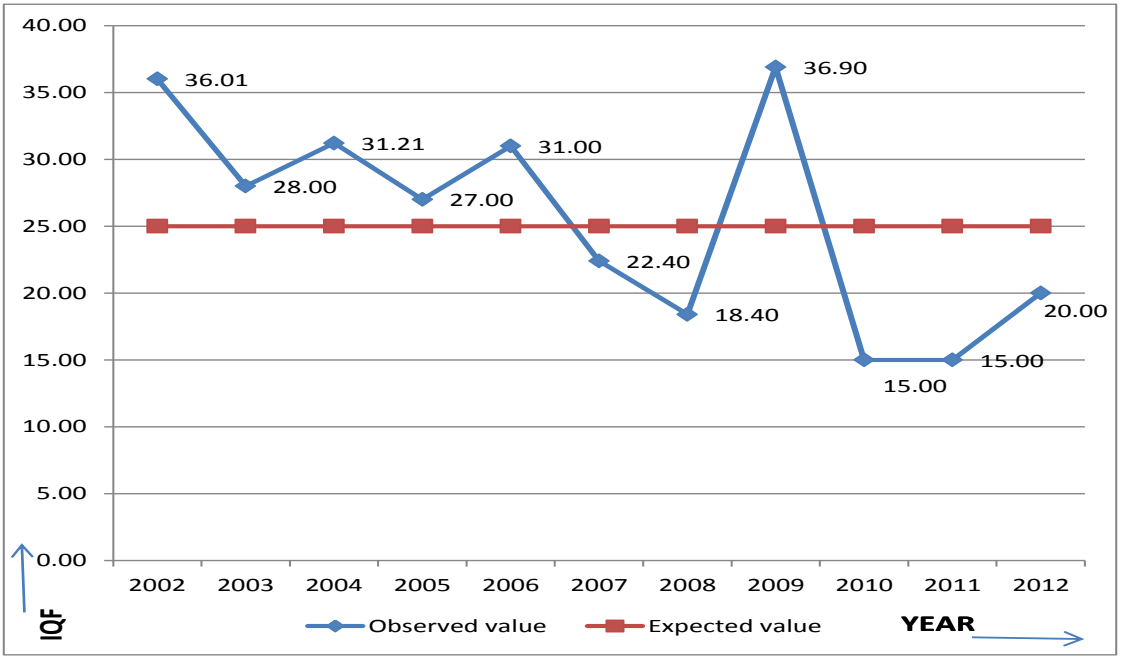


Figure 4.14 (b) Quality chart for IQF

By calculating how the standard deviation relates to the mean, otherwise known as the coefficient of variation (CV) gives a more uniform method of determining the relevance of the standard deviation. The closer the CV is to 0, the greater the uniformity of data. The closer the CV is to 1, the greater the variability of the data.

$$CV = S/M \quad ,$$

where “S” is standard deviation, “M” is sample mean.

Considering the data analyzed in table 4.9, the CV for both IQF and IQA is approximately 0.32. This is rather large, indicating that the data has a great deal of variability with respect to the mean and there is no general consensus among the sample or observed values.

Similarly from investigation and analysis made in figure 4.14 (a and b), erratic behaviour was noticed on the quality charts from 2007. The full implementation of UEP is expected to promote the attainment of quality level around the international standard of IQA value of 110 and IQF value of 25 points (i.e. Z-score tending towards zero). The IQA and IQF values tend towards this standard in the year 2008 and later stabilized in 2011.

Table 4.10 Calculating the Z-score (PAN, 2013)

Calculating the Z-score

UEP	SN	YEAR	IQA (O)	EXPECTED VALUE (E)	Z=(O-E)/S		IQF (O)	EXPECTED VALUE (E)	Z=(O-E)/S
BEFORE	1	2002	130.70	110.00	0.59		36.01	25.00	1.39
	2	2003	124.00	110.00	0.40		28.00	25.00	0.38
DURING	3	2004	135.00	110.00	0.71		31.21	25.00	0.79
	4	2005	155.00	110.00	1.28		27.00	25.00	0.25
	5	2006	149.00	110.00	1.11		31.00	25.00	0.76
	6	2007	111.00	110.00	0.03		22.40	25.00	-0.33
	7	2008	97.00	110.00	-0.37		18.40	25.00	-0.83
	8	2009	196.00	110.00	2.44		36.90	25.00	1.50
	9	2010	117.00	110.00	0.20		15.00	25.00	-1.26
AFTER	10	2011	108.00	110.00	-0.06		15.00	25.00	-1.26
	11	2012	109.00	110.00	-0.03		20.00	25.00	-0.63

At mean Z = 0

The z-score represents the number of standard deviations that a data value is away from the mean.

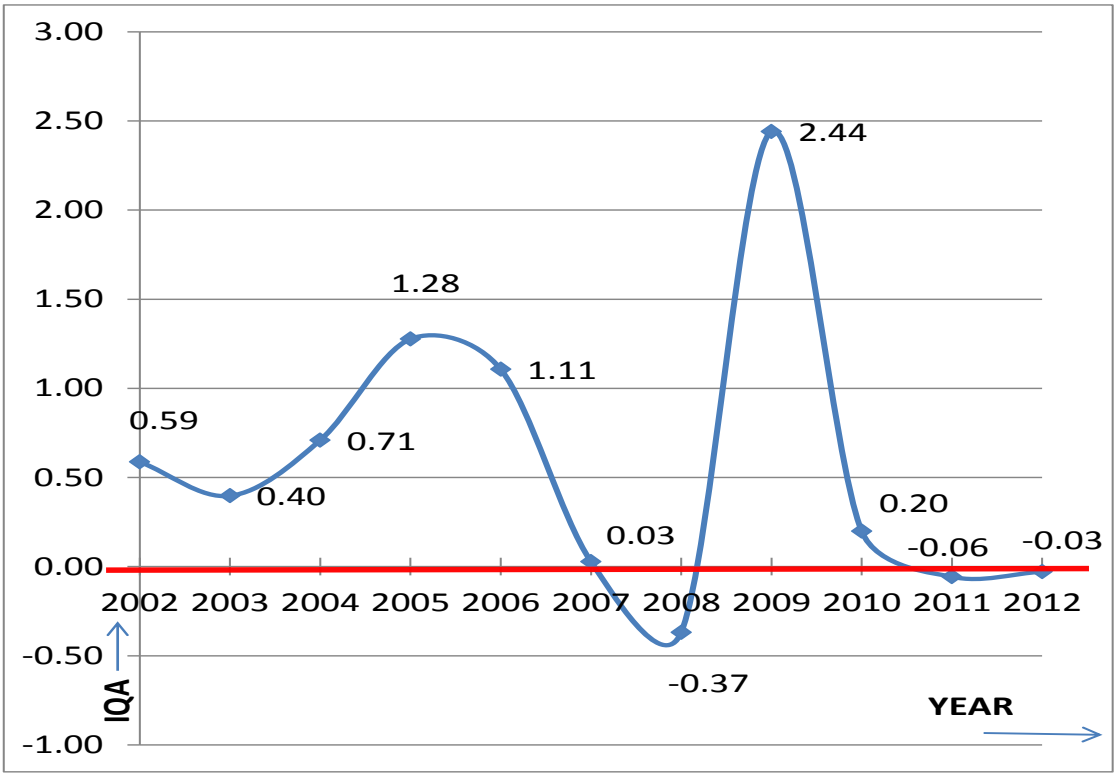


Figure 4.15 (a) Z-score chart for IQA

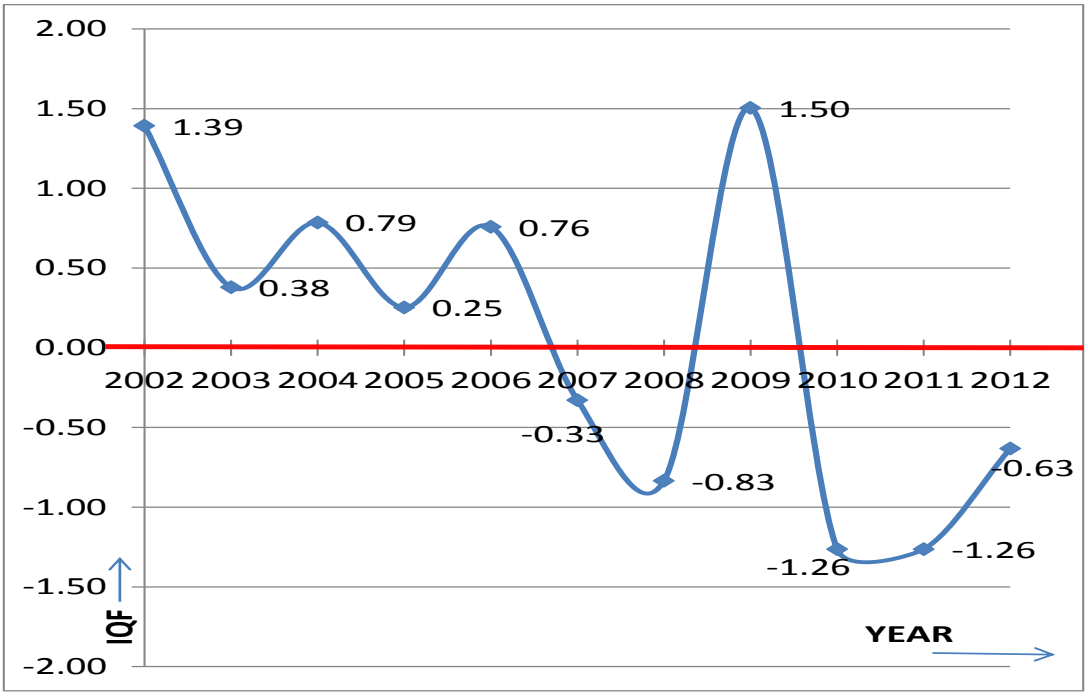


Figure 4.15 (b) Z-score chart for IQF

Considering the quality indicators IQA and IQF indicated in table 4.10 and analyzed in figure 4.15 (a and b), there is no good explanation for the **erratic behaviour** noticed in

2009. From 2010 to 2012 the behaviour later tends towards expected values as Z-score tends to zero (0). Sustaining quality standard achieved in 2008 is one critical issue associated with UEP philosophy.

4.3 PRODUCTION VOLUME

From investigations, production volume was erratic ranging from over 5,000 cars in 2003 to over 7,000 in 2009. This is attributed to the implementation of UEP. The sharp drop in cumulative production and sales volume of Peugeot products is said to be attributed to government policy (economic, political) on one hand and work organization (management) on the other.

4.4 SUMMARY OF FINDINGS

Based on the data gathered, analyzed and interpreted, the findings are summarized as follows:

- The percentages recorded for the application of UEP tools is more predominant in the production line than any other functional area.
- All critical aspects were more or less considered (only 4 out of 15 were not taken into account by at least 50% of the participants, (see table 4.3).
- The fact that the lowest score (critical value) is 40% is an indication that all aspects considered are relevant/important for this research topic (see table 4.4)
- Apart from tools that were indicated by respondents as “not used at all”, hypotheses show that majority of the tools have remarkable relationship with UEP implementation success.

CHAPTER FIVE

DISCUSSION

5.1 DISCUSSION OF RESULTS

From the research objectives earlier enumerated and from the application of the theoretical model of the Henley transformation framework it can be established that:

1 UEP is more philosophical than just a toolbox.

2 These tools are important, but the basic ideology of UEP is that people are the most important asset.

3 UEP is a fully integrated management and manufacturing philosophy. The strong balance between the key functions (operations and support functions), the top down approach and the role of continuous improvement are vital elements for successful UEP implementation.

The problems associated with the implementation of work management/optimization tools are broadly related to lack of total commitment from everyone to make it work. This survey shows that majority of respondents are aware of the philosophy even though it is not deeply rooted in lot of job functions.

In order to relate the survey findings to the existing theory and evidence within the context of the literature review the specific questions considered are enumerated in table 5.1.

Table 5.1 Relating the survey findings to the existing theory and evidence

Question	Theory and evidences	Survey findings
Understanding of the UEP philosophy	Global understanding of improvement philosophy	Understanding of UEP philosophy is not global
Usage of tools and techniques	Top three tools which are not used are Theory of Constraints ToC, six sigma	Top three tools which are not used are six sigma (due to cost), Theory of Constraints ToC and Value Stream

	and production smoothing	Mapping VSM (see figure 4.6).
Scope of UEP implementation	Second biggest function that is largely integrated is quality (34%). Total integration of all functional areas.	Second biggest function that is largely integrated is quality (28%) according to analyzed data from respondents. Total integration of all functional areas (not achieved).
Importance of critical management factor	1. All critical management factors are important for successful UEP implementation 2. Enhancement of overall performance	1. Not all critical management factors are applied, but voted "important" by majority of the respondents. 2. Quality data analyzed shows quality improvement to international standard.

It was deduced from the survey findings that, roughly 80% of the respondent associate the UEP with toolbox of techniques to improve manufacturing and operations (see figure 4.2) and 88% also associate it with the use of team work and continuous improvement. Generally it can be said that the survey confirms the theories of recent literature. All critical aspects were more or less considered (only 4 out of 15 which were not taken into account by at least 50% of the respondents, see bottom of table 4.3). From the findings of this study, and based on data analyzed in chapter four it can be deduced thus:

i. A huge variety authors (as shown in the literature review/theory) have underlined the need for a strongly supported top-down approach and the need for leadership in the process of UEP change. From responses the top five aspects (see table 4.3) fall

in the first category of the Henley transformation framework (see table 2.3) it can be said that based on the survey data ‘mobilizing for change’ seems to be the most important step on the UEP pathway.

ii. From analysis, employee pull and management push concerning the initiative are placed on rank 3 and 6 (see table 4.4). The literature discusses both approaches and does not come to a decision on which one is more important. To the respondents in the survey, employee pull is more critical. However, converting at a certain stage from top-down leadership to bottom-up initiatives in order to create an incremental change is relevant in the eyes of the respondents (53% answered yes, see table 4.4).

Use of Kanban, walk the floor, total productive maintenance, quality animation and display guide and bottleneck elimination with ToC, are more prominent in the production line alone (see figure 4.6).

iii. The fact that the literature did not deliver a sequence in which tools and concepts need to be deployed can be retrieved in the survey as 60% of participants associated resources freed up by productivity gains and reinvested into the search for still greater improvement a priority (see table 4.6). Based on this it cannot be said that this is not relevant for success although the reading supports this. However, there is no statistical evidence, as the data is only based on opinions, especially when asking if expectations were met or not. The participating persons may have defined success and their expectations in different ways which limits the conclusions drawn from the data.

iv. Many authors of books and articles in manufacturing improvement have clearly shown the importance of the ‘integration of all organizational functions’ in the transformation process. In comparison with the survey data this field is where the biggest gap between reality and theory exists. Considering analysis in figure 4.8 the function “quality” (53% respondents) is fully integrated into the process followed by

production (48% of respondents). Only 33% respondents fully integrated operations. Engineering, R & D, product and process development, HR, Purchase, finance, sales and marketing are even much lower. Whether a reward and incentive system is critical for successful UEP implementation or not could not be clarified. The respondents however do have a clear opinion: they have rated this aspect on the 10th rank of the importance scale (see table 4.4). It can be said that the sample supports those authors who deny the need for additional compensation.

In analyzing the need for skills, capabilities and resources, both the literature and the survey support the importance of the availability of a good change agent (rank 9, see table 4.4)

v. Six sigma is not used in PAN due to the fact that the initiative will require more advanced statistical tools. The creation of UEP pilots and training zones facilitates continuous improvement.

It can be said that the survey findings fit with existing theory. 40 out of 80 participated in giving full responses to questionnaire (i.e. 50%). Data drawn out of table 4.4, (Critical management factors for successful UEP implementation) clearly supports the theory. 10 out of 15 of the critical aspects have reached 52% (and above) of the possible top score (all participants voted “important”). When building quartiles (<25% “not important”; <50% little important; <75% “important” and <100% “very important”) all critical aspects taken from the literature on average have at least been voted by the respondents to be “important” for successful UEP implementation.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

a. CONCLUSIONS

The aim of this study was to investigate why the implementation of the work management philosophy, "UEP" is not yielding the expected results in PAN. Looking critically into the specific objectives of the study and considering the analyzed questions in the hypothesis earlier discussed, the following conclusions were drawn:

i. Statistical analysis shows that on average, UEP philosophy is well understood but less than 10% of the survey participants are entirely fulfilled with their UEP implementation. The indication here is that the stakeholder expectations were not entirely met. The best practice here is that the right strategy needs to be in place to ensure appropriate mobilization for UEP change?

ii. Analyzed data shows that not all organizational functions are integrated in the UEP transformation. Dealers, suppliers, subsidiaries and other key business partners are not adequately integrated into this system. The best practice here is to properly align the organization so as to extend the implementation process to all job functions and other business partners.

iii. Analyzed data shows that not all relevant UEP tools were used for the implementation. More focus was on the production line. This jeopardized the effectiveness of the entire operations. The success of the policy is determined by how broad the necessary tools are utilized throughout the value chain.

iv. Analyzed data shows that not all critical management factors were considered for the UEP implementation. The fact that the analyzed data shows that all aspects of the critical management factors for successful UEP implementation are generally relevant for successful UEP implementation, majority of this

aspects are not considered in the course of UEP implementation (for effective system optimization).

v. Analyzed data shows that international quality level attained due to UEP full implementation could not be maintained. The application of UEP tools helps in eliminating quality defects. The reason quality has gained such prominence is that organizations have gained an understanding of the high cost of poor quality. Quality affects all aspects of the organization and has dramatic cost implications. The most obvious consequence occurs when poor quality creates dissatisfied customers and eventually leads to loss of business.

The findings in this survey shed light on the existing body of knowledge. It clearly explains reasons why the UEP philosophy is not yielding the expected results. This is not only attributed to lack of full integration of the process in all functional areas but also to lack of total commitment at all levels. The most common roadblock to the successful implementation of UEP is the failure on the part of management - and particularly senior level leaders - to understand UEP as a comprehensive approach to manufacturing and management.To further sustain quality standardand system optimization, the control limits need to be made tighter and the coefficient of variation (CV) brought closer to zero. All these are possible through an effective use and total integration of UEP philosophy.

6.1.1 Limitations of findings

The entire population of staff at the point of this survey was 250. More than 50% of this population is junior workers with low intellectual capacity. The survey was aimed at getting the right input from supervisory staff at all functional areas in the company and the dealerships. The researcher had difficulty getting right data from the dealers and suppliers for their sense of neglect and non-inclusion in the transformation process.

6.1.2 Implication of findings

UEP philosophy is broadly used in Peugeot Automobile worldwide. It is working perfectly in France. This survey has extensively identified the non-integration of purchase, sales, human resources, research and development, dealers and suppliers as the major reasons why Unity and Efficiency in Production (UEP) method is not yielding the expected results in PAN Nigeria. This survey has also identified that continuous improvement, sustained quality standard and teamwork are vital for enhancing the operations of automobile companies in Nigeria.

Recommendations proffered could set the system back on track of greatness, high level of productivity and profitability. The policy could also be extended to other manufacturing outfits and not automobile alone.

6.2 RECOMMENDATIONS

6.2.1 Implementation recommendations

i. **Train the organization and make sure that everybody thoroughly understands the UEP philosophy.** Within an organization, only a good education and training programmes helps in starting and running a successful UEP culture. Training and education at all levels is vital to the success of UEP. It should cover all aspects required through to problem solving techniques.

ii. **Employee Empowerment and Involvement.** Empowerment of employees is involving them in organizational planning, have the abilities and tools to perform tasks well and can trust and be trusted by management. Employee empowerment means that workers are prepared for and are authorized to fully participate in work and safety planning.

iii. **Ensure that the board and top management actively drive and support the change with strong leadership.** This has proved to be the key in the continuous

UEP and quality improvement or sustenance process. The survey has shown that the most important success factors are related to top management support during the whole change process. Strong senior manager availability on the shop floor, regular Kaizen event and UEP training participation are mandatory if an organization seeks to implement the UEP on a sustainable basis. Management should be aware of this responsibility. To sufficiently battle resistance to change from all levels in the organization, implementation of the UEP manufacturing methodologies must be sponsored by higher levels of management in the company. Grass-roots sponsorship is frustrating and cannot be expected to persuade higher management levels if they do not want to participate in the change.

iv. **Do not only concentrate on UEP tools and techniques.** Everyone in the organization (including all stakeholders) should be committed to make it work. It is critical to success that both the change agents and the functional managers have a good understanding of the relevant UEP tools and its concepts. Moreover it is important that responsible persons do understand that this is a basic presumption and not the essence of the UEP. Once certain knowledge of these tools has been developed in an organization it is essential that all stakeholders, especially the workers' union are involved.

v. **Find a good change agent.** It is critical that an experienced change agent is responsible for team facilitation and the rollout. A very good knowledge of the UEP methodology and concepts is mandatory, good social and communication skills, the ability to integrate, to fascinate and to implement changes are attributes the Kaizen facilitator should either develop or have. If these resources are not dedicated 100% towards UEP transformation, there is a big risk of losing speed, quality and support

vi. **Benchmark.** It is a systematic method by which organizations can measure themselves against the **best industry practices**. It promotes best superior

performance by providing an organized framework through which organizations learn how the best in class do the things, understand how these best practices differ from their own and implement change to close the gap

vii. **Information Availability, Evaluation and Analysis.** A key part of the quality management infrastructure is information system. Continuous Quality improvement relies on steady flow of accurate information about processes that generate a company's products and from various constituencies like workers, agents, vendors and customers. Analysis of this information allows management to make effective decisions on Quality related issues and tasks. The use of **Enterprise Resource Planning ERP** such as **SAP** helps in integrating over all company operations.

viii. **Reward and Recognition.** Firms that are serious about achieving quality and customer satisfaction must integrate theses aspects to their recognition and reward system. Rewards and recognition is one of the enablers, which maximizes employees potential and involvement and in doing so become one of the main contributors to the company's journey to quality and optimization.

ix. **Integrate the supporting functions into the UEP rollout and build internal customer and supplier relationships.** As UEP is a fully integrated management philosophy it is recommended that the idea of continuous improvement is also transferred into those organizational functions which support manufacturing and operations. It is relevant that all departments understand their roll in the UEP transformation process. The best way to do that is by creating internal customer and supplier relationships. The external dealers and suppliers should be totally integrated into the system.

6.2.2 Recommendation for further research

Both the results of the fieldwork and the discussion have shown that the analysis of the hypothesis quoted did not lead to statistically significant results. The small sample size

and data drawn from those survey participants whose expectations on UEP were not met has resulted in information that does partly not support the survey participants' opinions. Therefore it is recommended thus:

i. To conduct a similar research with strong focus on two data sets, one with a sample taken from organizations which were successful with their UEP efforts and one with organizations which did not have success. However, in that case it would be necessary to define **"success"** with relevant performance parameters to make the data sets comparable.

ii. A sample size of **200** answering parties in each data set should allow one to draw statistically significant conclusions. As shown in the literature review (table 2.3), UEP is much more a pathway than a goal. Therefore it would also be interesting to conduct a similar questionnaire in 5 to 10 years with the same sample. As they on average now have 5 years of experience using UEP it could shed even more light on the critical success factors when the average experience is even longer.

iii. The findings from the further reading showed the need for establishing UEP **performance parameters** and the use of a strategic tool like **policy deployment** for top-down planning. It cannot be concluded that the survey results do verify this importance. If the whole organization is not incorporated into the UEP transformation then the use of tools like policy deployment does not make sense.

iv. Use of Kanban, walk the floor, total productive maintenance, quality animation and display guide and bottleneck elimination with TOC (see figure 4.6) are more prominent in the production line alone. It is worthy of note that the weakness of drawing data related findings from a survey that is mostly based on opinions limits the significance and explanatory power of conclusions drawn out of it. Inconsistencies like this can only be investigated by further research.

REFERENCES

Agus, A. (2005). *The Structural Linkages between TQM, Product Quality Performance, and Business Performance:* Preliminary empirical study in electronics companies. Singapore Management Review, 27(1), PP. 87-105.

Benders, J. and Morita, M. (2004).*Changes in Toyota Motor's Operation Management*. International Journal of Production Research.Vol. 42. No 3, PP. 433-444.

Berk, J. and Berk, S. (2000). *Quality Management of the Technology Sector.* Boston, MA: Newnes, P.7.

Breyfolge I. and Forrest W. (1999).*Implementing Six Sigma, Smarter Solutions using Statistical Methods.*Austin, Texas, USA.

Carter, R. (2004). *Best practices:* Freudenberg NOK/Cleveland, GA: Continuous Kaizens. In: IMPO, June 2004.

Convis, G. (2001). *Role of Management in a Lean Manufacturing Environment;* In: Learning to think lean.01-1014, 2001.

Drickhamer, D. (2004). *Lean Manufacturing: The third generation.* In: Industry Week, March 2004.

Goldratt, E.M (1986). *The goal: A Process of Ongoing Improvement.* Croton-on-Hodson, New York NY: North River Press ISBN 0-88427-061-0

Herbolzheimer, E. (2003). *Business Transformation*. Henley Management College; Henley-on-Thames.

Herderson, B. A. and Larco, J.L. (2000).*Lean Transformation – How to Change Your Business into a Lean Enterprise.* First edition,The Oaklea Press; Richmond, Virginia, USA.

Keating, E.K., Oliva, R., Repenning, N.P., Rockart,S. and Sterman, J.D. (1999). *Overcoming the Improvement Paradox.*In: European Management Journal, Vol. 17, No. 2, PP. 120 – 134.

Kobayashi, I. (1995). *20 Keys to Workplace Improvement.*Revised edition; Productivity Inc. Portland, OR, USA.

Krishnan, P.V., Vijaya, R.B. and Mohan, K.P. (2011).Work in Progress Optimization through Lean Manufacturing. Research scholar, department of management, VITAS, VELS University, Pallavaram. India. PP. 19-25.

Lareau, W. (2003).*Office Kaizen – Transforming Office Operations into a Strategic Competitive Advantage.*ASQ Quality Press, Milwaukee, Wisconsin, USA.

Likert, R. (1932). *A Technique for the Measurement of Attitudes.*Archives of Psychology 140(1), PP. 44-53 (the original article).

Mader, R. P. (2005). *Lean Thinking Works in Construction too.* In: Contractor, February 2005.

Maskell, B. and Baggaley, B. (2003).*Practical Lean Accounting: A Proven System for Measuring the Lean Enterprise.* New York, USA. Paper (1999). A comparison of business improvement approaches between Japanese firms and US: A model application, Hawaii, USA.

Murray, R.S. (1987). *Theory and Problems of Probability and Statistics.*SI (metrics) edition. Schaum's Outline Series, McGraw-Hill book company USA. PP. 155-251.

Neuhauser, C. (2009). *The Chi-square Test for Goodness of Fit*. An Open-access Article, Distributed under the Terms of the Creative Commons Attribution Non-Commercial Share Alike License. Howard Hughes Medical Institute

Ohno, T. (1988). *Toyota Production System:* Beyond Large-Scale Production. Productivity Press Inc.,Portland. ISBN 0-915299-14-3

Osada, T. (1991).*The 5S's: Five Keys to a Total Quality Environment*. Asian Productivity Organization Tokyo.

Pande, P. S., Neuman, R.P. and Cavanagh, R.R. (2001).*The Six Sigma Way: How GE,*

Motorola, and Other Top Companies are Honing Their Performance. New York, NY: McGraw-Hill Professional. ISBN 0071358064.

Paper, A. (1999*).A Comparison of Business Improvement Approaches between Japanese Firms and US:* A Model Application, Hawaii, USA.

Pagano, R.R. (1990). *Understanding Statistics in the Behavioral Sciences.*(3rd Edition). St. Paul, MN: West Publishing Company.

Paris, M. (2000). *Don't Abandon the Shop Floor.* In: Manufacturing Engineering. November 2000. PP.136.

Parks, C.M. (2002). *Instill Lean Thinking.* In: Industrial ManagementSeptember – October 2002, PP.15 – 18.

Peugeot Automobile Nigeria. (1975). *PAN layout*: A documentary of Peugeot Automobile Nigeria Limited Kaduna: Author.

Peugeot Automobile Nigeria. (2002). *Facts about PAN*: *A Documentary of Peugeot Automobile Nigeria Limited Kaduna and the Quality System*: Author.

Peugeot Automobile Nigeria.(2003). *Unity and Efficiency in Production UEP.* Reference Guide: Author.

Peugeot Automobile Nigeria. (2003). *Stages of Development of UEP*: Reference Guide: Author.

Peugeot Automobile Nigeria. (2006). Finished Vehicle Quality Level Targets for *2006, A Documentary of Peugeot Nigeria Limited Kaduna, Quality System:* Author.

Peugeot Automobile Nigeria. (2007). Finished Vehicle Quality Level Targets for *2007, A Documentary of Peugeot Nigeria Limited Kaduna, Quality System:* Author.

Peugeot Automobile Nigeria.(2013). *PAN quality report***.***A Documentary of Peugeot Automobile Nigeria Limited Kaduna*: Author.

Peugeot Société Automobile. (2014). *France's Leading Patent Filer for the Seventh Year in a Row*. Retrieved June 2, 2014, from

http://www.psa-peugeot-citroen.com

Powell, T.C. (1995). *Total Quality Management as Competitive Advantage:A Review and Empirical Study*. Strategic Management Journal, 16(1), PP. 15-37.

Rachna, S. and Peter, T.W. (2007).*Defining and Developing Measures of Lean Production.*Journal of operations management.Volume 25, PP 785-805.

Rother, M.and Shook, J. (2000). *Learning to See.*Lean Enterprise Institute; Boston, USA.

Rother, M. and Harris, R. (2001).*Creating Continuous Flow.*Lean Enterprise Institute; Boston, USA.

Rothwell, S. (1994).*Managing HR and Managing Production.* In: Manager Update. Volume 5/4. Centre for Employment Policy Studies, Henley.

Saunders, M., Lewis, P. and Thornhill, A. (2003).*Research Methods for Business Students.*Third edition, Prentice Hall.

Shingo, S. (1989).*A Study of the Toyota Production System.* Productivity Press, Portland, Oregon, USA.

Spear, S. and Bowen, H. K. (1999). *Decoding the DNA of the Toyota Production System.*Harvard Business Review. PP. 97 – 106.

Spear, S.J. (2002).*The Essence of Just-In-Time: Embedding Diagnostic Test in Work-Systems to Achieve Operational Excellence*.In: Production planning and control, 2002, Vol. 13, No. 8, PP. 754 – 767.

Spear, S.J. (2004).*Learning to lead at Toyota.* In: Harvard Business Review, May 2004, PP. 78 – 86.

Tapping, D., Luyster, T. and Shuker, T. (2002).*Value Stream Management: Eight Steps to Planning, Mapping, and Sustaining Lean Improvements.* Productivity Press, New York. USA.

Tapping, D. and Shuker, T. (2003) *Value Stream Management for the Lean Office –*

*Eight Steps to Planning, Mapping, and Sustaining Lean Improvements in Administrative Areas.*Productivity Press, New York, USA.

Tempel, F., and Holländer, M. (2001).*Get Rid of Waste through Team Harmony,* Landsberg, Germany.

Tilson, B. (2001). *Success and Sustainability in Automotive Supply Chain Improvement Programmes:* A case study of collaboration in the mayflower cluster in International Journal of Innovation Management, Vol. 5, No. 4, December 2001, PP. 427 – 456.

Vasilash, G.S (2000). *How Toyota does it – very day.* In: Automotive Manufacturing & Production. PP. 48 – 49.

Voss, C. A. (1995).*Operations Management – from Taylor to Toyota and beyond*. In: British Journal of Management, Volume 6.Special Issue.PP.17 – 29.

Wheatley, M. (2005).*Think Lean for the Long Term.* In: Manufacturing Business Technology. PP 36 – 38.

Womack, J.P., Jones, D. and Roos, D. (1990).*The Machine That Changed the World.* New York, NY: Rawson Associates, PP.11.

Womack, J.P. and Jones, D.T. (2003).*Lean Thinking: Banish Waste and Create Wealth in Your Corporation.* New York: Free Press.

APPENDIX 1

STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-3.9	.00005	.00005	.00004	.00004	.00004	.00004	.00004	.00004	.00003	.00003
-3.8	.00007	.00007	.00007	.00006	.00006	.00006	.00006	.00005	.00005	.00005
-3.7	.00011	.00010	.00010	.00010	.00009	.00009	.00008	.00008	.00008	.00008
-3.6	.00016	.00015	.00015	.00014	.00014	.00013	.00013	.00012	.00012	.00011
-3.5	.00023	.00022	.00022	.00021	.00020	.00019	.00019	.00018	.00017	.00017
-3.4	.00034	.00032	.00031	.00030	.00029	.00028	.00027	.00026	.00025	.00024
-3.3	.00048	.00047	.00045	.00043	.00042	.00040	.00039	.00038	.00036	.00035
-3.2	.00069	.00066	.00064	.00062	.00060	.00058	.00056	.00054	.00052	.00050
-3.1	.00097	.00094	.00090	.00087	.00084	.00082	.00079	.00076	.00074	.00071
-3.0	.00135	.00131	.00126	.00122	.00118	.00114	.00111	.00107	.00104	.00100
-2.9	.00187	.00181	.00175	.00169	.00164	.00159	.00154	.00149	.00144	.00139
-2.8	.00256	.00248	.00240	.00233	.00226	.00219	.00212	.00205	.00199	.00193
-2.7	.00347	.00336	.00326	.00317	.00307	.00298	.00289	.00280	.00272	.00264
-2.6	.00466	.00453	.00440	.00427	.00415	.00402	.00391	.00379	.00368	.00357
-2.5	.00621	.00604	.00587	.00570	.00554	.00539	.00523	.00508	.00494	.00480
-2.4	.00820	.00798	.00776	.00755	.00734	.00714	.00695	.00676	.00657	.00639
-2.3	.01072	.01044	.01017	.00990	.00964	.00939	.00914	.00889	.00866	.00842
-2.2	.01390	.01355	.01321	.01287	.01255	.01222	.01191	.01160	.01130	.01101
-2.1	.01786	.01743	.01700	.01659	.01618	.01578	.01539	.01500	.01463	.01426
-2.0	.02275	.02222	.02169	.02118	.02068	.02018	.01970	.01923	.01876	.01831
-1.9	.02872	.02807	.02743	.02680	.02619	.02559	.02500	.02442	.02385	.02330
-1.8	.03593	.03515	.03438	.03362	.03288	.03216	.03144	.03074	.03005	.02938
-1.7	.04457	.04363	.04272	.04182	.04093	.04006	.03920	.03836	.03754	.03673
-1.6	.05480	.05370	.05262	.05155	.05050	.04947	.04846	.04746	.04648	.04551
-1.5	.06681	.06552	.06426	.06301	.06178	.06057	.05938	.05821	.05705	.05592
-1.4	.08076	.07927	.07780	.07636	.07493	.07353	.07215	.07078	.06944	.06811
-1.3	.09680	.09510	.09342	.09176	.09012	.08851	.08691	.08534	.08379	.08226
-1.2	.11507	.11314	.11123	.10935	.10749	.10565	.10383	.10204	.10027	.09853
-1.1	.13567	.13350	.13136	.12924	.12714	.12507	.12302	.12100	.11900	.11702
-1.0	.15866	.15625	.15386	.15151	.14917	.14686	.14457	.14231	.14007	.13786
-0.9	.18406	.18141	.17879	.17619	.17361	.17106	.16853	.16602	.16354	.16109
-0.8	.21186	.20897	.20611	.20327	.20045	.19766	.19489	.19215	.18943	.18673
-0.7	.24196	.23885	.23576	.23270	.22965	.22663	.22363	.22065	.21770	.21476
-0.6	.27425	.27093	.26763	.26435	.26109	.25785	.25463	.25143	.24825	.24510
-0.5	.30854	.30503	.30153	.29806	.29460	.29116	.28774	.28434	.28096	.27760
-0.4	.34458	.34090	.33724	.33360	.32997	.32636	.32276	.31918	.31561	.31207
-0.3	.38209	.37828	.37448	.37070	.36693	.36317	.35942	.35569	.35197	.34827
-0.2	.42074	.41683	.41294	.40905	.40517	.40129	.39743	.39358	.38974	.38591
-0.1	.46017	.45620	.45224	.44828	.44433	.44038	.43644	.43251	.42858	.42465
-0.0	.50000	.49601	.49202	.48803	.48405	.48006	.47608	.47210	.46812	.46414

STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
3.0	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900
3.1	.99903	.99906	.99910	.99913	.99916	.99918	.99921	.99924	.99926	.99929
3.2	.99931	.99934	.99936	.99938	.99940	.99942	.99944	.99946	.99948	.99950
3.3	.99952	.99953	.99955	.99957	.99958	.99960	.99961	.99962	.99964	.99965
3.4	.99966	.99968	.99969	.99970	.99971	.99972	.99973	.99974	.99975	.99976
3.5	.99977	.99978	.99978	.99979	.99980	.99981	.99981	.99982	.99983	.99983
3.6	.99984	.99985	.99985	.99986	.99986	.99987	.99987	.99988	.99988	.99989
3.7	.99989	.99990	.99990	.99990	.99991	.99991	.99992	.99992	.99992	.99992
3.8	.99993	.99993	.99993	.99994	.99994	.99994	.99994	.99995	.99995	.99995
3.9	.99995	.99995	.99996	.99996	.99996	.99996	.99996	.99996	.99997	.99997

APPENDIX 2

CHI-SQUARE DISTRIBUTION TABLE

Hypothesis is Supported								Hypothesis not supported		
Differences are Insignificant								***Differences are significant***		
p	**0.99**	**0.95**	**0.80**	**0.50**	**0.30**	**0.20**	**0.10**	**0.05**	**0.02**	**0.01**
C-1										
1	.00016	.0039	.064	.455	1.074	1.642	2.706	3.841	5.412	6.635
2	.0201	.103	.446	1.386	2.408	3.219	4.605	5.991	7.824	9.210
3	.115	.352	1.005	2.366	3.665	4.642	6.251	7.815	9.837	11.341
4	.297	.711	1.649	3.357	4.878	5.989	7.779	9.488	11.668	13.277
5	.554	1.145	2.343	4.351	6.064	7.289	9.236	11.07	13.388	15.086

Critical Values of the χ^2 Distribution

df \ p	0.995	0.975	0.9	0.5	0.1	0.05	0.025	0.01	0.005	df
1	.000	.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879	1
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597	2
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838	3
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860	4
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750	5
6	0.676	1.237	2.204	5.348	10.645	12.592	14.449	16.812	18.548	6
7	0.989	1.690	2.833	6.346	12.017	14.067	16.013	18.475	20.278	7
8	1.344	2.180	3.490	7.344	13.362	15.507	17.535	20.090	21.955	8
9	1.735	2.700	4.168	8.343	14.684	16.919	19.023	21.666	23.589	9
10	2.156	3.247	4.865	9.342	15.987	18.307	20.483	23.209	25.188	10
11	2.603	3.816	5.578	10.341	17.275	19.675	21.920	24.725	26.757	11
12	3.074	4.404	6.304	11.340	18.549	21.026	23.337	26.217	28.300	12
13	3.565	5.009	7.042	12.340	19.812	22.362	24.736	27.688	29.819	13
14	4.075	5.629	7.790	13.339	21.064	23.685	26.119	29.141	31.319	14
15	4.601	6.262	8.547	14.339	22.307	24.996	27.488	30.578	32.801	15

APPENDIX 3

QUESTIONNAIRE

Section I. Questions testing the basic understanding of the UEP philosophy

Q1. When did your organization start efforts to introduce UEP principles (specify year)?		
1	Year	
Q2. What do you associate with the UEP philosophy (any of the listed items may be selected)?		
1	A method to reduce headcount	
2	A toolbox of techniques to improve manufacturing and operations	
3	The use of team work and continuous improvement	
4	A fully integrated management philosophy	
5	A way to create new work and business	
6	The consequent elimination of non value adding tasks in order to reduce lead time	
7	A system for organizing and managing product development, operations, suppliers and customer relations	
8	A system to make products with fewer defects in order to strive for perfection	
9	A system to reorganize the firm by product family and value stream	
10	A philosophy that absolutely focuses on customer value	
11	Other (please describe)	
Q3. Why did your company decide using UEP practices (any of the listed items may be selected)?		
1	Continued pressure to improve operational performance	
2	Maintain competitive advantage in price and service	
3	Pressure to improve profit	
4	Customers demanding shorter order cycle (lead) time	
5	Customers demanding reduced prices	
Q4. Overall expectations of using UEP principles (only one response can be selected here) you had were		

1	Not at all fulfilled	
2	Hardly fulfilled	
3	Partially fulfilled	
4	Largely fulfilled	
5	Entirely fulfilled	

Section II. Questions analyzing the usage of tools and techniques

Q5. Please tick the specified UEP tools your organization is using in order to become UEP enterprise (only one category can be selected per response).

	Category Response	Not used at all	Used in the whole organi-zation	Used in production line only	Used on the whole value stream including customers and suppliers
1	**5S** (Cleaning and safe working environment) & visual control				
2	Walk the floor procedure				
3	Operational meeting				
4	Management tools; progress agreements, briefing, recognition etc.				
5	Idea scheme				
6	Continuous improvement groups				
7	Quality animation and display guide				
8	Versatility Chart and Presence Chart				
9	Health and safety				
10	Daily action plan / Typical day guide				
11	Total Productive Maintenance (TPM)				
12	Theory of Constraints (TOC)				
13	Six Sigma **6σ**				
14	Kanban and standardized material buffers				
15	Value Stream Mapping VSM				

16	Other (please describe)				

Section III. Questions analyzing the scope of UEP implementation

Q6. Which of the following functions is strategically integrated in your company's UEP rollout (only one category can be selected per response)?

	Category Response	Not Integrated at all	Hardly Integrated	Partially Integrated	Largely Integrated	Fully Integrated
1	Engineering, R&D, Product and Process Development					
2	Quality					
3	Production					
4	HR					
5	Finance					
6	Purchase					
7	Operations					
8	Sales and Marketing					
9	Other (please describe)					

Section IV. Questions testing the importance of critical management factor

Q7. Which of the following aspects is or was considered during your organizational UEP rollout (only one category can be selected per response) and which one in your opinion (on a scale from 1 to 4) is critical to successful UEP transformation (1: not important, 2: little important, 3: important, 4: very important)?

	Category Response	Yes	No		Critical (1 to 4) Scale
1	Availability of a crises that motivates the organization to change				
2	Elimination of Managers who would not cooperate in order to get commitment to UEP				

3	Board and top management actively driving and supporting change				
4	Finding a good change agent				
5	Getting shop floor commitment and employee trust				
6	Communication of the transformation process, goals etc				
7	Managerial push (mandatory participation in workshop and training)				
8	Employee pull (employee fully understand the benefits on UEP and improvement on themselves independent of management's support				
9	Leaders (Group, Team) motivate, train, facilitate the work of those adding value rather than tell them what to do				
10	Top management presence and availability on the shop floor (and offices)				
11	Implementing reward and incentive system for successful transformation (after stage validation)				
12	Converting from top-down leadership to bottom-up initiatives				
13	Resources freed up by productivity gains and reinvested into the search for still greater improvement				
14	Striving for perfection/excellence				
15	Integrating suppliers and customers into the UEP transformation				
16	Other (please describe)				