# A Supplier Quality Performance Tool

**- An integration of Costs of Quality into future supplier selections at Sony Mobile Communication**

Isabella Zell
Niklas Johansson

**A Supplier Quality Performance Tool at Sony Mobile Communication**

---



Department of Business Administration
Lund University, School of Economics and Management
Box 7080
SE-220 07 Lund

Department of Industrial Management and Logistics
Lund University, Faculty of Engineering,
Box 118
SE-221 00 Lund

Master Thesis in Technology Management - No 230/2012
ISSN 1651-0100
ISRN LUTVDG/TVTM--12/5230--/SE

Lund 2012
E-husets Tryckeri
Printed in Sweden

# Abstract


**Title**: A Supplier Quality Performance Tool
- An integration of Costs of Quality into future supplier selections at Sony Mobile Communication.

**Authors:** Isabella Zell
Niklas Johansson

**Tutors:** Christer Kedström, *Associate Professor Business Administration, School of Economics and Management, Lund University.*

Andreas Norrman, *Professor, Department of Industrial Management and Logistics, Faculty of Engineering*, *Lund University.*

**Project Host:** Johan Pålsson, *Strategic Buyer, Sony Mobile Communication.*

**Problem Definition:** The supplier selection process at Sony Mobile Communication indicates that except for technical requirements, the major aspects to investigate are commercial conditions and especially purchase price. In some supplier selection situations the quality department gives indications of poor quality from a supplier but cannot connect the actual costs. The Strategic Buyer listens but do not know how much the poor quality will cost the company in the long run and can consequently not motivate a selection of a supplier with a more expensive purchase price. Sony Mobile has a wish to analyze suppliers' historical quality performances and integrate this data into future supplier selections.

**Purpose:** The purpose of the master thesis is to develop a tool to integrate historical data of suppliers' quality performances into future supplier selections with a cost focus.

**Method:** The thesis has followed a constructive research approach. Empirics and theories have been studied in an iterative process. Focus has been to understand the processes at Sony Mobile Communication and to identify their cost drivers. In order to fulfill the purpose of developing a tool, a process of developing a model with focus on validity by Ljung and Glad has been applied.

**Conclusions:** The identified cost drivers in theory were searched for at Sony Mobile Communication. We searched for cost drivers in four major areas; First Point of Check, Production, After-sales and Quality Management. Several cost drivers were identified and the available ones were included in the final version of the Supplier Quality Performance Tool. The cost drivers were connected to specific costs given by employees at Sony Mobile and the production site BMC. The Supplier Quality Performance Tool was constructed align with the purpose; to integrate historical supplier quality performance into future supplier selections. The tool has been tested and Strategic Buyers' intuitions regarding specific suppliers were confirmed. The tool will give Sony Mobile Communication better insights of the quality performance of their suppliers and also initiate greater quality focus.

**Keywords:** Supplier quality performance, supplier selection, cost drivers, Total Cost of Ownership, Sony Mobile, Supplier Quality Performance Tool, Cost-ratio plan, Costs of Quality.

## Acknowledgement

The case at Sony Mobile Communication spring 2012 has been very interesting and learning. Various challenges have arisen during the process, which have contributed to a great deal of learning for the future.

We would like to give a special thanks to our project host at Sony Mobile Communication, the Strategic Buyer Johan Pålsson who has given us his fully support during the entire process. We would also like to thank all the employees at Sony Mobile Communication and BMC that we have interviewed or e-mailed several times. Each one of them has been very helpful and contributed to the development of the Supplier Quality Performance Tool.

The tutors at Lund University; Christer Kedström and Andreas Norrman have also been a great support during the process. They have shown interest to the subject and contributed with relevant input, which the authors are very thankful for.

Finally, we would once again like to emphasize how grateful we are that we got do our master thesis at Sony Mobile Communication. It has been a great way to finish our study time of five years.

Lund, May 2012

Isabella Zell Niklas Johansson

# Abbreviations

Analytical Hierarchy Process (AHP)
Accepted Prototype (AP)
Cost of Quality (CoQ)
Core Unit (CU)
Core Unit Test 1 (CT 1)
Core Unit Test 2 (CT 2)
Core Unit Test 3 (CT 3)
Deviated Parts Per Million (DPPM)
Embody Test Software (ETS)
End of lifetime (EOL)
Fault Verification Analysis (FVA)
Final Flash (FF)
Final Quality Check (FQC)
Global Root Cause Analysis (RCA)
Incoming Quality Check (IQC)
Industrialization Product Quality Management (IPQM)
Out of Box Audit (OBA)
Product Qualification (PQ)
Ready to launch (RTL)
Request for information (RfI)
Request for quotation (RfQ)
Root Cause Analysis (RCA)
Sales Item (SI)
Service Mount Assembly (SMA)
Supplier Quality Assurance (SQA)
Supplier Quality Engineers (SQE)
Sample Test Acoustic (STA)
System Prototype one (SP1)
System Prototype two (SP2)
Total Cost of Ownership (TCO)
Total Quality Management (TQM)

# Table of Contents

# 1. Introduction

*Initially, a general view of the researched problem is given, followed by an introduction to the studied company Sony Mobile Communication (Sony Mobile) and their specific problem. Subsequently, a detailed problem definition, the purpose and the delimitations for the thesis are defined. Finally, an overview of the structure of the thesis is presented.*

## 1.1 Background

The suppliers are very important to a company due to the fact that they most likely are contributing to the company's core business. The relationship with the suppliers is thereby crucial and most necessary is that a great deal of trust is built between the parties.

This makes the process of selecting suppliers central. Many parameters can be included and taken into consideration in order to make as correct decisions as possible. One problem is that the gathering of relevant information connected to involved suppliers takes a lot of time. Thereby, companies use various evaluation criteria in their selection. The company chooses the criteria they believe will have greatest impact when selecting appropriate suppliers to their company. Potential criteria to include in the supplier selection are purchase price, ability to supply the required quantity, maintenance of quality standard and financial standings (Kumar and Suresh, 2009). Purchase price is probably the most common criteria to include since companies want as great margin as possible. The criteria regarding quality is important, but can be hard to estimate. The difficulties lie in the complexity of knowing the real outcome caused by poor quality. In some cases it might be more beneficial and profitable to choose a supplier with somewhat lower quality in front of one with a higher purchase price as well as it can be more profitable in the long run to pay extra for higher quality.

Despite the complexity in quantifying quality, it is important to have a comprehension of the possible effects from high and low quality. Poor quality can lead to major costs later on in the production process and the later in the production process the faults are discovered the more expensive it will be (Sörqvist, 2012). An even worse scenario is if the faulted products actually reach the customers. This might lead to lost customers and an increasing badwill. Thereby, it is crucial for a company to invest in activities that decrease the risk of poor quality. The effects of products with high quality can be higher than the company expected or, it won't make any difference.

## 1.2 The case at Sony Mobile

Sony Ericsson Mobile Communications started in 2001 as a 50:50 joint venture between Sony and Ericsson. Ten years later, autumn 2011, Sony acquired the whole organization and the correct name for the operation studied in this thesis is Sony Mobile Communications. The company will as from now be entitled Sony Mobile in the thesis. Focus will primarily be on the strategic purchasing departments of components within Sony Mobile, but several departments will be involved throughout the process, especially Supplier Quality Engineering department and production.

The purchasing department responsible for direct material is divided into nineteen commodities, a commodity is signified as a category of components. A commodity has a Global Commodity Manager who is responsible for the purchasing strategy of the specific commodity and Strategic Buyers (Pålsson, 2012). Furthermore, the purchasing department responsible for direct material is divided into three major areas and these are named Electronics, Mechanics and Electro-Mechanics. Commodities are included within each of these areas. Electronics consist of seven commodities, Electro-Mechanics eight and Mechanics four commodities. Within each of the areas, Strategic Buyers and Supplier Quality Engineers are employed. The area that has major focus in this thesis is Electro-Mechanics and especially the commodity Connectors & Switchers, which furthermore is the commodity that initiated the master thesis.

A major responsibility of the strategic purchasing department within Sony Mobile is to select suppliers that will provide components to mobile phones. The Strategic Buyer within the department has great responsibility, as the chosen supplier will be part of the value chain three years ahead as well as the decision will generate millions of dollars in spend. Due to these reasons, it is important that the selection is thoroughly analyzed and motivated.

When choosing supplier at Sony Mobile technical requirements, costs of new production line, lead-time, legal aspects and commercial aspects especially purchase price are analyzed. In some supplier selections the Supplier Quality Engineering department gives indications of poor quality delivered from a supplier. The Strategic Buyer listens but do not know how much the poor quality will cost the company in the long run and can consequently not motivate a selection of a more expensive supplier (Pålsson, 2012). The quality aspect is thereby today mostly based on intuitions, which make it difficult to include in supplier selections. Sony Mobile has paid more and more attention to this problem and has a wish to integrate the Costs of Quality into the selection process (Pålsson, 2012).

Sony Mobile has acknowledged decreasing profitability past years, which has implied enhanced pressure at increasing margins. Thereby, purchase price has taken too much attention from other important evaluation criteria. Quality is one of these and one employee means that it is impossible to expect the same quality as before when the company requires much lower prices from the suppliers. Employees at the Customer Service department, the ones that are responsible for customer reclaims, claim that the amount of returned mobile phones caused by suppliers have increased from 2009 to 2010 (Eskilander, 2012). This fact indicates a decreasing focus on quality of the purchased products. An additional aspect contributing to a decreasing quality is the fact that Sony Mobile has started to develop more complex mobile phones (Ekberg, 2012).

The company has information regarding historical supplier performance, including quality performance of delivered products. Quality performance is registered in three main areas with related quality checks. The first area is called First Point of Check and the related quality checks are Incoming Quality Check (IQC) and Online-yield (Larsson, 2012). The second area is production process and the connected quality checks are performed in several steps during the process and the result of the checks are registered in a yield. Yield measures how much of the incoming material that results in a final and correct product (Åberg, 2012). The last area embraces the period when the product has reached the customers and is referred as After-sales. The quality checks in this phase are called Global Root Cause Analysis (RCA) and Fault Verification Analysis (FVA). The mobile phones analyzed in these phases are a sample of mobile phones that has been returned to Sony Mobile after having reached the customers (Eskilander, 2012).

The faults of quality are registered in the various quality checks, but no costs are related to the registered data and in some cases the data cannot be connected to specific supplier. One possible way to integrate the data into future supplier selections could be to determine costs related to faults of quality and make connections to the specific supplier. A ranking system is not enough since management requires data in monetary terms to be able to support the decision. Thereby, the buyer and his/her team need to know the monetary value of choosing one supplier in front of another (Pålsson, 2012).

A tool that integrates historical supplier quality performance into the selection of supplier at Sony Mobile with a cost focus is supposed to solve this issue. Usage of the tool shall preferable contribute to a decrease of the total costs related to a purchase at Sony Mobile. Moreover, the tool can be used in negotiations with suppliers as well.

## 1.3 Problem definition

*"The Cost of Quality isn't the price of creating a quality product or service. It's the cost of NOT creating a quality product or service."* - Campanella, 1999.

Sony Mobile chooses suppliers based on several aspects. However, purchase price has taken too much focus past years and the company has a notion that quality faults imply a lot of additional costs, which in the end can lead to one supplier being more expensive than another despite lower purchase price.

Today, Sony Mobile registers discovered quality faults, but do not know the related costs and do not have a procedure for integrating the findings into future supplier selections.

In theory the problem of integrating historical supplier quality performance into future supplier selections is emphasized and articles are written regarding the importance of it. However, no literature is written on how to accomplish the integration in practice. This is confirmed in an article written by Sánchez-Rodriguez et al (2004). The thesis will make an attempt to contribute to theory, by introducing a perspective of how to integrate historical supplier quality performance into future supplier selection.

## 1.4 Purpose

The purpose of the master thesis is to develop a tool that integrates historical data of suppliers' quality performances into future supplier selections with a cost focus.

## 1.5 Delimitations

The dimension of quality that is investigated in the empirical study is faults in terms of faulted components. Thereby dimensions of quality as late deliveries, incorrect deliveries are excluded. Focus of the empirical study is at one of four of the production sites named BMC in China. Sony Mobile owns this site to fifty percent and data is thereby available.

The purchasing process differs depending on area and the thesis is delimitated to the area named Electronic Mechanics. However, adjustments will make it applicable at the other areas as well.

The tool will only be usable at existing suppliers.

Noticeable is that all numbers presented in the thesis is fictional and are thereby not related to Sony Mobile’s operation.

## 1.6 Thesis outline

Figure 1.1 illustrates the process of the thesis. It starts with this chapter, the *introduction* that includes a presentation of the case at Sony Mobile and the problem definition of the thesis. In next step the *methodology*; constructive research approach is presented and the application to this thesis. In the *theoretical framework*, theories regarding purchasing process, supplier selection and quality are presented. Following step regards the *empirical study* where mapping of the processes within a mobile phone project and identification of cost drivers at Sony Mobile are performed. In next step the *Supplier Quality Performance Tool is developed* and more deeply described in the Supplier Quality Performance Tool chapter. In the same chapter reflections and theoretical and empirical contribution are discussed.


Figure 1.1: Overview of the structure of the thesis.

# 2. Methodology

*Following chapter starts with a brief description of the authors' approach to the specific problem, followed by a presentation of the constructive research approach. Subsequently, the constructive research approach applied on this thesis is described. Finally, the quality and reliability of this thesis is discussed.*

## 2.1 Brief description of the approach of the master thesis

In the process of developing a tool that Sony Mobile can use in future supplier selections, the authors needed a comprehension of the organization and the processes linked to the specific problem within Sony Mobile. In theory, seventeen quality cost drivers were identified and these were helpful in the search of quality cost drivers at Sony Mobile. A mapping of quality checks was furthermore performed in order get an understanding of where faults of quality are discovered in the process. It was found that quality checks are connected to certain cost drivers and the authors started to search for data connected to the cost drivers. Additionally, the authors searched for associated costs. The available and verified cost drivers were included into the Supplier Quality Performance Tool. Finally, the tool was tested together with Strategic Buyers.

## 2.2 Constructive research approach

The methodology constructive research approach is chosen due to the fact that it emphasizes a development of a solution intended to solve a problem as well as contribute to theory in some way. This approach is distinguished of having strong and distinct empirical achievement. Important to mention is that the approach also emphasizes the fact that if a project fail at a practical point, it can yet have significant theoretical contribution. The elements of a constructive research approach are illustrated in the figure below (Lukka, 2003). The figure illustrates that the four surrounding areas are contributing to the square in the middle. The square in the middle represents the result or solution to the specific problem.

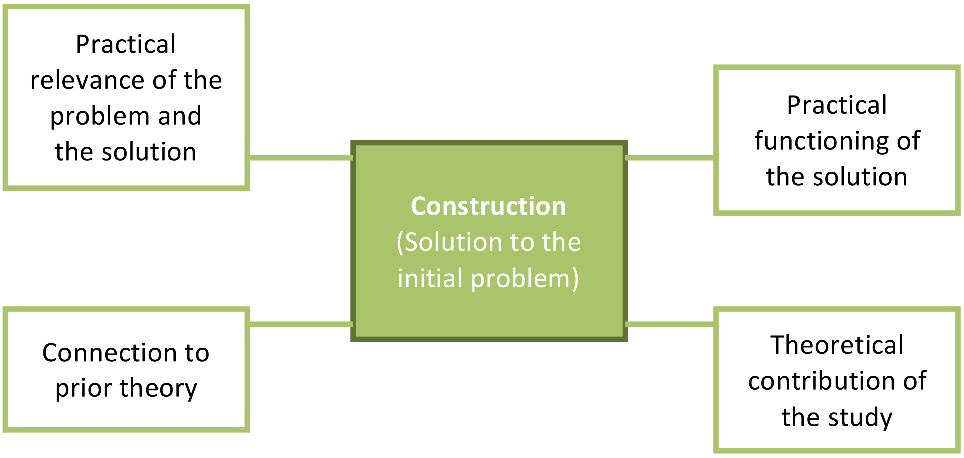


Figure 2.1: Constructive research approach (Lukka, 2003, page: 85).

According to Lukka (2003) a constructive research approach consist of seven steps. Even though the seven steps are presented in a certain order, Lukka (2003) emphasizes that the process often is iterative and the steps do not follow each other in a sequence. The seven steps consist of:

1. **Find a practically relevant problem.**
   The selection of topic is very important and it is necessary to pay attention to both practical and theoretical concerns.

2. **Examine the potential for long-term research co-operation.**
   A challenge in this phase can be to persuade the organization that the researcher will contribute to the project to such an extent that it is worth investing in it. It is significant to discuss expectations and to make a formal agreement for both parties. It is recommended that the contract include access to data and possibility of publishing the findings of the project. By doing so, the risk for non-academic contribution is avoided. These activities will make it easier to ensure the long-term co-operation.

3. **Obtain deep understanding of the topic area.**
   It is of great importance that the researcher has great knowledge of the subject and theories that is written about it. It is necessary for the progress of the work and for the analysis phase where the theoretical contribution shall be identified. This part is

the main difference between a constructive research and a consulting project. Furthermore, this step includes gathering of empirical data as well. The empirical study can be in terms of a survey, interviews, case studies and observations etcetera. This is dependent on the subject and where the researchers believe they can gather relevant data.

**4. Innovate a solution idea and develop a problem solving construction, which also has potential for theoretical contribution.**

This step is characterized of much creativity and thereby only a few advices are given. Lukka (2003) states that the process for developing the solution shall be seen as a co-operative work between the practitioner and the researcher and should be based on input from both empirical and theoretical studies. This process is probably iterative and includes developments of many prototype ideas.

**5. Implement the solution and test how it works.**

The first practical test of the solution is performed here and is one of the main characteristics of the constructive approach. It is crucial that the researcher together with the potential users of the solution are committed to the solution and that they act accordingly. It can be seen as the researcher sells the solution to the practitioners. Thereby, manuals, training and prototypes can be developed and presented. This is an important step in order to develop a solution as close to reality as possible and to ensure that the potential users understand it. The focus in this step is thereby to test the proposed solution and gain feedback from the potential users. This can be performed in several ways and examples are: prototypes, pilot projects etcetera.

**6. Ponder the scope of applicability of the solution.**

Analyses of the solution are made here and it is crucial for the researcher to step back from the empirical study and give an objective view to the solution. It can also be necessary to investigate the scope of the solution. A relevant question can be whether it is possible to use the solution at several departments or even at other companies. Furthermore, it is significant to discover the possibility for implementation at other places.

**7. Identify and analyze the theoretical contribution.**

To identify the theoretical contribution is of great value from an academic point of view. As in step 6, it is important for the researcher to be able to distant him/her from the result and actually investigate the contribution. Two types of potential theoretical contributions exist:

- A completely new contribution to prior theory.
- A modification of existing theory. In addition to designing new constructions and testing them, a constructive research project is a way to apply and develop existing theory.
  (Lukka, 2003).

## 2.3 Development of the tool

With the purpose to develop a tool that Sony Mobile can use in the decision-making of supplier selections, theories regarding development of models have been studied. This study can be included in part three of the constructive research approach. Several types of models exist and examples are verbal models, mental models and physical models. Focus from now will be on a fourth type of model called mathematical model, where various important measurements are linked together in order to facilitate to a more correct decision during a supplier selection. When developing the model it is important to have two fields of knowledge in mind. The first one is called expertise of domain and covers the importance of having control of the important areas to study and cover in the model. The next field regards the transformation of the expertise of domain into a user-friendly and explicit model (Ljung and Glad, 1991).

Within the field of developing a user-friendly and explicit model lays the importance of validating and verifying it. This can be done by motivating the steps towards developing the model as well as presenting what variables that are excluded in the model. Testing the model is another way to verify it, where a comparison of the outcome of the model and reality is crucial. Figure 2.2 shows important steps in the process of developing a model with focus on validity (Ljung and Glad, 1991).

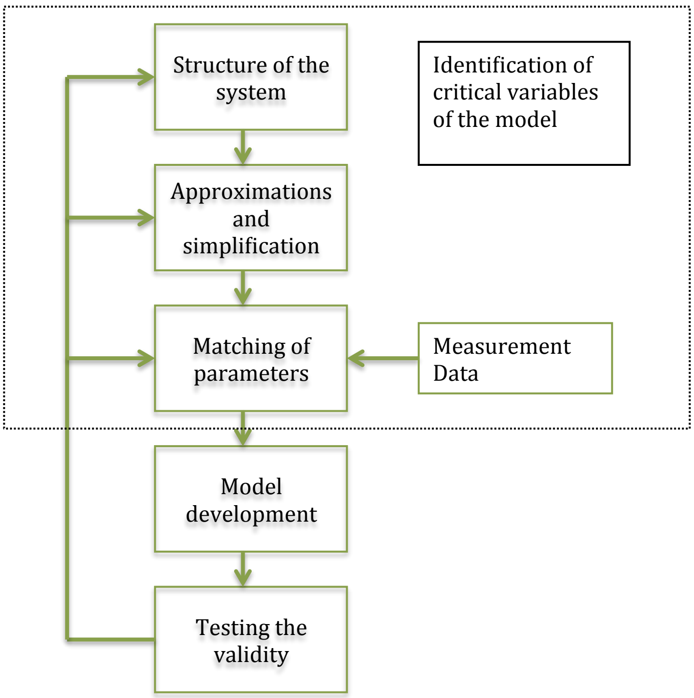


Figure 2.2: Process of developing a model with focus on validity (Ljung and Glad, 1991 p.391).

The mathematical model can be of different character; a model is deterministic if only exact numbers and variables are included and no contingency is presented. When contingency aspects and probability aspects are included in the model, it is called a stochastically model. A statically model is characterized for including variables that have a direct relationship. A dynamic model, on the other hand, includes variables that can be dependent on other factors than the ones in the model (Ljung and Glad, 1991).

Another important aspect is to determine the scope of the tool. Lars Sörqvist, Associate Professor within Quality at KTH Royal Institute of Technology has written a book called *Costs of Faults of Quality* where this issue is emphasized. He states that if the company needs information of each cost in detail, a great deal of workload needs to be accomplished. The information will on the other hand be accurate and reliable. Contrary, if the company decides to investigate the costs at a more general level, the workload will be lower as well as the accuracy of data. This complexity is illustrated in figure 2.3 (Sörqvist, 1998).

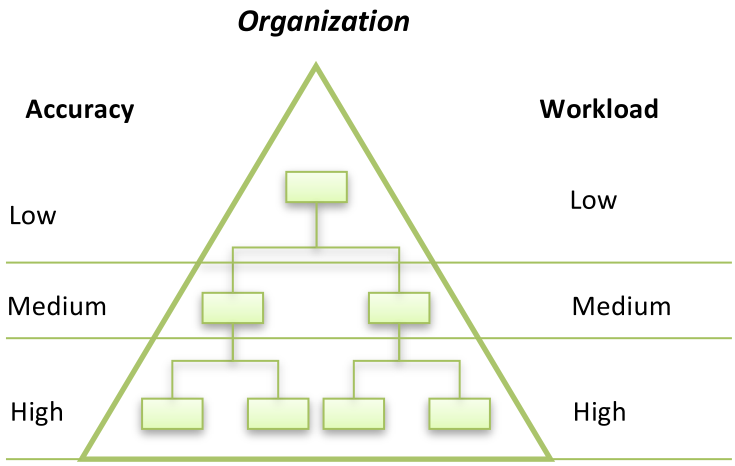


Figure 2.3: Level of accuracy and workload (Sörqvist, 1998, page:67).

## 2.4 Constructive research approach applied to this master thesis

The seven steps embraced in the constructive research approach will all be concerned in this thesis. The steps are presented in sequence of each other below.

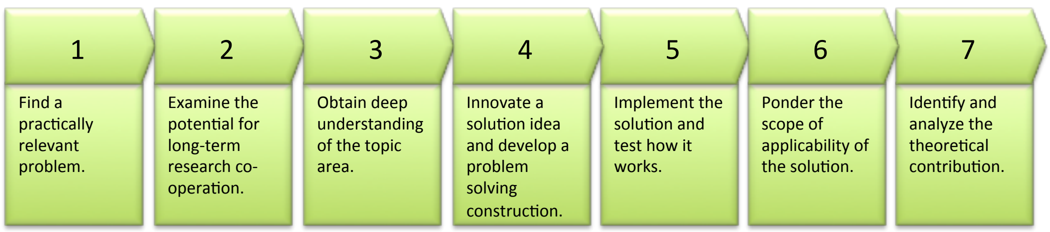


Figure 2.4: Constructive research approach applied to this thesis.

1. **Find a practically relevant problem.**

The specific subject; to integrate Costs of Quality into supplier selections was proposed by Sony Mobile due to their problem of not knowing what poor quality costs.

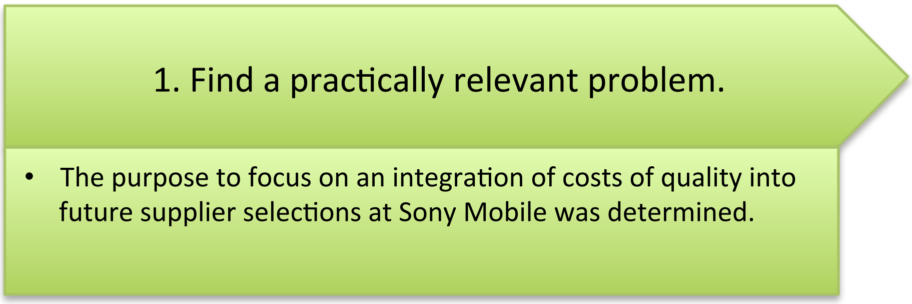


Figure 2.5: Summary of step 1.

**2. Examine the potential for long-term research co-operation.**

When the problem was identified, a discussion regarding the research was started. A brainstorm regarding potential areas that would be of interest was held and discussed with the company to ensure a deeper investigation of the subject. For instance, a discussion regarding available data of registered faults of quality was held.

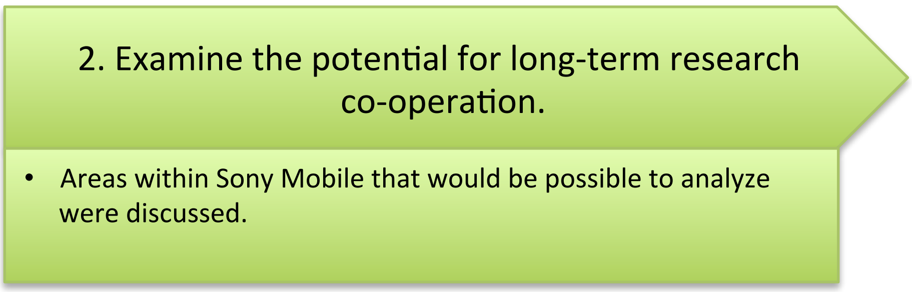


Figure 2.6: Summary of step 2.

**3. Obtain deep understanding of the topic area.**

At this point, the preparation phase ended and the operational work started. This part was fulfilled through two parts; study of literature regarding the subject or closely related subjects and empirical study. The empirical study was divided into two major areas; *Mapping of processes within a typical mobile phone project at Sony Mobile* and *Identification of cost drivers.*

**Literature study**

The purpose of the literature study follows Lukka's (2003) idea of attaining a wide knowledge of the subject or closely related subjects. The studied theories have created a wide knowledge and some theories are applied in the empirical study while others serve as inspiration to the empirics.

The conduction of relevant literature took a wide perspective in the beginning and was narrowed as the authors got better understanding of the field of search. The literature study was subsequently divided into two parts; *purchasing process* and *quality*. In the purchasing process part, theories regarding Supplier *Selection, Total Cost of Ownership (TCO), Analytical Hierarchy Process (AHP) and Supplier Performance Evaluation* were considered, see chapter 3. These were selected in order to get a wide perspective of elements included in a supplier selection. Total Cost of Ownership is a quantitative way of choosing supplier, which is the major focus in this project. The AHP-process shows how quantitative and qualitative data can be transformed into a quantitative perspective of the same issue. The AHP approach is included in theory in order to present an alternative perspective of how to select supplier.

Quality is a wide concept and due to this the theoretical framework regarding quality starts by a presentation of different *dimensions and definitions of quality*, followed by *Total Quality Management* and ends with a discussion regarding *costs related to quality issues and the categorization of these,* see chapter 3.

The process of finding relevant theory started by a review of relevant courses studied past years. Focus was primarily the course: Industrial Purchasing at the Faculty of Engineering at Lund University. The book *Purchasing and Supply Chain Management* by van Weele was a great resource from this course. Regarding articles, the major sources were the database of Lund called Summon as well as the library of Lund University.

Regarding quality, Bertil Nilsson *Adjunct Assistant Professor* of the *Department of Industrial Management and Logistics* at *Lund Institute of Technology* was contacted initially. Nilsson had recommendations regarding literature and so did our tutors at the University. A great resource was the book *Costs of faults of quality* written by Sörqvist.

Furthermore, the authors searched for literature that combined the two areas; purchasing process and quality. The major source was databases and key words as "quality into supplier selection" or "measurements of faults of quality when choosing supplier" were used. The authors discovered difficulties in finding articles that combine the two areas. One article was found that emphasized the importance of including Costs of Quality into supplier selection, but nothing was written regarding how it actually is integrated (Sánchez-Rodriguez et al, 2004).

The literature study resulted in a theoretical tool, where three theoretical frameworks were combined. This tool has formed the basis in the development of the Supplier Quality Performance Tool and it reappears later in the thesis.

**Empirical study**

The empirical study was divided into two areas, illustrated in figure 2.7. The areas are *Mapping of processes within a typical mobile phone project at Sony Mobile* and *Identification of cost drivers.*

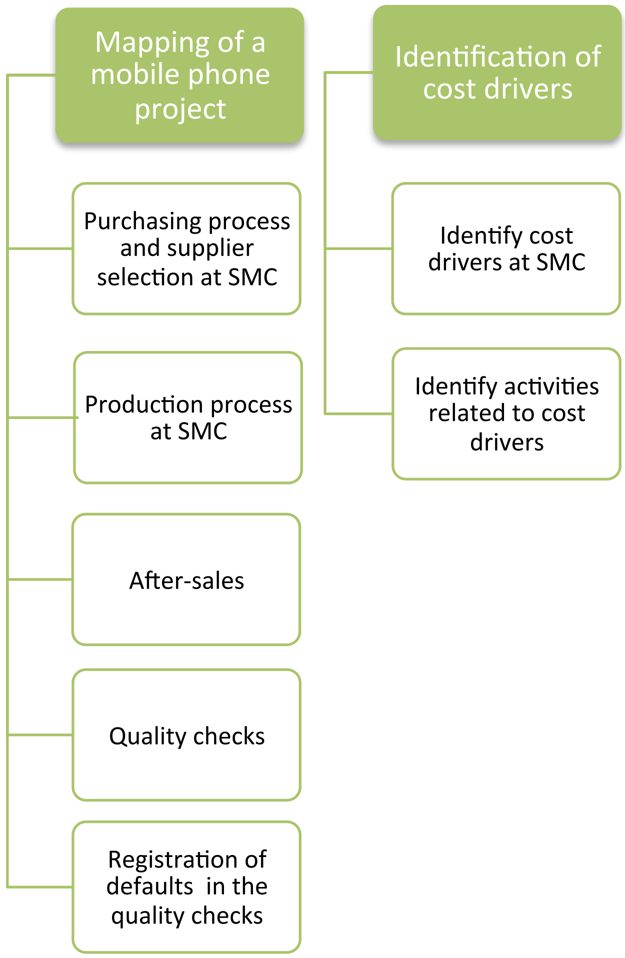


Figure 2.7: Illustration of the empirical study.

**Mapping of processes within a typical mobile phone project at Sony Mobile**

In the beginning of the process, the importance of getting a distinct comprehension of the processes within a mobile phone project at Sony Mobile was emphasized by the authors. This was due to the belief that it would be essential in order to develop the Supplier Quality Performance Tool. Meetings were held with various employees; four Strategic Buyers, two Global Commodity Managers, three Supplier Quality Engineers, the Director of Supplier Quality Assurance, one Senior Project Manager, one Senior Quality manager, one Staff project manager, one IPQM-manager, one Staff Project Manager, one Senior Repair Development and one Engineer Senior Manager of Quality Feedback in order to get various perspectives of the processes within a mobile phone project. The perspectives varied and the authors developed their interpretation of the processes within a mobile phone project. The interpretation was demonstrated to the buyers and feedback was given. Regarding the production process, the authors initiated a meeting with the Staff Engineer, Industrialization & Production, who is responsible of a prototype of the production process at Sony Mobile. During this meeting the prototype of the production process was demonstrated and a better understanding of how the process functions and what quality checks included was attained.

With the purpose to create a tool that Sony Mobile can use in their future supplier selections, the registration of faults of quality in the quality checks had to be gathered and analyzed. As comprehension of the processes and quality checks within Sony Mobile was created, the authors identified four major areas to search for data. The areas were divided into First Point of Check, Production, After-sales and Quality Management.

**Identification of cost drivers**

Cost drivers identified in theory were searched for within the four areas. The theoretical cost drivers gave inspiration to what to search for in the empirical study. The authors discovered that the cost drivers defined in theory were differently defined at Sony Mobile. Thereby, the authors needed to identify the connection between theoretical cost drivers and empirical cost drivers. Due to this issue the same cost driver will be called differently in the theoretical framework and in the empirical study. The identified cost drivers were subsequently categorized into the theoretical tool, developed by the authors. This was made in order to get a comprehension of where Sony Mobile spends their resources connected to Costs of Quality.

Important to mention is that in the process of gathering of data connected to cost drivers the authors have been very careful to ensure that the discovered faults are caused by supplier and not due to design or production. Another important aspect has been to verify that the data can be connected to the components' part number or even better to specific supplier.

As information regarding cost drivers and the amount of faults was gathered, next step was to identify the activities taken by Sony Mobile or BMC to solve the faults of quality. In other terms, the real costs behind the cost driver. These were firstly compiled through a brainstorm performed by the authors themselves where theoretical definitions of cost drivers where analyzed and applied at Sony Mobile. Secondly the activities were searched for during interviews with Strategic Buyers and employees from the Supplier Quality Engineering department within Sony Mobile. The identified actions were eventually a result of theoretical perspective and empirical perspective. Subsequently, these actions needed to be converted into monetary terms in order to get a comprehension of the actual Costs of Quality in the various steps. This was made by identifying costs related to the actions, followed by taking contact with employees that could have the cost estimations.

During the process of gathering of data, issues were discovered and delimitations were determined. The delimitations and its reasons are further described in chapter 5 regarding Construction of the Supplier Quality Performance Tool.

3. Obtain deep understanding of the topic area.

- Literature study:
  - The theoretical framework was divided into two major areas; purchasing process and supplier quality performance.
  - The theoretical tool based on three theories was developed.
- Empirical study:
  - Mapping of processes within a typical mobile phone project at Sony Mobile was preformed.
  - Cost drivers at Sony Mobile were identified.

Figure 2.8: Summary of step 3.

**4. Innovate a solution idea and develop a problem solving construction, which also has potential for the theoretical contribution.**

During the process of developing a tool that integrates historical data of suppliers' quality performances into future supplier selections, information gathered from theories and interviews with employees at Sony Mobile were analyzed and interpreted. The theoretical process of development of a model with focus on validity developed by Ljung and Glad (1991) was followed to a great extent.

In the middle of the process of the master thesis interviews with potential users of the tool were held with the purpose to get comprehension of the major needs associated with the tool. Instead of having interviews with each of the potential user, a workshop all together was booked. The workshop included seven employees from different areas and with various positions. One Supplier Quality Engineer and one Strategic Buyer from each of the areas were booked. From *Electronic Mechanics*, two Strategic Buyers were invited since both of them have been involved during the process. When the workshop was performed the crucial characteristics of the tool were stated. The reason for having one workshop instead of individual interviews was to include and emphasize the various perspectives and having discussions regarding them. The findings are further described in chapter 4.

As the cost drivers were identified in step three and analyses of what type of data that is registered related to the cost driver was made a comparison of the cost drivers was performed. The comparison was made on the aspects; availability, reliability and costs. The cost drivers that were excluded were due to the fact that they were not registered or unverified.

As the suitable cost drivers for the Supplier Quality Performance Tool were identified, a first draft of the tool was created. In the development of a solution idea or a first draft of the Supplier Quality Performance Tool the authors once again needed to ensure that data regarding the cost drivers in the four areas; First Point of Check, Production, After-sales and Quality Management were gathered and that it was sorted correctly. Furthermore, the costs for repairing the faults of quality in each of the steps also needed to be compiled. During the development of the tool, the theoretical framework regarding Cost-ratio plan was applied.

The solution idea: A tool that includes data of suitable cost drivers from past year. The tool shall be able to handle analysis at component level and should be developed aligned with the needs of the potential users. Align with Cost-ratio plan, the costs related to each cost driver needs to be summarized into a total Cost of Quality and added to the new purchase price. A more correct price is thereby created and can be used in the supplier selection.

4. Innovate a solution idea and develop a problem solving construction, which also has potential for theoretical contribution.

- Construction of the Supplier Quality Performance Tool:
  - Cost drivers at Sony Mobile were compared.
  - The included cost drivers of the Supplier Quality Performance Tool were applied to the theoretical tool.
  - A first draft of the Supplier Quality Performance Tool was developed.

Figure 2.9: Summary of step 4.

**5. Implement the solution and test how it works.**

When a first draft of the tool was developed it was tested on two suppliers and discussed with Strategic Buyers. The purpose with the test was to present the usage of the tool to future users and to get a comprehension of the accuracy of the result computed by the tool. Important feedback in the presentation of the first draft was that the buyers wanted the tool to be able to handle analysis at supplier level.

The authors turned the feedback into actions and developed a second draft, where the tool also could handle analysis at supplier level. As the second draft was developed a test session was initiated by the authors. This is further described in chapter number 5 regarding Construction of the Supplier Quality Performance Tool.

An important aspect is that the included cost drivers of the Supplier Quality Performance Tool were discussed during the entire process to ensure their relevance. The cost drivers were furthermore evaluated continuously and the ones finally included in the tool have been validated several times.

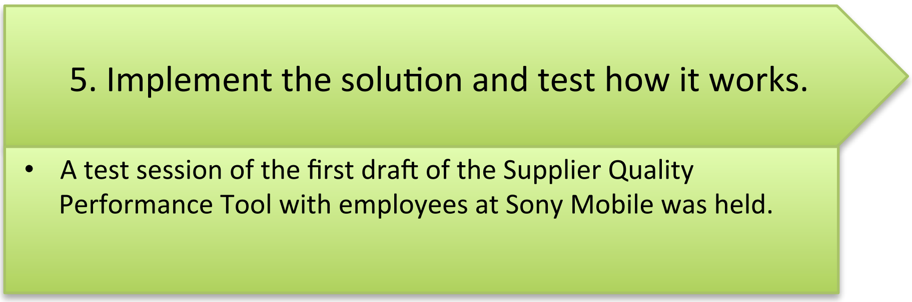


Figure 2.10: Summary of step 5.

**6. Ponder the scope of applicability of the solution.**

The developed Supplier Quality Performance Tool is possible to use at all commodities within Electronic Mechanics. Regarding the area Electronics, adjustments need to be performed in order to be able to use the tool. For Mechanics, there is no need for a Supplier Quality Performance Tool. This is further described in chapter 6.


Figure 2.11: Summary of step 6.

**7. Identify and analyze the theoretical contribution.**

The theoretical contribution is the developed theoretical tool, where three theoretical frameworks have been combined. The theoretical tool presents a new way to grasp where resources due to faults of quality are spent and where they are not spent.  Moreover, the tool provides a perspective of how to integrate costs of faults of quality into future supplier selection. The empirical contribution regards the Supplier Quality Performance Tool. This is a practical example of how to integrate Costs of Quality into future supplier selections. This tool is based on the theoretical tool, the difference is that one part of the theoretical tool don't have to be applied to the usage of the Supplier Quality Performance Tool. This is further described in chapter number 5,regarding Construction of the Supplier Quality Performance Tool.

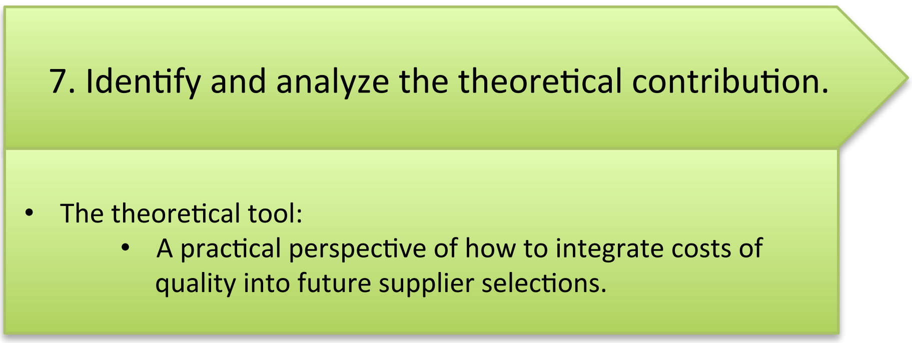


Figure 2.12: Summary of step 7.

## 2.5 Benefits and potential risks

When using a constructive research approach, both benefits and risks can be identified. It is essential to take advantage of potential benefits and avoid potential risks at largest extent. One benefit is the possibility of two-ways perspectives from theoretical studies as well as empirical studies. Furthermore, the empirical studies performed by the researchers will lead to a smaller gap between practitioners and researchers.

Potential risks with the project have been identified and discussed. These risks are:

- Problems with access to data and information needed to be able to develop the tool.

- That the tool won't be used due to complexity or non-accuracy.
- That the total Costs of Quality calculated by the tool are exaggerated and that suppliers thereby have to bear higher costs than they should.
- That the authors fail to express the validation of the tool.
- Lack of time to test and validate the tool with employees at Sony Mobile.
- That the developed result is too important that the organization will not publish it.

Managing the risks:

- During the process difficulties in finding the data needed have been acknowledged. The authors have been directed to various departments in order to find the data searched for. More than thirty interviews have been performed in order to find relevant and correct data. This has been time consuming but also resulted in a wide knowledge. Finally the authors have received relevant data from various departments at Sony Mobile and from the production facility BMC.
- The tool is developed in excel which the users are familiar with, this is made in order to avoid a tool that won't be used due to the complexity of it. The tool is based on formulas that are easy to follow. As a complement an instruction document has been developed in order to guide the user regarding gathering of reports, gathering of data and how to use the tool. To minimize the risk of non-accuracy the data included in the Supplier Quality Performance Tool is gathered from the source where it has been registered. The data has not been sent to anyone in between.
- To avoid that suppliers have to bear larger costs than what they actually have caused the costs throughout the tool have rather been understated than exaggerated. An additional aspect is that all cost drivers are not included in the tool due to unavailability of data or unreliability.
- The validity of the tool has especially been communicated in the methodology where the main activities are described as well as the purpose with the activities. Furthermore, it is in the empirical study described what cost drivers that have been identified and which are excluded and the reason for it. The interviewed employees are described and the spread of these gives indications to a wide knowledge base. Moreover, many theoretical frameworks are presented in

order to give a wide perspective of the subject. This illustrates that the authors have studied a lot of literature and applied the most relevant ones.

- A time schedule has been used by the authors during the process in order to ensure that there is time to perform a test.
- To avoid that the result is too important for the organization the authors have converted the numbers into fictional numbers. The real numbers have been given to Sony Mobile.

## 2.6 Quality and reliability of the thesis

In order to prevent some of the risks above to occur, it has been important to have validation in mind throughout the process. In this paragraph focus will be the importance of reinforcing the conclusions and ensuring general results. Three categories are identified in this area:

*Reliability*: it is crucial that the process is clearly presented to the reader. This is important in order to get a distinct picture of the approach. For instance, it is important to present how the data gathering has been made and it can be necessary to show the interpretation of the data to the person that provided it. By doing so, potential misunderstandings are avoided. Furthermore, it is important to give grounds to why the studied persons have been selected. (Höst, 2006)

*Validity*: to increase the validity of the project it is important to show the relevance between what is measured and the objective. In other words, it is important to measure right things and find the right objective. Another potential way is to study the object by several methods and from different perspectives. (Höst, 2006)

*Representative*: the representativeness is mainly related to the selection. A well and detailed description of the investigated context can increase the representativeness. (Höst, 2006)

Svensson (1994) points at an important criteria regarding validity, entitled *discourse criteria*. Focus lie on whether the argument or statement can manage alternative arguments. If the argument has few weaknesses, the result has often been developed in a high quality process. Additionally, the literature emphasizes the importance of gaining approval from empirical studies. Concerning empirical studies it is crucial to present the compliance regarding reality and interpretation. Letting the involved persons get access to the interpreted material and give feedback can complete this. Closely related to empirical studies is the importance of consistency of the project (Svensson, 1994).

Throughout the process focus has been on validating the actions taken. Following paragraphs regard the implementation of the categories in this thesis. It is divided into the main categories of the process; mapping of processes within a mobile phone project and identification of cost drivers. In the empirical study, chapter 4, the most relevant reference is presented. However, this does not mean that it is the only employee that has emphasized the fact.

### 2.6.1 Mapping of processes within a typical mobile phone project at Sony Mobile

Within this activity a presentation of how the processes have been studied has been made. The employees that have been interviewed were presented and the purpose of interviewing as many employees was described. The fact that the position of the interviewed employees varies gives indications that a wide perspective has been gathered. Furthermore, the employees selected to interview are the ones the authors have perceived to have important and relevant information. The results of the interviews were by the authors summarized and an interpretation of a mobile phone project was created. The interpreted processes were as Svensson (1994) emphasizes, presented to the selected interviewed employees in order to gain additional feedback. The processes needed to be slightly revised after the presentation of the interpretation. The empirical study has subsequently been sent to two employees in order to receive feedback on the interpreted material.

### 2.6.2 Identification of cost drivers

An important aspect in the identification of cost drivers is that the authors have paid a lot of attention in finding data connected to as many cost drivers as possible. If one employee has argued for an exclusion of one cost driver, the authors have confirmed the reason with other employees before the cost driver has been excluded. The concerned cost drivers are further described in chapter number 5 regarding Construction of the Supplier Quality Performance Tool.

Furthermore, during the creation of the Supplier Quality Performance Tool focus has been to certify the decisions taken by discussing it with relevant employees. An activity related to this is the need of being observant to which persons that are relevant to discuss various issues with.

An example of an issue was related to the scope of the tool during half time. The identified problem is related to the complexity presented by Sörqvist (1998) in figure 2.3. The question was whether the scope of the tool should be general or specific. A more specific tool will imply a more accurate result, while the with a specific tool is that updates of it will require a lot of time, which might lead to the tool not being used. Though, a general tool can be implemented at all commodities. The data will not be as accurate since the costs will be based on average costs. The risk is thereby that the non-accuracy of data leads to misleading results, which subsequently might lead to the tool not being used. The issue was raised with the Director of Sourcing Mechanics Electronics who emphasized the importance of them both. In the end, he considered the most important aspect to be as accurate data as possible.

# 3. Theoretical framework

*At first, theories regarding purchasing process and supplier selection are presented. In the supplier selection section, Total Cost of Ownership, analytical-hierarchical process and supplier performance evaluation have major focus. Subsequently, the supplier quality performance part starts with a short definition of quality and is followed by an introduction of total quality management and Costs of Quality. Finally, the theoretical tool is presented.*

The theoretical framework is divided into two parts; purchasing process and supplier quality performance. The theories mentioned in the opening paragraph are chosen in order to present several perspectives within the two areas. Three of the theories will have major focus in the development of the Supplier Quality Performance Tool and these are Total Cost of Ownership, Cost-ratio plan and Costs of Quality.

## 3.1 Theories included in the purchasing process part

Figure 3.1 illustrates the studied theories related to the purchasing process part. The purpose with the figure is to clarify the correlation between various theories.

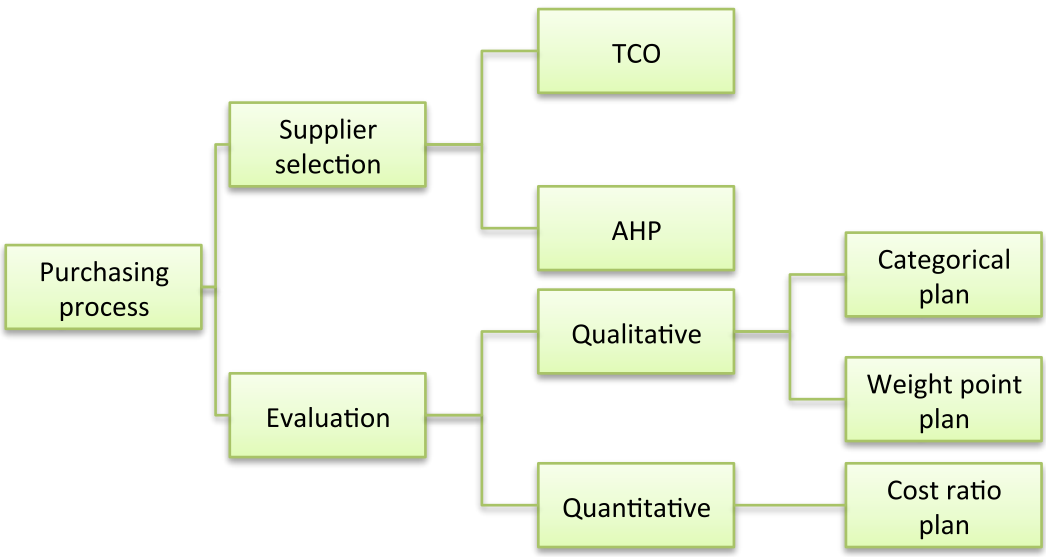


Figure 3.1: Theories included in the purchasing process part.

## 3.2 Purchasing process and supplier selection

The purchasing process includes following steps; determining specification, selecting supplier, contracting, ordering, expediting and evaluating and finally follow-up and evaluating, see figure 3.2 (van Weele, 2010).

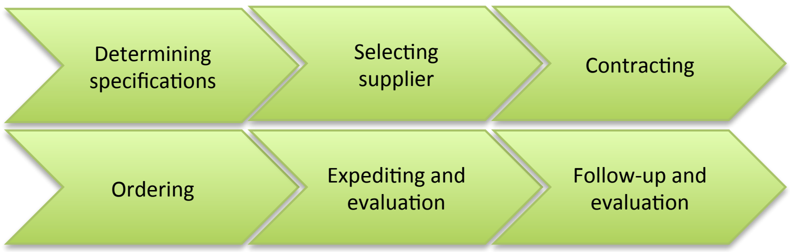


Figure 3.2: Purchasing process (van Weele, 2010, p: 9).

The selection of a supplier can be of different character and the purchasing process is normally not fully utilized. The single time the organization utilizes the whole purchasing process is when a new product or service shall be purchased from a new supplier. The most common purchasing situation is rebuys and within rebuys the purchasing process is not fully utilized. van Weele (2010) divides the purchasing situation into three different categories; *new-task situation*, *modified rebuy* and *straight rebuy.* The new-task category is when the company decides to buy a completely new product from an unknown supplier. This category carries high risk due to the fact that the specifications of the product are established during the process. The second category; modified rebuy, regards purchases of a new product from a known supplier or a purchase of an existing product, but from a new supplier. When this purchasing category occurs it can be due to findings of better alternatives than existing ones. Each of the steps in the purchasing process are not used in this type of purchase, instead focus lies on the last five steps of the process. The first step, selecting supplier, is included when having an existing product and selecting a new supplier. The last category; straight rebuy, is the most common in purchasing situations. This is when the company buys existing products from a known supplier. This type of purchase is exposed to low risk since the purchaser has earlier experiences of both the product and the supplier. A mutual contract often exists and the responsible department places the order through an e-procurement solution in order to fasten the transaction. Finally, in straight rebuys, the three last steps of the

purchasing process are utilized. At times, the contract needs to be updated and renegotiated, which means that the contracting step is included (van Weele, 2010).
The supplier selection process exists in order to support the purchaser in the decision making process. The process is divided into several steps and companies use various approaches/methods. Following paragraph starts with an overall description of the selection process and is followed by a presentation of two supplier selection methods.

The supplier selection process is a key to success of buyer-supplier relationship. Supplier selection is a cross-functional activity, where following functions can be involved: purchasing, design, quality, production, production planning. Environmental and sustainability criteria are also important factors to have in mind (van Weele, 2010).

The selection process starts from a base with many potential suppliers and ends with one or a few selected. The supplier selection process is illustrated in figure 3.3. **(1)** The selection process starts by a summarizing of prequalification requirements based on order specification made by the buyer. These prequalification requirements have to be met by the suppliers. **(2)** Furthermore, a bidders' long list is assembled, which includes the suppliers that meet the buyers' prequalification. Usually the suppliers with excellent past performance will be signed for this list. **(3)** Consequently, a request for information (RfI) will be sent to the selected suppliers. This is a request where the suppliers are invited to submit general information that may help them to qualify as suppliers. **(4)** These suppliers are contacted by the purchasing company in order to gain information from earlier projects and earlier experiences with the purpose to make as qualified selections as possible. In some cases, the company visits the supplier or makes an audit to ensure the supplier´s capability. Larger companies usually use an 'approved vendors list' to select supplier for the bidders´ long list. **(5)** The bidders´ long list is subsequent to the gathered information, reduced to a shorter list called bidders´ short list. The bidders´ short list includes the suppliers that meet the buyer´s pre-qualification and that will be requested to send a bid. **(6)** When the bidders´ short list is completed the company sends a request for quotation (RfQ) to the suppliers at the short list. More details are included in the RfQ than the RfI and contain a set of requirements. **(7)** At this stage the company invites the suppliers to provide a bid that meets the requirements in the RfQ. This is made in order to make it easier for the purchaser to evaluate the suppliers against each other. This process is referred to as the tendering process. The tendering process can either be open or close. An open tender is performed without prequalification of suppliers and a close tender is limited to a small group of suppliers that have been preselected. **(8)** When the evaluations of the suppliers in the RFQ and the bids with detailed information have been sent, the buyer evaluates it based on several aspects, for example: logistics, technical, quality, financial and legal (van Weele, 2010).

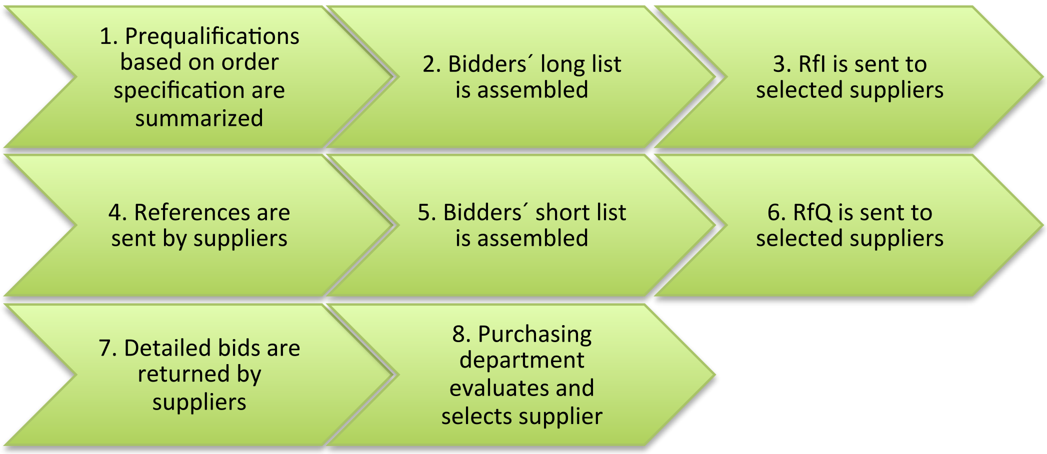


Figure 3.3: Supplier selection process (van Weele, 2010, p: 36).

When one supplier is selected, the supplier selection proposal consists of:

- The underlying biddings, which have been considered.
- The underlying ranking schemes.
- A selection of a certain supplier.

In the field of supplier selection, both qualitative and quantitative approaches exist (Xinxing et al, 2008). Benyoucef et al (2003) describes three selection methods; *elimination method*, *optimization method* and *probabilistic method*. In this thesis two other supplier selection methods have been chosen to study more thoroughly and these are Total Cost of Ownership (TCO) and Analytical Hierarchical Process (AHP). The difference between these is that TCO takes definitive costs related to various parameters into consideration (Ellram and Siferd 1993), while AHP ranks various parameters with regards to their importance to the company against each other. Costs can be included in AHP as well, but not in definitive terms (Saaty, 2008).

An additional aspect the purchaser needs to investigate is the risks connected to the specific supplier/suppliers. This is especially critical when the company only has one supplier or is purchasing a critical component. Many different aspects can be analyzed related to the supply risk (Levary, 2007):

- The supplier's availability of technological base necessary to produce the component.
- Volume flexibility for a supplier to change from producing significantly larger or smaller batches of a component.
- Ability to convert the production of one component to another.
- Reliability of supplier.
- Supplier located in a country with low country risk, which includes political risk, risk of natural or man-made disasters, and currency convertibility risk.

### 3.2.1 Total Cost of Ownership (TCO)

*"TCO is an innovative philosophy aimed at developing an understanding of the true cost of doing business with a particular supplier for a particular good or service"* – (Ellram, 1994).

"*TCO is an attempt to quantify all of the costs related to the purchase of a given quantity of products or services from a given supplier"* – (Degraeve and Roodhoft, 1999).

Trends at the market have increased the interest of Total Cost of Ownership. Trends that have had influence are for instance: extended emphasis on quality of purchased material, supplier base rationalization and increased global competition. To stay competitive at the market, costs identifications in several dimensions are important (Ellram, 1993).

An important platform for Total Cost of Ownership is a theory called activity based costing. The activity based costing system facilitates the estimation of the cost of resources used in organizational processes to produce outputs (Cooper and Kaplan 1992). Furthermore, it is a pricing method that identifies activities in an organization and connects costs to each of the activities. By doing so, the organization gets greater hold of true costs of the products and can eliminate the ones that are unprofitable and lower the price for the overpriced ones (van Weele, 2010). An equation for calculating costs for an activity is presented below.

$$\text{Activity} = \text{Activity usage} + \text{Unused capacity}$$
(Cooper and Kaplan 1992)

The variable 'unused capacity' is defined as the difference between the costs of resources used, estimated through the ABC-model, and the costs for resources supplied or available, reported in the financial statement of the organization. An ABC-model can help the company mix prices, products and customers. It can also help the company to reduce resource usage, which will imply unused capacity. The unused capacity can either be managed away or used to process more throughput. Summarized, ABC is used to categorize costs associated to certain activities in order to comprehend the true cost of a product.

The aim with Total Cost of Ownership is to understand the true cost of a product. Theories emphasize the importance of including all costs related to a purchase and not only the purchase price. It can be seen as both a purchasing tool and a philosophy. When identifying cost elements, it is recommended that the company search for costs in three dimensions. The first dimension includes the *pretransaction* phase that embraces the whole way from the idea/concept phase until order placement phase. Costs related to this phase can be investigation and qualification of sources. Next dimension regards the actual *transaction* from order placement to receipt and typical costs are purchase price, delivery and inspection costs. The last dimension; *post transaction* includes costs related to the phase where the customer has received the receipt to disposal of the product by the firm or consumer. Common costs in this dimension can be costs of returns, warranties etcetera. By including these three dimensions, the whole chain associated with a purchase is covered (Ellram, 1993).

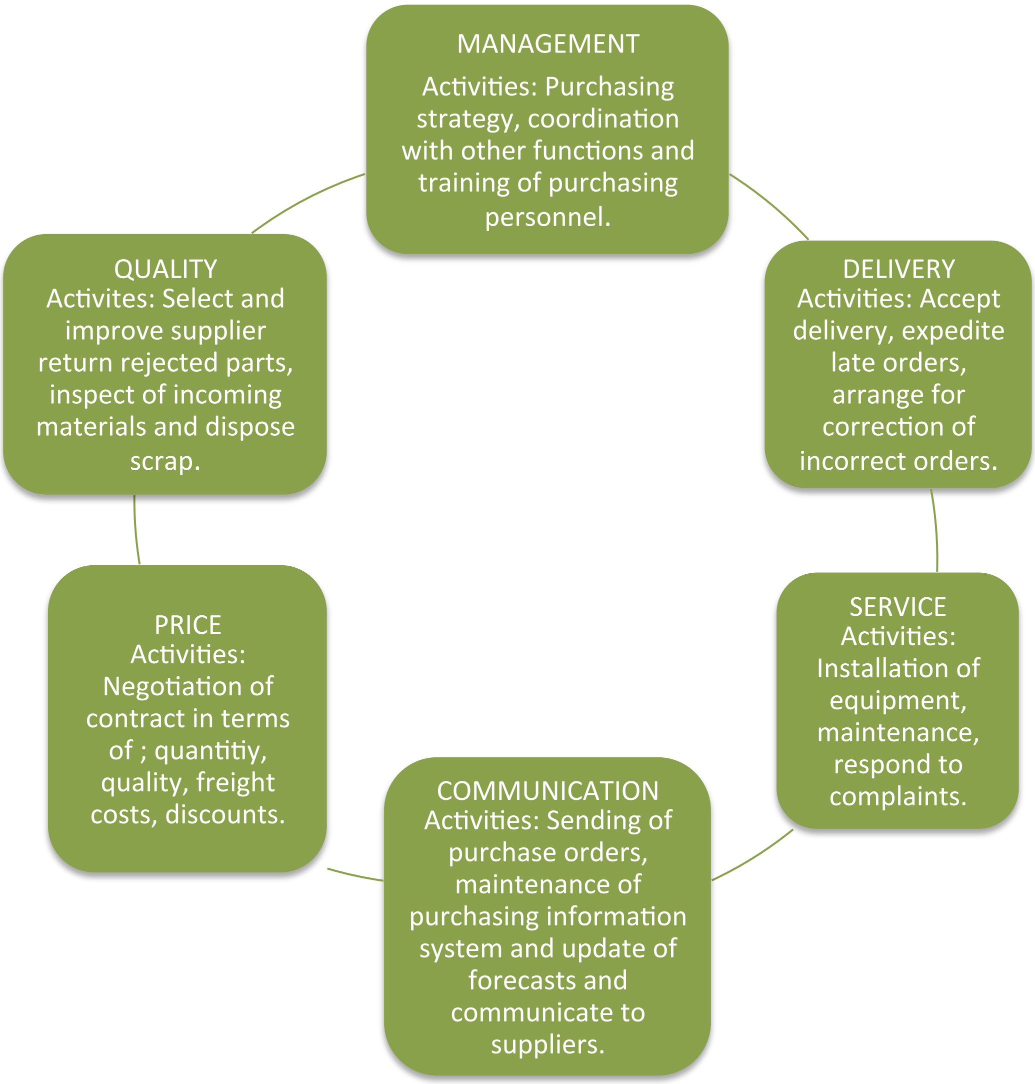


Figure 3.4: Purchasing activities contributing to the Total Cost of Ownership (Ellram and Siferd, 1993 p: 166).

Areas included in the Total Cost of Ownership are; management, delivery, service, communications, price and quality. The parameters and examples of activities in each of the parameters are illustrated in figure 3.4 above.

The activities are related to different costs that need to be included in the estimation of Total Cost of Ownership. According to Ferrin and Plank (2002) it exist thirteen cost drivers, which are presented below.

- *Operation cost* where manufacturing and assembly costs are included.
- *Quality costs* are often related to consequences of poor quality. These cost drivers are total quality management, inspection, quality improvement, calibration, replacement, rework, scrap, production downtime, out-of-service, durability, customer returns, badwill and Costs of Quality.
- *Customer-related costs* refer to user satisfaction, customer perception and customer specifications.
- *Logistics costs* regard costs related to freight, packaging, warehousing, tariffs and duties.
- *Technological advantage* refers to the ability of technology to affect the buyer's structure. Other costs in this category are the ones related to the supplier's ability to manage changing technology.
- *Initial purchasing price*.
- *Opportunity cost*, the major cost driver within this category is overhead costs.
- *Supplier reliability and capability costs* include partnering costs, teaming costs and suppliers' ability to grow.
- *Maintenance costs* comprise spare parts, labor and repair costs.
- *Inventory costs* contain storage and safety stock.
- *Transaction costs* refer to supplier conversion cost and order size.
- *Life cycle costs* regard calculation of costs over time.
- The category called *miscellaneous* has many cost drivers. Examples are warranties, taxes, installation and technical support.

#### 3.2.1.1 Further definition of quality cost drivers

- *Total Quality Management* (TQM) is a wide concept that includes both quality of the products and internal processes and functions. The focus of internal processes and functions regard the wish to prevent quality issues to occur (Sörqvist, 2002).
- *Inspection* includes evaluation and measurements to verify the quality of a supplier or quality (Business dictionary, 2012).

- *Quality improvement* is signified as the systematic approach to reduce and eliminate waste and rework in the production process (Business Dictionary, 2012).
- *Internal audit* regards evaluation of various parts within a company with the purpose to make the processes more effective (Britannica, 2012).
- *Vendor visits* regard visit to vendor due to quality issues. The purpose with vendor visits is to increase the quality performance of the supplier.
- *Safety stock* is defined as the additional volume that is purchased to guarantee that the production will not run out of products and to be prepared for variations in demand (Axsater, 2006).
- *Calibration* concerns the comparison of the value of measurement instrument and the value of known measurements (NE, 2012).
- *Replacement* regards the exchange of an inferior or superior item (Business Dictionary, 2012).
- Correcting of defective products during or after inspection is called *rework*. Rework includes disassembly, repair, replacement and reassembly (Business Dictionary, 2012).
- *Scrap* can be defined from two perspectives. Scrap can be seen as the cost related to a wasted component. The other perspective regards the costs of other components that need to be wasted due to issues with one component. (Merriam Webster, 2012).
- *Production downtime* refers to a period when an equipment or machine is not functional due to either problems with the machine itself or due to problems in the material of the products (Business Dictionary, 2012).
- *Out-of Service* is when a machine or equipment is not functioning.
- The probability that a product will last for a long time without requiring a lot of maintenance is defined as the product's *durability* (Business Dictionary, 2012).
- *Customer return* is when a customer returns a product due to unmet expectations (Event Sales, 2012).
- *Badwill* refers to bad experiences perceived by the customer or by media that decreases the value and reputation of the company (NE, 2012).
- The costs an organization spends to maintain a certain quality is referred as *Costs of Quality*. It can include prevention costs, appraisal costs, internal failure costs and external failure costs (Accounting for Management, 2012).

### 3.2.1.2 Implementation of TCO

Ellram (1993) has developed an eight-stage process for developing and implementing Total Cost of Ownership, see figure 3.5. The first step of an implementation regards identifying the need and interest of the implementation. Due to the complexity of implementing TCO it is important to understand its purpose. The second step includes the determination of what type of product or purchase that is of interest. The development of a TCO team is the next step and its recommended to develop a cross-functional team. Step four includes a lot of work; identification of relevant costs, determination of relevant costs, classification of available costs and which are not and document data sources for the future. These activities are followed by tests and implementation of the model, the fifth step. The sixth step regards analyzes of the test result and follow-ups on these. Now, studies can be made whether the TCO-system shall be linked to other systems as well. The last step; number eight, regards the need of continuous updates and maintaining of the system (Ellram, 1993).

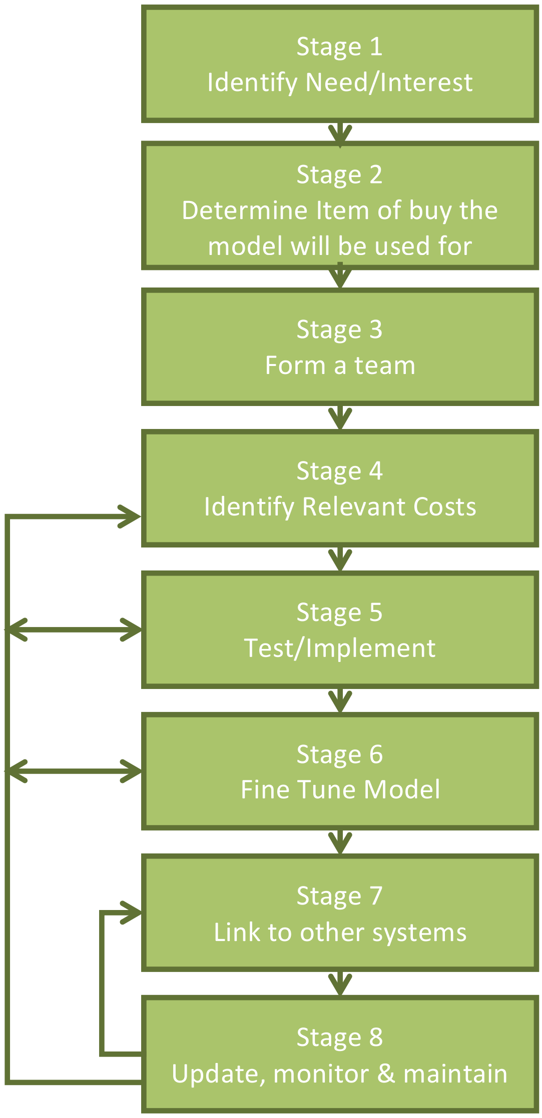


Figure 3.5: Implementation of Total Cost of Ownership (Ellram, 1993 p: 53).

According to Ellram (1994) a TCO-model can either be standard or unique. What type of model to use can depend on company culture, the reason for implementing TCO, the availability of computer systems to support the model and what type of decision the model shall support. The standard model is signified for being used repetitively in different types of purchases. The model needs little modification and the user only needs to insert the relevant costs for the purchase and delete irrelevant ones. A unique model is on the other hand developed for a certain product or purchase. The cost factors vary a lot depending on what to purchase and the user determines what factors to include. The costs are often based on historical experience and the model is in general more complex and time-consuming than a standard model (Ellram, 1994).

In conclusion, a standard model is used when the same cost factors are needed for different types of purchases and the costs can be modified. The unique model is used when cost factors are replaced depending on what to purchase (Ellram, 1994)

#### 3.2.1.3 Barriers and benefits with TCO

Major barriers identified when implementing Total Cost of Ownership is the lack of a standard approach. The fact that the approach varies widely by company and that it might vary by products purchased as well makes the approach complex and time consuming. An implementation will probably need a cultural change, which also is hard to accomplish. An additional factor is that costs included in TCO often are situation-specific (Ellram, 1995). Ellram (1993) has performed a research of Total Cost of Ownership and found more specific barriers for not implementing TCO. These were lack of data resources, training and education. The concept of TCO is easy to understand in theory, while it is more complex in practice. Resource problems that many of the interviewed companies recognized were lack of computer systems to support TCO-data. Accounting and reporting systems were not developed enough, so the data had to be gathered manually. One recurring problem was also that the data needed to estimate Total Cost of Ownership was not gathered. Starting this process will require labor intense work.

As mentioned above, Total Cost of Ownership as a concept is easy to understand and easy to get a comprehension of. The concept also brings the Total Cost of Ownership into perspective and can work as support in future supplier selections. An implementation of TCO can provide access to important data for analyses and negotiations, which can imply lower costs of purchasing a product (Ellram and Siferd, 1993). Furthermore, an implementation of TCO can imply improved decision making, improved internal and external communication, improved understanding of costs and improved supplier performance. Summarized, TCO serves as a consistent supplier evaluation tool that can improve the value of supplier performance comparisons among suppliers, which in the long run can help clarify and define supplier performance expectations (Ellram, 1995).

### 3.2.2 The Analytic Hierarchy process (AHP)

The Analytical Hierarchy Process (AHP) is a method with the purpose to simplify the decision-making when selecting supplier. The method enables the purchaser to interact different factors in complex and unstructured situations. It also provides a ranking order of the overall preferences for each of the decision. The AHP is performed in following steps (Saaty, 2008):

1. Define the problem related to the purchase and determine what kind of knowledge that is needed to solve the problem.

2. Structure the decision, normally by a tree called hierarchy tree where the goal of the decision is on the top. The goal is dependent on several objectives, each of these objectives is consequently dependent on established alternatives, see figure 3.6.

3. Develop a set of matrixes where the different elements are compared against each other.

4. Finally, use the priorities from the elements to weight against each element. This is performed for each element against the other elements.

When comparing the criteria, a scale of numbers is used to indicate how much more important one criterion is to another. To give an easy understanding of how AHP could work in practice an example developed by the authors is presented. The example regards a selection of a supplier where two aspects have been selected as the most important; flexibility and quality.

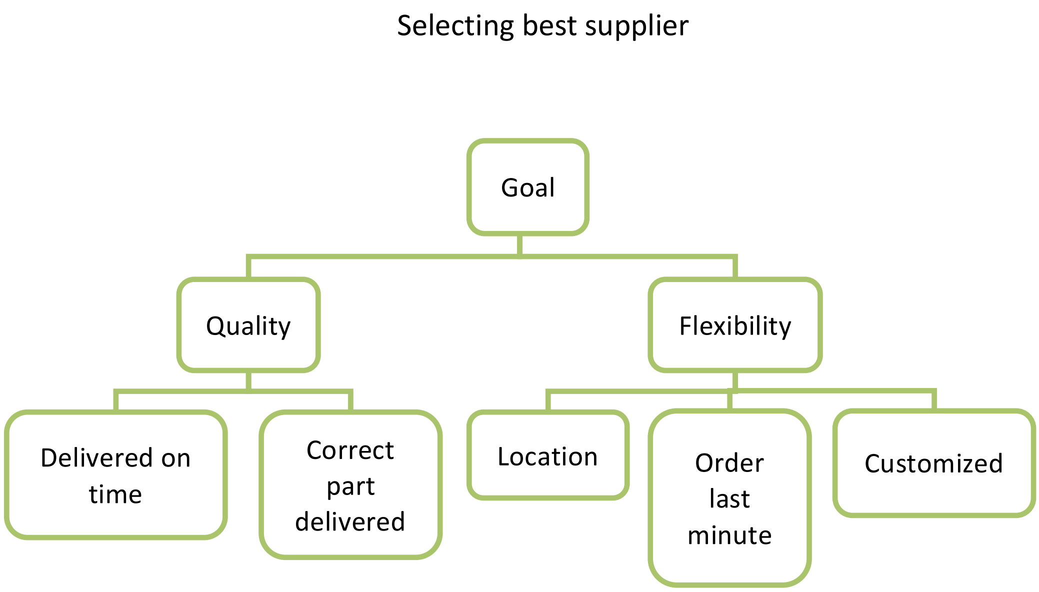


Figure 3.6: Selecting best supplier tree (Saaty, 2008).

The two objectives in this tree are quality and flexibility. These two are weighted against each other. In this example the quality is prioritized three times higher than flexibility. Both of the objectives flexibility and quality are dependent on underlying alternatives chosen by the company. Table 3.1 shows the weighting between the two objectives.

Table 3.1: Quality and flexibility weighting.

| | **Quality** | **Flexibility** | **Priorities** |
|---|---|---|---|
| **Quality** | 1 | 3 | 0,75 |
| **Flexibility** | 1/3 | 1 | 0,25 |

As illustrated in table 3.1 above, the quality aspect is ranked higher than the flexibility aspect due to the purchasers' preferences and is thereby prioritized. The column; *priorities* is calculated by the total weight from each criteria divided by the total weight of all criteria. In this example, quality: $1 + 3 = 4$, flexibility: $\frac{1}{3} + 1 = 1\frac{1}{3}$ gives a total of $5\frac{1}{3}$.

When calculating the priorities it gives $\frac{4}{5\frac{1}{3}} = 0{,}75$ for quality and $\frac{1\frac{1}{3}}{5\frac{1}{3}} = 0{,}25$ for flexibility. The same calculations are made for the underlying alternatives; *Location, order last minute* and *customized* under flexibility and *delivered on time and correct part* under quality.

From the priorities and the supplier tree, a decision of which supplier that best matches the set requirements can be taken. Once the criteria are prioritized the total score of the different suppliers are made in a separate table. When weighting the suppliers against each other the elements from each supplier are compared. This is made for all elements and a total score is summarized. The supplier with the highest total score is chosen.

### 3.2.3 Supplier Quality Assurance

A technique to improve quality performance is to implement Supplier Quality Assurance (SQA). SQA includes all activities operated by a company in the aspiration to accomplish zero-defects quality performance in its relationship with the suppliers (van Weele, 2010).

Quality assurance is a very important factor in supplier selection. It includes keeping the methods of quality management and to perform verifications. The verifications can be made both internally and externally. Internally, the checks are generally called auditing while external checks regard verifications towards national and international standards, for instance ISO-9000 standards (van Weele, 2010).

### 3.2.4 Supplier Performance Evaluation

Burt (2003) has identified three common evaluation plans for suppliers; the *categorical plan*, the *weighted point plan* and *Cost-ratio plan*. The plans are stated as evaluation tools, but can be used in the supplier selection as well.

#### 3.2.4.1 Categorical Plan

In a categorical plan, departments of the company make informal evaluation records. Each department identifies their own evaluation criteria and ranks the suppliers. The ranking can be preferred, neutral or unsatisfactory for each supplier. The departments involved in the informal evaluation records are usually supply management, quality, accounting and engineering. Subsequently, the relative importance of the criteria is weighted against each other and a total ranking of each supplier is performed (Burt, 2003).

#### 3.2.4.2 Weighted Point Plan

The major focus of a weighted point plan is to prioritize performance factors against each other. Performance factors can be factors as quality, service and price. The weights are individually determined by each company and can for instance be: quality twenty five percent, price forty five percent and service thirty percent. Once the factors have been selected and weighted, the actual performance of each supplier for each performance factor is measured. Subsequently, the total score of a supplier is calculated by multiplying the individual score of each factor with the weight of the factor (Burt, 2003).

#### 3.2.4.3 Cost-ratio plan

The Cost-ratio plan, also called cost ratio method, is a method that evaluates supplier performance using standard cost analysis. When using a cost-ratio plan, the organization identifies key factors that increase costs. These factors can be: quality, service, delivery and price from supplier performance (Burt, 2003).

Elements included in the quality factor are (Burt, 2003):

- Visit to vendor’s plant for approval of samples.
- Inspection costs.
- Cost of defective product.
- Reworking costs.
- Manufacturing losses on rejected items.

Elements included in the delivery factor are (Citeman, 2009):

- Postage and telegrams.
- Telephones.
- Visit to vendor’s plant for expediting the delivery.
- Extra cost for getting quick delivery.

What variables to include in the Cost-ratio plan are determined by the cost impact the variable has as well as the reliability of the cost. The method is divided into a four-step approach. The first step of the method is to determine the internal costs associated with quality, delivery, and service. The second step regards converting these into a cost ratio, where the costs are expressed as a percentage of the total value of the purchase. For example, if the costs related to quality is one hundred thousand Euros for a given month and the total purchase of this month is five million Euros, the quality cost ratio is two percent. This is performed for each of the cost related to the total price.

The third step is to summarize the cost ratio from all the factors to give a total cost ratio for each supplier. In the last step, the cost ratio is adjusted to the cost figure. The cost ratio, or index, is subsequently used as a multiple in future purchases from this supplier in order to discover the true Total Cost of Ownership (Ellram, 1995). For instance, if the cost ratio for quality were two percent, service one percent and delivery one percent the total cost adjustment would be four percent. For a price of six hundred Euros the net adjusted price would be $600 + 600 \times 0{,}04 = €624$. In practice, the supplier with the lowest adjusted price is chosen (Humphreys et al, 1998).

## 3.3 Theories included in the supplier quality performance part

Figure 3.7 illustrates the theories included in the supplier quality performance chapter.

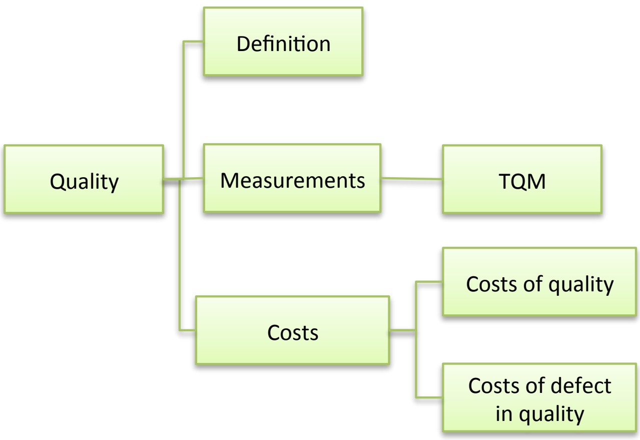


Figure 3.7: Theories included in the supplier quality performance part.

### 3.3.1 Definitions of quality

Several dimensions as well as definitions of quality exist. Examples of dimensions are (Hansen and Mowen, 1997):

- Performance; how well a product or service functions.
- Aesthetics; the appearance of tangible products.
- Serviceability; the ease of maintaining and repairing the product.
- Reliability; the probability that the product or service will perform as expected for a specified length of time.
- Durability; the length of time a product functions.
- Quality of conformance; how the product meets its specifications.
- Fitness of use; the suitability of the product for carrying out its announced functions.

### 3.3.2 Total Quality Management (TQM)

Total quality management (TQM) is a wide concept that includes both quality of the products and quality of internal processes and functions. The purpose of TQM is to increase the amount of satisfied customers both internally and externally. Internally, increased quality can indicate lower costs and increased motivation. Externally, it can result in customers having a higher willingness to pay for the products as well as more frequent returning customers (Sörqvist, 1998).

### 3.3.3 Costs of Quality

Crosby (1984) stated that it is not quality that costs, it is rather the lack of quality that is a major cost driver. Thereby, theory emphasizes the importance of investing in activities that can prevent faults of quality. By investing in preventive activities, costs related to repairs and rework will decrease and the total Cost of Quality will decrease. Sörqvist has illustrated this in a bar chart to give a clear picture of the costs, see figure 3.8. Furthermore, Cost of Quality (CoQ) can be divided into four main categories, presented below:

1. *Prevention costs*; related to the design, implementation and maintenance of the total quality management system (Tsai, 1998).

2. *Appraisal costs;* associated with the suppliers' and customers' evaluation of purchased materials, processes, products and services to ensure that the product meets the specification. (Tsai, 1998). Subcategories include testing and inspection of incoming material as well as product quality audit (Hoque, 2003).

3. *Internal failure* costs occur when products or material fail to meet quality requirements. These costs occur before reaching the customers (Hoque, 2003).

4. *External failure costs* include costs related to issues once the product has reached the customer. Examples of costs are complaints, returns, repair etcetera (Hoque, 2003).

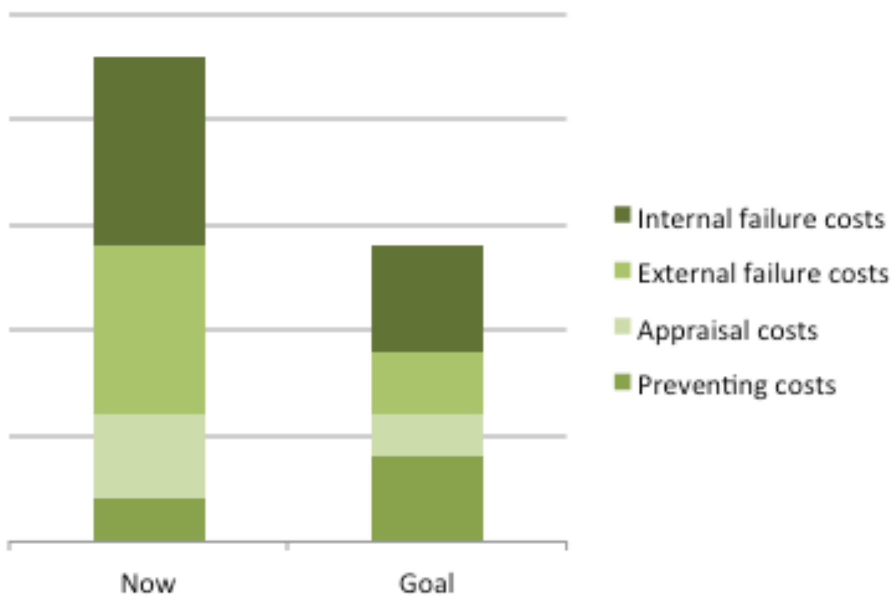

Figure 3.8: Categories of Cost of Quality (Sörqvist, 1998, p:35).

Sörqvist (1998) divides quality costs further and identifies five major costs:

1 Traditional Costs of Quality; costs related to faults of products, for instance repair, delays and guarantees.
2 Hidden Costs of Quality; this level includes the remaining costs caused by faults in products, for instance direct salary and direct material.

3 Lost revenue; revenues the company misses due to the fact that the products do not meet customers' expectations. If defected or insufficient products reach customers the company can lose customers in a long time ahead.
4 Customers' costs; these costs are related to external customers perceiving quality issues with a product. This can imply lost customers and can cost the company a lot of money in the long run. The company looses goodwill.
5 Community costs; the costs that affect the society in general. It can be environmental related costs caused by faults of quality.

Cost of defect in quality can be seen as mobile or inert. Costs that are mobile are costs that changes quickly when a change in quality is performed. Costs that have longer adjustment time are for instance cost of control. The reason for the longer adjustment time is due to the fact that controls are made subsequent to the changes. It could be unnecessary for a company to measure the Costs of Quality if the improvements in quality do not lead to decreasing of quality costs directly (Sörqvist, 1998).

## 3.4 Theoretical tool

Throughout the first area of theory, theories regarding supplier selection methods, tools for supplier selection and evaluation methods have been presented. In order to create a Supplier Quality Performance Tool that Sony Mobile can use in future supplier selections, two of the theories above will get major focus. One reason for choosing the theories is due to the fact that Sony Mobile wants the Supplier Quality Performance Tool to be based on quantitative data. Moreover, it is important that the quantitative data is represented in monetary terms. Furthermore the aim of the thesis is to create a tool that adds the Costs of Quality to the purchasing price in order to specify a more accurate cost of the purchased component. A cost-breakdown is emphasized in theories regarding Cost-ratio plan and this can be applied to costs related to quality issues. *Total Cost of Ownership (TCO)* and *Cost-ratio plan* will form the basis for the development of the Supplier Quality Performance Tool. The theory regarding *Costs of Quality* will be included in the theoretical tool as well. In practice, TCO and Cost-ratio plan will be helpful in the identification of cost drivers, the cost drivers will subsequently be categorized into the categories within Costs of Quality and operate as parameters in the Cost-ratio plan. In the usage of the Supplier Quality Performance Tool, the second step; to categorize cost drivers into Costs of Quality is not a required step.

The chapter regarding quality of supplier performance takes a broad perspective. The cost drivers included in the Supplier Quality Performance tool are due to direct quality issues discovered in the products. The type of quality studied is what Hansen and Mowen (1997) defines as performance, aesthetics and quality of conformance. Sörqvist (1998) has identified four categories of costs related to quality and each of these categories includes several cost drivers. These cost drivers can be important to be aware of when selecting supplier. Thereby, these parameters are relevant to include in a theoretical tool. The cost drivers are identified in theory regarding TCO and Cost-ratio plan and are categorized into Sörqvist's four categories, see figure 3.9. Notice that the parameter Cost of Quality, mentioned in TCO, is not categorized. This is due to the fact that it is an overall cost driver that covers all remaining cost drivers. In practice, the theoretical tool can give the concerned company an indication of where their Cost of Quality focus is.

| **Prevention cost** | |
|---|---|
| Quality improvement | $ |
| Total quality management | $ |
| Prevention cost $(P_i)$ | $\sum \$$ |

| **Appraisal cost** | |
|---|---|
| Quality improvement | $ |
| Vendor visits | $ |
| Calibration cost | $ |
| Inspection cost | $ |
| Safety stock | $ |
| Internal audit | $ |
| Appraisal cost $A_i$ | $\sum \$$ |

| **Internal failure costs** | |
|---|---|
| Replacement cost | $ |
| Rework | $ |
| Scrap | $ |
| Production downtime | $ |
| Out of service | $ |
| Internal failure cost $(I_{i)}$ | $\sum \$$ |

| **External failure** | |
|---|---|
| Customer return | $ |
| Badwill | $ |
| External failure cost $(E_i)$ | $\sum \$$ |

Figure 3.9: Theoretical tool. Developed by the authors, a combination of the theories TCO, Cost-ratio plan and Costs of Quality.

In the theoretical tool, the costs included in the categories above are summarized into a total Cost of Quality, see formula 3.1. The costs are according to the formula connected to component and supplier. If the buyer wants to evaluate a supplier instead of a specific component he/she shall use formula 3.2.

$$TCoQ_c = \sum_{i=1}^{i=tot\ comp} P_{ci} + A_{ci} + I_{ci} + E_{ci}$$

$$c = the\ supplier\ c$$

$$i = the\ component\ i$$

Formula 3.1: Total Cost of Quality for one type of component caused by one supplier.

$$TCoQ_c = \sum_{k=1}^{k=tot\ comp\ types} \sum_{i=1}^{i=tot\ comp} P_{cik} + A_{cik} + I_{cik} + E_{cik}$$

$$c = the\ supplier\ c$$

$$k = type\ of\ component$$

$$i = the\ component\ i$$

Formula 3.2: Total Cost of Quality caused by one supplier.

The total Cost of Quality is subsequently divided by the historical amount of purchased components, which will result in the Cost of Quality for one component, see formula 3.3.

$$TCoQ\ for\ one\ component = \frac{TCoQ_c}{Historical\ amount\ of\ purchased\ components}$$

Formula 3.3: Total Cost of Quality for one component purchased from one supplier.

The total Cost of Quality for one component can furthermore be used in future supplier selections and give the supplier a more correct price of what the supplier is offering. Finally, the total Cost of Quality will be added to the new purchase price and generate a total price for the purchased component, see formula 3.4.

$$New\ purchase\ price_c = purchase\ price_c + TCoQ_{C,one\ component}$$

Formula 3.4: The new purchase price for one component when including the total Cost of Quality.

The theoretical tool will form the basis in the empirical study and in the development of the Supplier Quality Performance Tool at Sony Mobile.

Regarding Total Quality Management (TQM), major focus in this thesis will be to study the quality of the products. Simultaneously, it is desirable that the usage of the developed tool will lead to an improvement of the internal processes within Sony Mobile. The aim with the tool is that it shall lead to lower costs and increased customer satisfaction due to a decreasing amount of mobile phones with poor quality. Furthermore, the development of a tool is categorized under prevention costs. The purpose is to invest money in a tool in order to decrease the correction costs. Furthermore, the categories of costs investigated are traditional Costs of Quality and hidden Costs of Quality. The other costs will probably be affected by faulted quality, but will not be analyzed further in this thesis.

## 3.5 Reflections of the theoretical framework

The presented theories have as mentioned in methodology functioned as an approach to acquire a wide knowledge of the subject and closely related subjects. Furthermore, it has served as inspiration in the process of creating a tool that Sony Mobile can use in future supplier selections. Some theories have been applied in the search of potential cost drivers and others have been applied directly in the development of the tool. The remaining theories are referred as contribution to knowledge of the subject.

# 4. Empirical study

*The chapter starts by a presentation of the processes within a typical mobile phone project within Sony Mobile. It starts in the concept phase, followed by the project. In the project the purchasing process at Sony Mobile is presented followed by production process and finally after-sales. Finally, the identified cost drivers are presented.*

## 4.1 Processes within a typical mobile phone project at Sony Mobile

The processes within a mobile phone project is presented from the authors' perspective after having interviewed among others four Strategic Buyers, two Global Commodity Managers, one Senior Project Manager, one Staff project manager and the Director of Supplier Quality Assurance. The description of the production process is to great extent based on the demonstration of the actual production prototype line at Sony Mobile.

Several processes are included within a mobile phone project at Sony Mobile, see figure 4.1 below. Before the project actually starts, a concept phase exists and ideas of a new mobile phone are developed. Subsequently, the project starts and the first process is the purchasing process, including supplier selection. Subsequently, the production process is started. The production process is divided into two processes called development process and high volume process. In the first one; the development process, prototypes are developed during a period of one year. When all components are fulfilling the requirements and are functioning together in the mobile phone, the mobile phone is ready to be launched at the market (Åberg, 2012). In this phase the production is reformed to the second process; the high-volume production process, and the mobile phone is launched continuously. The supplier and component is evaluated iteratively through this process. The production process continues until the project's end of lifetime (EOL). EOL is the time where the specific mobile phone dies and is not sold anymore. The noticed and registered supplier evaluation is not in a structured way resubmitted into future supplier selections. A mobile phone project normally lasts for three years (Pålsson, 2012).

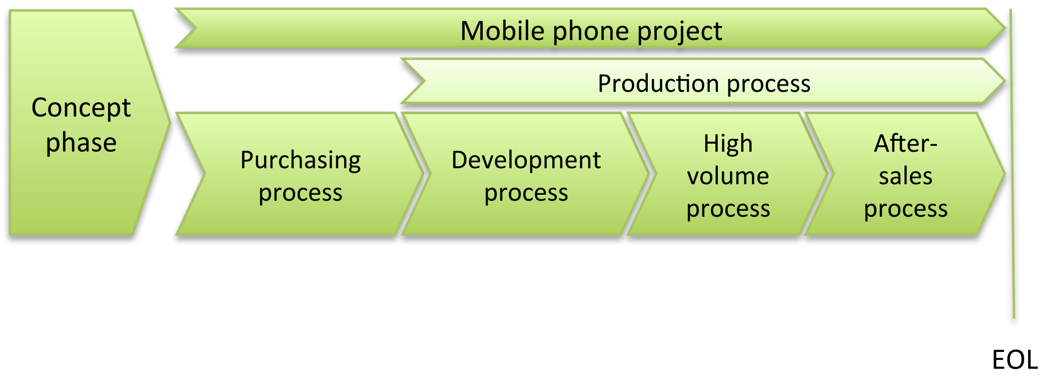


Figure 4.1. A mobile phone project at Sony Mobile. The figure is developed by the authors after several interviews with employees at Sony Mobile, see page 16 for the exact employees.

### 4.1.1 Concept phase

Ideas of a new mobile phone are generated in this phase and several departments are working together in a project team. The involved departments are design, R&D, IPQM and purchasing. This phase takes place right before the project starts and the output in this phase is a concept of how the new mobile phone shall function and ideas of the design. Ideas of components that shall be included in the mobile phone are developed and communicated to the purchasing department (Pålsson, 2012).

### 4.1.2 Purchasing process and Supplier selection at Sony Mobile

The needs of components, which have been communicated from R&D and design in the concept phase to the purchasing department, initiate the supplier selection at Sony Mobile. As a first step the Strategic Buyer formulates a request for quotation (RfQ) to potential suppliers. The RfQ includes basic requirements of the component. The responsible development department formulates the requirements of its included components. The requirements are based on historical experiences and managements' requests (Wolff, 2012).

During the third step, the suppliers answer the RfQ and submit a specification of the specific product. All suppliers that have received an RfQ are automatically qualified in the first screening. Subsequently, two types of evaluations are performed. One evaluation is classified as technical and a technical evaluator checks that the suppliers fulfill the technical requirements of the component. A typical requirement can be that the component is allowed to be maximum 12 millimeters long. The second evaluation is called commercial evaluation and the major aspect to analyze is purchase price. The commercial evaluator, a Strategic Buyer, motivates his/hers decision by controlling price and the result of the technical evaluation (Wolff, 2012). Normally, negotiations with the suppliers are performed in this phase. The last step regards the actual selection of supplier. The supplier with the lowest purchasing price that fulfills the technical requirements set by Sony Mobile is chosen. If a more expensive supplier would be chosen, the Strategic Buyer needs to gain approval from purchasing managers (Pålsson, 2012).

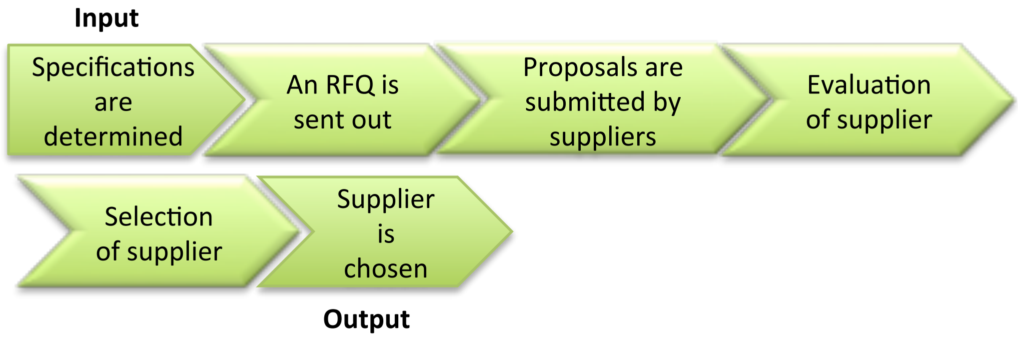


Figure 4.2. Supplier selection process at Sony Mobile. Developed by the authors after interviews with Strategic Buyers.

The supplier selection process at Sony Mobile Communication indicates that except for technical requirements, the major aspects to investigate are commercial conditions and especially purchase price. In some supplier selections the Supplier Quality Engineering department gives indications of poor quality delivered from a supplier. The Strategic Buyer listens but do not know how much the poor quality will cost the company in the long run and can consequently not motivate a selection of a more expensive supplier (Pålsson, 2012). The quality aspect is thereby today mostly based on intuitions, which make it difficult to include in supplier selections.

When the quality department gives indications of poor quality, the information is often gathered from the three areas; First Point of Check, Production and After-sales (Larsson, 2012). These are further described in the chapters regarding Production process and After-sales.

### 4.1.3 Production Process

When the purchasing department has ordered the components, the creation of the production line can start. The production line needs to be assembled and during the first phase; the development phase several prototypes are developed in order to create as qualified products as possible. Subsequently, the production process can be turned into a high-volume production (Åberg, 2012). These phases are further described below and the production process is described in detail in the part regarding high-volume production. This is followed by a presentation of the quality checks in the areas; First Point of Check, Production and After-sales.

#### 4.1.3.1 Development process

In order to produce a complete mobile phone, production lines at BMC have to be assembled. The industrialization department at Sony Mobile is responsible for setting up the production process as well as testing it. The procedure starts one year before the first mobile phone is launched. During this year prototypes are developed in the following steps (Åberg, 2012):

- System Prototype one (SP1)
- System Prototype two (SP2)
- Accepted Prototype (AP)
- Product Qualification (PQ)

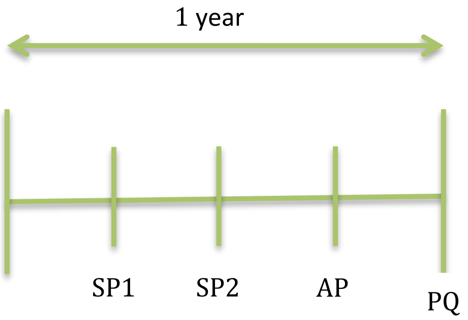


Figure 4.3: The development process (Åberg, 2012).

Prototypes are developed in order to find potential issues in the new design. Important to mention is that the prototypes are going through the same quality checks as in high-volume process, further described in paragraph 4.1.4. The identified issues are furthermore solved and the risk of launching mobile phones with issues at the market is decreased. This is performed in the steps mentioned above and when the mobile phone is in the product qualification (PQ)-phase and have been qualified the mobile phone is ready to be launched (RTL) (Anderberg, 2012). However, the mobile phone is not yet launched at the market, instead it is presented at mobile fairs. The mobile phone is firstly launched when the production process is extended to handle production in higher volume (Pålsson, 2012).

#### 4.1.3.2 High volume process

The department called Operations is responsible for the production in the high volume process. The production process ranges from when components are arriving from the suppliers to the production site BMC until a finished mobile phone is launched at the market. Several steps are performed along the way. The production process at BMC is divided into several steps with quality checks to detect the problems that can occur.

To start with, the production process is divided into three major parts; Service Mount Assembly (SMA), Core Unit (CU) and Sales Item (SI), see figure 4.4. In the Service Mount Assembly (SMA) phase the components are connected to a circuit board through automation. Subsequently, the circuit board is moved to the assembly line and the mobile phone is assembled. This phase is called Core Unit (CU) and is followed by a phase called Sales Item (SI). SI is where the software is implemented into the mobile phone and is ready to be launched at the market (Åberg, 2012).


Figure 4.4: Overall production process at BMC (Åberg, 2012).

### 4.1.4 Quality checks

Quality checks are performed at several steps at Sony Mobile. They are categorized into the areas First Point of Check, Production and After-sales and are illustrated in figure 4.5.

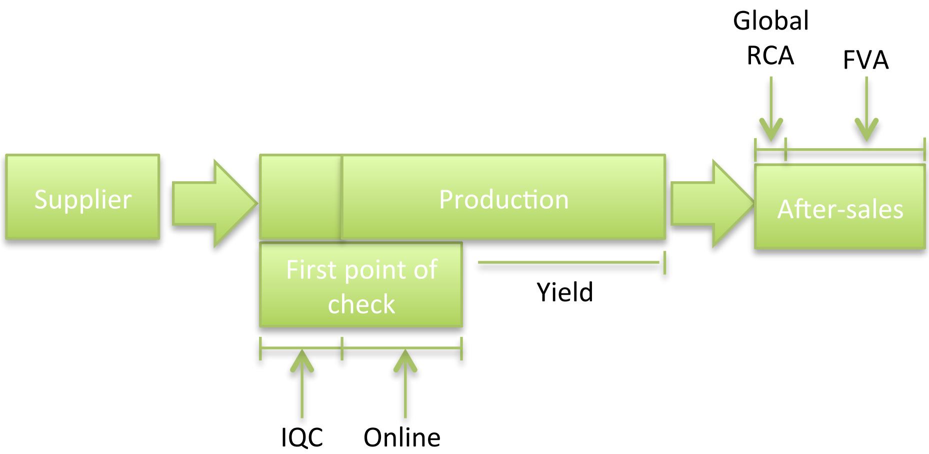


Figure 4.5: The quality checks at Sony Mobile. Developed by the authors.

#### 4.1.4.1 First Point of Check

In the First Point of Check two quality checks exist; IQC and Online-yield, these are presented below.

The majority of components that are delivered in separate pieces and used in the beginning of the production process undergo a first quality check called Incoming Quality Check (IQC) before the production process starts. A sample of the ordered batch is checked and the size of the sample is determined by an Acceptable Quality Level (AQL)-tool. This tool calculates the amount of pieces that need to be checked in order to statistically ensure the whole batch. Subsequently, the AQL-tool calculates the amount of faults that are allowed in the sample. If the quantity of faults exceeds the amount determined by the AQL-tool, the whole batch will be rejected. It means that the batch will be returned to the supplier, and the supplier needs to deliver a new batch. If the quantity of faults is beneath the amount accepted by the AQL-tool, the remaining products will continue through the production process and the faulted ones are lost components (Larsson, 2012).

The remaining types of components are firstly checked in the production process, this is often due to the packing of these components. Thousands of components can be delivered in a tape on reel and if the reel is unpacked and tested these will be destroyed. Neither, is a sample of components possible to test due to the risk that the remaining components will be destroyed as well (Ekman, 2012). Thereby, these components are firstly tested in the production process and the result of this test is defined as Online-yield. Two tests are connected to this yield factor and the first is referred to an online-test and the second a Service Mount Assembly (SMA)-test (Larsson, 2012). The SMA-test consists of two tests presented below. Due to the fact that they are registered together they are referred as SMA-test. The two tests referred as SMA-test are (Johansson, 2012):

1. Embody Test Software (ETS), the first test with the purpose to check that all components are placed rightly at the circuit board. One hundred percent of the circuit boards are tested.
2. The Board Trim test includes a radio signal that controls the function of the board.

The registered faulted components in Online-yield are to ten percent discovered in the online test and are sorted out in pick and place (Jönsson, 2012). Pick and place is when the machine sorts out the faulted components. The remaining ninety percent is discovered in the SMA-test. These ninety percent need to go through a repair-loop. A repair-loop in this phase means that the faulted component will be soldered of and replaced by a new one. When it is possible to blame the supplier, the supplier takes the costs. According to Larsson (2012) this happens in twenty-five percent of the repairs. Important to mention is that the discovered faults in SMA, included in the Online-yield only are faults caused by supplier and faults caused by production or design are not included.

#### 4.1.4.2 Production

Due to the fact that only a sample is tested in IQC, faulted components can continue to the production process. In the production process, eight tests are accomplished (excluding SMA) and additional inspections are performed in order to avoid faulted mobile phones to be launched at the market. These tests are fulfilled in various steps of the production process and are presented below. The results of the tests are registered in yield-factors. The tests are categorized within the two areas; Core Unit (CU) and Sales Item (SI) and are together with Service Mount Assembly (SMA) illustrated in figure 4.6.

Core Unit (CU):

1. Core Unit Test 1 (CT 1) embraces tests of display. Sixty percent of the mobile phones are tested automatically while forty percent is tested manually.
2. Core Unit Test 2 (CT 2) comprises tests of the camera within the mobile phone.
3. Core Unit Test 3 (CT 3) focuses on testing the antenna of the mobile phone. It is a radio test with the purpose to check if the phone can receive phone calls.
4. Sample Test Acoustic (STA) is an acoustic test of the mobile phone. The STA is performed at one hundred percent of the mobile phones where the microphone and earphone is tested.
5. In the Final Flash (FF), the same software as the customer uses is connected to the mobile phone in order to check the functionality.
6. Start-up regards starting all of the mobile phones to check the functionality.

Sales Item (SI):

7. Out of Box Audit (OBA) is a final test that is performed on a few mobile phones. The test embraces many areas such as display, cosmetic etcetera.
8. Final Quality Check (FQC) is a similar test as OBA, but a larger amount of mobile phones are tested. However, the tests are covering fewer areas.
   (Larsson, 2012)

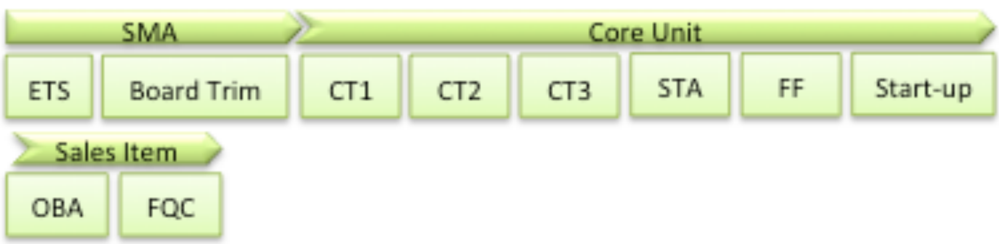


Figure 4.6 Quality checks at BMC. Developed by the authors together with a Staff Project Manager.

Continuous screenings of the visual performance of the mobile phones are performed during the production process. If a cosmetic fault is discovered the mobile phone is taken from the production (Larsson, 2012). When a fault is discovered in whichever quality check, the mobile phone is put aside. The top five issues will go through a root cause analysis in order to find the source of the problem. Three major sources exist and these are design, production or material (Åberg, 2012).

#### 4.1.4.3 After-sales

As the last quality check of production, the final quality check (FQC), has been performed the mobile phone is launched at the market. Sony Mobile has several ways to gain feedback from customers in this phase. The first action regards analyses of the first three to four hundred returned mobile phones. Regardless of issue of the mobile phone, the customer leaves the faulted one and gets a new in return. This is called a Global Root Cause Analysis (RCA) and reaches from the product being launched and twelve to fourteen weeks ahead, see figure 4.7. The Global RCA is performed in a short-term perspective and the goal is to find a solution to the issues as fast as possible to avoid that subsequent launches of the same mobile phone bear the same issues (Eskilander, 2012).

Subsequent to Global RCA, a Fault Verification Analysis (FVA) is performed. This test reaches from twelve to fourteen weeks after the market launch until the product's end of lifetime (EOL), see figure 4.7. The FVA has recently changed and before ten thousand market returns were analyzed at assembly level. (Eskilander, 2012). From February 2012, six thousand mobile phones are analyzed. The major difference is that a root cause analysis is made at the mobile phones in FVA and can thereby be traced to part number (Olsson, 2012).

In parallel, Line RCA works at a long-term perspective and the purpose with Line RCA is to find solutions to avoid similar types of faults in future launches of mobile phones. The Line RCA reaches from the ready to launch (RTL)-phase until the product's end of lifetime (EOL) see figure 4.7 (Eskilander, 2012).

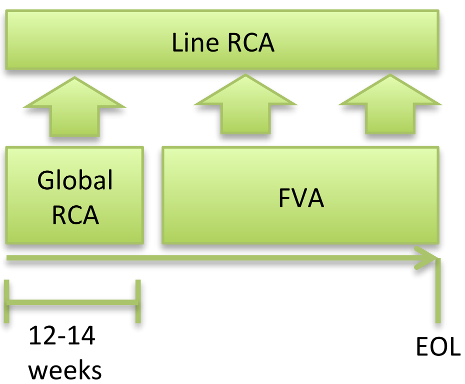


Figure 4.7: Quality checks at After-sales (Eskilander, 2012).

The purpose with the Global RCA test is furthermore to find the source of the fault. In other words, the aim with the test is to check whether the faults are caused by design, production or material. If the fault is caused by material, suppliers have caused it, but the data is not connected to a specific supplier. The data is connected to the part number of the component. In the cases when Sony Mobile only has one supplier delivering the component, it is easy to track the fault back to this supplier (Eskilander, 2012). In other cases, where Sony Mobile has three to four suppliers, it is hard to figure out which supplier that caused the fault (Ekman, 2012).

As mentioned above, problems discovered in the FVA have only been traceable to assembly level. As mentioned, in February 2012 it was decided that a root cause analysis shall be performed at FVA as well. This means that a FVA is made, and subsequently a Global RCA will be done. This initiative makes it possible to track problems caused by suppliers at larger extent (Olsson, 2012).

### 4.1.5 Registration of faults in the quality checks

As emphasized, the three major areas where quality checks are performed are First Point of Check, Production and After-sales. Regarding the registration of faults in quality checks an additional area was created by the authors and is referred as Quality Management. This area is separated from the others due to the fact that data registered in this area is dependent on data registered in several quality checks.

#### 4.1.5.1 First Point of Check

In the First Point of Check data is registered from the two quality checks; Incoming Quality Check (IQC) and Online-yield. The data registered in IQC is the amount of checked components, discovered faults and whether the batch is accepted or rejected. In the cases where the faulted components excess the amount allowed by the AQL-tool the batch is rejected (Larsson, 2012). Registration of faults in Online-yield is performed in two tests; Online-test and SMA-test (Anderberg, 2012). The registration in IQC and Online-yield is in terms of amount of faulted components.

#### 4.1.5.2 Production

The registered faulted components in production, result in several yield-factors. Yield is measured in several steps of the production process and one hundred percent of the components are checked in these steps (Johansson, 2012). Yield is defined as the amount of ingoing products that result in correct and finished products. If the yield-ratio is one hundred percent it means that all components successfully went through the production process. Yield measured in production is difficult to trace to production, design or material. This is due to the fact that a root cause analysis not is performed on each of the discovered faulted components. The root cause analysis is only performed on the top five issues. Consequently the Yield-ratio cannot be connected to a specific component and supplier (Johansson, 2012). However, BMC has registered the percentage of repair caused by supplier connected to specific component (Zhang, 2012). This data is registered reversed to the yield-factor, but reflects the same amount of repairs.

#### 4.1.5.3 After-sales

In After-sales the quality checks Global Root Cause Analysis (RCA) and Fault Verification Analysis (FVA) exist. Global RCA is connected to supplier, while FVA only is registered at assembly-level (Eskilander, 2012). As mentioned, the FVA will be registered at supplier level as well. The registration in Global RCA and FVA is in terms of amount of faulted components. Sony Mobile also registers the amount of returned mobile phones in total. A manager of customer feedback states that seven percent of the sold mobile phones are in average returned to Sony Mobile.

#### 4.1.5.4 Quality Management

Quality Management refers to the work the Supplier Quality Engineers at Sony Mobile and BMC perform when quality issues occur. An issue arises when larger quality problems occur, and is thereby dependent on the result of the registration of faults in the other areas. The main ratio these employees check are called Deviated Parts Per Million (DPPM) and is defined as amount of deviated parts per million pieces. DPPM is measured both in First Point of Check and in several steps of the Production process.

The responsible SQE sets a DPPM-target on his/hers components. The target varies depending on component and is determined based on historical deliveries. A problem with DPPM is that not all of the components are tested which makes the ratio somewhat deceptive. The faults registered in DPPM can be caused by material, production or design (Larsson, 2012). The purpose with the DPPM-ratio is that the SQE shall get a comprehension of quality performance in general.

## 4.2 Identification of cost drivers at Sony Mobile

The registration of quality checks mentioned above refers to what is registered at Sony Mobile in terms of discovered faulted components. However, activities related to a discovered faulted component are referred as cost drivers. A cost driver can also be defined as unpredictable activities that occur due to a faulted component. The cost drivers identified in theory have served as inspiration in the empirical study. However, the cost drivers identified in theory are defined differently to the ones identified in the empirical study. Thereby, both of the definitions are presented. The cost drivers are categorized into the areas First Point of Check, Production After-sales and Quality Management.

### 4.2.1. First Point of Check

In the First Point of Check, the cost drivers *replacement*, *rework* and *scrap* are included. (Theoretical definition)

In Incoming Quality Check (IQC), *replacement* is defined as the time it takes for the employees to sort out the faulted components and send them back to the supplier. The time it takes to perform an extra IQC when the component is returned from the supplier is in this phase defined as a *rework* (Larsson, 2012). The time for each cost driver is difficult to separate, thereby, these two cost drivers are merged into the cost driver rework, see table 4.1. In IQC a small amount of *scrap* can be included. This is when faulted components are discovered, but the amount of faults in the sample is allowed by AQL and the batch is thereby accepted. The wasted components are in these situations very few and are thereby not included as a cost driver (Larsson, 2012).

Ten percent of the components registered in the Online-yield factor are discovered in the online test. No costs are related to these since the supplier will replace the faulted component and the costs related to the pick and place process are difficult to estimate and very small (Larsson, 2012). The remaining ninety percent of the components registered in the Online-yield factor are discovered in the SMA-test and thereby need to go through a repair when a fault is discovered. This time is estimated to thirty minutes by an Supplier Quality Engineer (SQE) at Sony Mobile (Berglund, 2012). An additional cost driver; *scrap* related to when a repair occur, is the cost for the waste of the faulted component. However, this cost shall only be included in seventy-five percent of the repairs since the remaining twenty-five percent is paid by the responsible supplier (Larsson, 2012). A repair is what in theory is defined as a *rework*.

Table 4.1: Cost drivers in First Point of Check.

| | |
|---|---|
| **Rework in IQC** | 10 minutes |
| **Replacement in Online test** | Unverified and small |
| **Rework in SMA-test** | 30 minutes |
| **Scrap** | Component specific (seventy-five percent) |

### 4.2.2 Production

The cost drivers included in production are *rework, two categories of scrap, production downtime* and *safety stock.* (Theoretical definition)

The costs related to a discovered fault in the production regards the average time to repair one fault. This is referred to what in theory is entitled *rework.* A repair-loop at BMC includes the activity of sorting out the product from the production line, analyzing the correct symptom, disassembling the faulted component, soldering of a new component and performing a test, see figure 4.8 below. The time for one repair on Electronic Mechanical components are estimated to sixty minutes by the Supplier Quality Engineer department (Larsson, 2012).

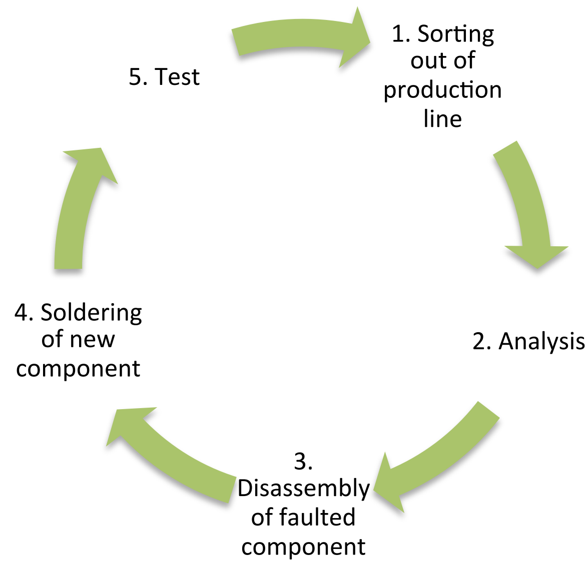


Figure 4.8: Repair loop at Sony Mobile. Developed by the authors after instructions from a Senior Quality Manager.

Related to costs for a rework is the cost for waste of the faulted component. This is defined as a first type of scrap-cost. As emphasized above, it should only be calculated on seventy-five percent of the repairs since the remaining twenty-five percent is paid by the responsible supplier (Larsson, 2012).

The second category of s*crap* regards the amount of components that need to be wasted due to a discovered fault with another component. This data is estimated on every new project, but no data exist regarding actual costs. This makes it hard to validate the estimated data since it is impossible to grasp a correlation between estimations and real outcome (Bognäs, 2012). The problem with scrap costs is also that the costs vary a lot depending on type of component.

Costs related to production can be due to *production downtime* caused by faulted products. However, this cost is large when it really occurs, but the frequency of it is very low. According to Supplier Quality Engineers it is almost impossible that a production stop should occur due to one specific component. This is due to the fact that the volume ordered always is very large and that all of these components should be faulted is very rare (Larsson, 2012).

The last cost driver in production is *safety stock*. A Strategic Buyer states that the volume of safety stock does not differ from suppliers that deliver the same component. A certain amount of wasted components are included in the ordered volume and this certain amount represents the safety stock. The costs are thereby not differing from various suppliers (Pålsson, 2012).

Table 4.2: Cost drivers in Production.

| | |
|---|---|
| **Rework in production** | 60 min |
| **Two categories of scrap costs** | Component specific |
| **Production downtime** | Unavailable |
| **Safety Stock** | Identical for all suppliers |

### 4.2.3 After-sales

In After-sales, the cost drivers *customer return* and *badwill* are identified. (Theoretical and empirical definition)

The costs for a customer return, varies from market to market and what kind of component that is repaired. The department Customer Service has calculated an average for each of the three areas; Mechanical, Electronic and Electro-Mechanics and one general average. For mechanical components the average is three hundred and thirty dollar, for electro-mechanical components the average is two hundred and thirty dollar and for electronic components the average is one hundred and thirty dollar. The general average for the three areas is set to two hundred and thirty dollar (Hagelin, 2012). Customer returns are the cost driver that bears the major costs.

An additional cost regards the badwill a customer return causes. This cost is difficult to estimate since Sony Mobile does not have any idea regarding how many customers they loose due to one return. However, this effect is very important to have in mind. The cost driver badwill is analyzed further in chapter 5.

Table 4.3: Cost drivers in After-sales.

| | |
|---|---|
| **Customer return** | 230 dollar |
| **Badwill** | Unverified |

### 4.2.4 Quality Management

The cost drivers included in Quality Management are *inspection, quality improvement and vendor visits.* (Theoretical definition)

The Supplier Quality Engineering (SQE) department is working to improve the quality when issues occur. There is no guideline to when an issue occurs, it is determined by the responsible SQE. The estimated time to solve one issue is twenty-five hours and is estimated by one of the responsible SQE within the Electro-Mechanical team (Larsson, 2012). This is referred to what in theory is called *inspection* and *quality improvement.*

Additional actions need to be taken if a supplier continuously delivers components with poor quality. For instance, when the DPPM-ratio indicates a high DPPM-level compared to the determined target, actions like *vendor visits* are taken. The purpose of the travels is to improve the supplier's production and quality performance. Travel expenses in terms of fly ticket and hotel are one example of costs, other costs related to the trip is the salary paid to the employees at Sony Mobile. A problem with this type of costs is that Sony Mobile does not have any restrictions regarding when a travel shall be taken. The travels are taken occasionally and sometimes combined with other businesses (Larsson, 2012). Thereby, the costs are difficult to estimate and connect to a certain component and supplier.

Table 4.4: Cost drivers in Quality Management.

| | |
|---|---|
| **Inspection and quality improvement time (SQE)** | 25 hours |
| **Vendor visits** | Unavailable |

### 4.2.5 Salaries

In order to estimate the costs related to the activities mentioned above, the salary of the employees need to be included. The salary varies depending on employment and the average salary per hour for an operator in production is fifteen dollar and the average salary for an engineer per hour is one hundred and sixty five dollar (Olsson, 2012).

Table 4.5: Salaries for employees at Sony Mobile.

| | |
|---|---|
| **Production operator** | 15 dollar |
| **Engineer (SQE)** | 165 dollar |

# 5. Construction of the Supplier Quality Performance Tool

*The general goal of the Supplier Quality Performance Tool is first presented in this chapter. This is followed by a description of how the gathered information was structured and a presentation of the identified cost drivers. The analysis of cost drivers follows as well as the development of the tool. Finally, the process of testing the tool is explained.*

## 5.1 The goal of the Supplier Quality Performance Tool

The goal of the Supplier Quality Performance Tool goes align with the purpose to integrate historical data of suppliers' quality performances into future supplier selections with a cost focus. This shall furthermore facilitate the decision-making of suppliers at Sony Mobile. Sony Mobile wants the tool to be based on quantitative data and not qualitative. Important is that the quantitative data is presented in monetary terms due to the fact that Strategic Buyers today mainly choose supplier based on what price the supplier offers. It is thereby crucial to determine costs related to quality issues to be able to argue for a supplier with higher purchase price, but lower costs related to quality issues. The supplier with lowest total cost will be chosen and unnecessary quality issues can be avoided. Thereby, it is necessary that data regarding amount of faults of quality can be connected to each supplier and component.

The tool will increase the buyer's knowledge of costs related to defect of quality. The tool cannot only be used in comparison of various suppliers, it can also be used in negotiations with them.

Regarding applicability, an ambition is that the tool can be used on the commodities within Electronic Mechanics. Thus, it is crucial that the tool is easy to get hold off and is easy to use. The employees and potential users have furthermore emphasized the importance of having a user-friendly tool that is easy to update and maintain, see 5.2.1. Ljung and Glad (1991) emphasize the importance of validating and verifying the model development and has created a general process that illustrates the development of a model with focus on validation, see figure 2.2. This process has formed the basis of the construction of the Supplier Quality Performance Tool. However, the process of constructing the Supplier Quality Performance Tool is somewhat modified and the headings do not follow the model completely.

## 5.2 Structuring of gathered information and identification of cost drivers

In the theoretical tool seventeen cost drivers were identified, these together with the information gathered from the mapping of processes within a mobile phone project formed the structure of what to search for in the empirical study. During the mapping of processes within a mobile phone project at Sony Mobile an understanding of the organization was developed as well as an understanding of cost drivers.

Eleven of the seventeen cost drivers could be identified at Sony Mobile and are illustrated in figure 5.1. The identified cost drivers were structured into the categories; First Point of Check, Production, After-sales and Quality Management. Data connected to each cost driver might not be available due to the fact that the frequency of them is not registered or due to the fact that data is not connected to component or supplier. This is further analyzed in 5.4.

The cost drivers were subsequently structured into the categories of Costs of Quality presented by Sörqvist (1998). Three of four categories could be found at Sony Mobile. Safety stock, inspection, quality improvement and vendor visits are embraced in the appraisal cost. Rework, replacement, scrap and production downtime is included in the category Internal failure costs and finally customer return and badwill is comprised within external failure costs, see figure 5.1. The categorization as below gives an overview of the cost drivers at Sony Mobile as well as it gives an overview of where the resources are spent. From figure 5.1 it is obvious that Sony Mobile does not spend much resources on prevention costs, but rather bear the costs when they arise.

The categorization as below is not a requirement in the usage of the Supplier Quality Performance Tool, but it can serve as enlightenment regarding where the Costs of Quality are spend in the organization. However, it is necessary to connect costs to the cost drivers in order to use the tool, but the categorization is not obligated.

| Prevention cost | Appraisal cost |
|---|---|
| | **Production**<br>Safety stock $<br><br>**Quality Management**<br>Inspection cost $<br>Quality improvement $<br>Vendor visits $ |
| **Prevention cost** $(P_i)$ $\sum \$$ | **Appraisal cost** $(A_i)$ $\sum \$$ |
| **Internal failure cost** | **External failure cost** |
| **First Point of Check**<br>Replacement $<br>Rework x 2 $<br>Scrap $<br><br>**Production**<br>Rework $<br>Scrap x 2 $<br>Production downtime $ | **After-sales**<br><br>Customer return $<br>Badwill $ |
| **Internal failure cost** $(I_i)$ $\sum \$$ | **External failure cost** $(E_i)$ $\sum \$$ |

Figure 5.1: Cost drivers identified at Sony Mobile applied to the theoretical tool.

### 5.2.1 Internal needs of the Supplier Quality Performance Tool

In the process of constructing the Supplier Quality Performance Tool, it was important to highlight internal needs connected to the tool. Thereby, a mapping and structuring of the internal needs related to the tool was made. Several needs were required from the purchasing management and were likewise confirmed by other departments. The needs were identified during interviews and discussions with employees. The needs have been communicated from employees at management level, such as Global Commodity Manager, Senior Project Managers, and one manager at Customer Service. Senior Supplier Quality Engineers and Strategic Buyers have subsequently confirmed the needs.

The needs connected to the tool are:

- The tool shall be based on quantitative data.
- The tool shall include costs of defects of quality and be added to the purchase price.
- The tool shall include data that relates costs to supplier and component.
- The tool shall be easy to understand.
- The tool shall be easy to use and update.

### 5.2.2 Structuring of the process of gathering of data

In order to structure the process of gathering of data, a decision regarding whether the analyses of data should be based on yearly performance or project performance needed to be taken. Advantages and disadvantages were identified with each of the categories of data. The outcome was that analyses on yearly basis were more beneficial. The main disadvantage with data on project basis is that this data can be deceptive. For instance, a supplier can in one project be responsible for a more complex component than it is used to. This might lead to additional registered faults of quality than normal. If the tool would be based on this data, it would not give a fair picture of the supplier's performance. Thereby, data on yearly basis will be more reasonable and reflect quality performance from several projects. Thus, data on yearly basis implies a disadvantage in form of larger amount of data to analyze than if the data would have been based on a project. On the other hand, yearly data infers a greater base of supplier performance for specific components. Summarized the scope of the analyses of data were determined to be based on yearly performance.

When analyzing costs related to a faulted component, it was found that some costs vary depending on component. The costs are mainly differing between standard and unique components. Consequently, a discussion whether the tool shall be general but less detailed or, more specific but more detailed was held. With a general and standardized tool the data will be more easy to handle and easy to update, but will include less accurate data. On the other hand, developing a unique tool for each of the commodities will mean additional work for the employees at the commodities and more detailed analyses have to be performed regularly. The strength with a unique tool is that it will infer more accurate data and give higher credibility to the total purchase price. After discussion with Strategic Buyers and the Sourcing Director of Mechanics Electronics at Sony Mobile, it was determined that accuracy of the tool was the most significant aspect.

Thereby the process of gathering of data was delimited to include commodities within Electronic Mechanics. It was furthermore determined that the tool should be developed to handle analysis at component-level. Consequently, the process of gathering of costs related to faulted components were structured and organized.

The discussion above can be referred to what Ellram (1994) highlights regarding standardized Total Cost of Ownership-models and unique Total Cost of Ownership-models, see 3.2.1.2. The Supplier Quality Performance Tool will according to the definition of Ellram (1994) be a combination of a standardized and unique model. It will be defined as a unique model due to the fact that the scope of it has been delimitated to only include commodities within Electro-Mechanicsin order to generate as accurate result as possible. However, it is defined as a standardized tool due to the fact that it will be possible to apply the tool to different types of purchases within Electronic Mechanics' commodities.

## 5.3 Approximations and simplifications

In the process of constructing the Supplier Quality Performance Tool a few approximations and simplifications needed to be made. The internal needs have been taken into consideration when identifying the approximations and simplifications.

To be able to develop a tool that is based on quantitative data, employees at Sony Mobile had to make approximations regarding activities connected to the cost drivers. Time for several activities have been approximated as well as costs related to cost drivers.

In the Online-yield, a simplification is made. Ninety percent of the faults are discovered in the Service Mount Assembly (SMA)-test and ten percent in Online-test. However, it is in the tool calculated that SMA-test stands for one hundred percent since the discovered faults in the Online-test bear an almost insignificant cost. This simplification is made in order to facilitate the usage and updating of the tool.

An additional simplification made with the purpose to facilitate the usage and updating of the tool regards the yield factor in production. Yield is measured in several steps of the production, but the authors determined to gather data from one step. Otherwise, the user would have been forced to gather several yield-factors and register them in several steps of the tool.

## 5.4 Analysis of identified cost drivers

In the process of identifying Costs of Quality at Sony Mobile, a broad perspective was taken. As emphasized in 5.2, the identified quality cost drivers in the theoretical frameworks; Total Cost of Ownership and Cost-ratio plan were taken into consideration in the beginning of the process and eleven of the seventeen cost drivers were finally identified. Moreover, the importance of reliability as emphasized in the Cost-ratio plan has been taken into consideration. The identified cost drivers have been discussed and evaluated during the entire process with various employees to ensure that the activities connected to them are relevant and reliable. Analyses based on availability and reliability of the cost drivers and the connected activities are presented in following paragraphs.

### 5.4.1 First Point of Check

In the Incoming Quality Check (IQC) a sample determined by an Acceptable Quality Level (AQL)-tool is checked. The identified faults of the sample can be up scaled to the whole volume ordered. This is due to the fact that the amount checked in the IQC is statistically ensured by the AQL-tool. However, the upscale is only valid in the cases where a yield-factor doesn't exist in production. If both an upscale of IQC and the yield-factor from production would be taken into account, the faults would be double counted. The discovered faults in IQC are ensured to be caused by the supplier since the components are checked directly after the delivery from supplier.

The components firstly tested in production include one hundred percent of the ordered components. The Online-yield factor will be the only yield factor for these components. This is due to the assumption that the faults caused by supplier should be discovered in this quality check since all of the components are checked. If an additional yield would be included, there is risk of a double counting of the faults. However, the tests in the production are not one hundred percent ensured and thereby customer returns are

taken into consideration. Two different types of data can be gathered from Online-yield. The first type of data includes all discovered faults in Online and the cause of the fault can be design, production or material. The second type of data only includes the discovered faults caused by supplier. The cause is determined by BMC that has incentive of blaming the supplier. However, interviews with employees at Sony Mobile confirmed that this data should be used due to the fact that the production site BMC to fifty percent is owned by Sony Mobile and shall be considered as reliable. This is further discussed in 6.3.

The cost drivers; replacement and rework are in the IQC referred as the time it takes for the worker to sort out the faulted components and return them to the supplier. Furthermore, it is referred as the extra time it takes to check the returned components from the supplier. These times are estimated by a Senior Factory Product Quality Manager at BMC and are considered to be reliable. They are merged and included in the cost driver *rework*. The time for a rework is multiplied with the salary of a production operator in order to get the total cost for a fault discovered in IQC, see formula 5.1. For the components registered in the online test, rework is the major cost driver. The amount of rework is multiplied with the time it takes to perform a rework and with the salary of a production operator, see formula 5.2. The time for a rework is estimated by a Supplier Quality Engineer at Sony Mobile and is confirmed by others with the same employment. Regarding the cost driver *scrap*, Sony Mobile has succeeded in claiming the suppliers for twenty-five percent of the discovered faults. For the remaining seventy-five percent the cost of wasted material will be added.

$$IQC\ cost_{one\ component} = IQC\ time_{one\ component} \times Production\ operator\ cost_{hour}$$

Formula 5.1. The total cost for a fault discovered in IQC (Cost driver: *rework).*

$$\begin{aligned} Online\ cost_{one\ component} \\ &= Time\ rework\ SMA_{one\ component} \times Production\ operator\ cost_{hour} \\ &+ 0{,}75\ x\ Component\ price_{scrap} \end{aligned}$$

Formula 5.2. The total cost for a fault discovered in Online. (Cost drivers: *rework* and *scrap.)*

### 5.4.2 Production

The amount of *rework*s in production can be comprehended by analyzing the yield-factor. As mentioned above, yield is measured in several steps of the production process. In order to develop a user-friendly tool, a total yield-factor will be used in the tool. This is due to the complexity of implementing several yield factors and several cost levels. An exception regarding yield factor is the components that are checked in the online test. For these, an Online-yield factor will be the single yield factor.

A total yield-factor has been difficult to identify and several employees have been contacted in order to identify an appropriate factor. The major discovered problem with yield has been that the discovered faults can be caused by production, design or supplier. In order to locate the faults caused by supplier it is necessary to get a comprehension of how large percentage they call for. The problem is that a root cause analysis is made on the top five issues and not on all of the discovered faults. So, for the top five issues it is possible to see if a supplier caused the fault. However, this data does not represent the whole truth. Several employees within production have confirmed that an up scale of this data would be deceptive (Johansson, 2012). Additional interviews were held in order to find an appropriate yield-factor, but it was not found. At one point, a discussion regarding an up scale of the amount of faults discovered in Incoming Quality Check was held.

One last attempt was tried and two contacts at BMC, one Senior employee of Quality Checks and the Manager of Product Management, was asked to compile the amount of reworks of a specific component. The reason for the rework should be due to faults caused by supplier. The two contacts at BMC responded and sent a report including the percentage of reworks connected to specific component on yearly basis. The fact that the reworks covered in this report regarded the faults caused by supplier was verified two times. Once again, the blaming of supplier is done by BMC that has incentive of blaming them instead of themselves. However, interviews with employees at Sony Mobile confirmed that this data should be used due to the fact that the production site BMC to fifty percent is owned by Sony Mobile and shall be considered as reliable.

The rework will be multiplied with the time it takes to perform one rework at BMC and with the salary for one production operator. The time is estimated by the responsible

Supplier Quality Engineer at Electro-Mechanics and is confirmed by other Supplier Quality Engineers. Sony Mobile has as mentioned succeeded in claiming the suppliers for twenty-five percent of the discovered faults. For the remaining seventy-five percent the cost of wasting the material will be added. This is referred to as a *first type of scrap*, see formula 5.3.

$$Production\ cost_{one\ component} = Time\ rework\ production_{one\ component} \times Production\ operator\ cost_{hour} + 0{,}75 \times Component\ price_{scrap}$$

Formula 5.3. The total cost for a fault discovered in production. (Cost drivers: *rework* and *scrap).*

*Production downtime* is at Sony Mobile referred to a production stop. The empirical study has shown that this issue emerges infrequently and is thereby not a large cost driver. Furthermore, it is very rare that a production stop is caused by faults with one specific component. This is due to the fact that the volume ordered always is very large and the probability that all of these components should be faulted is very rare.

The *second type of scrap* cost regards the additional components that are wasted due to a problem with one component. This cost is very difficult to estimate due to the fact that no such cost is registered. Bognäs and Gustafsson make estimations in the presence of a project, but no data is registered on the real outcome. This makes it problematic to verify whether the estimations that Bognäs and Gustafsson make are correct or not. Since the cost varies depending on component it is difficult to estimate an average cost. It has to be related to the specific component. This cost driver has been searched for during many interviews and employees at BMC have been contacted. However, no data was found regarding real outcome of costs and the cost driver had to be excluded in the end.

Regarding the cost driver *safety stock*, the volume of additional components ordered does not differ from supplier or component and are thereby an overall cost. The cost of safety stock is thereby the same for all suppliers. Consequently, the costs of safety stock will not be included in the tool.

### 5.4.3 After-sales

The amount of faults in After-sales is discovered in Global Root Cause Analysis (RCA) and Fault Verification Analysis (FVA) and can be gathered from reports retrieved in the RCA-database. The amount of faults registered in Global RCA can be connected to supplier, but not up scaled due to the fact that this information is somewhat deceptive. The data is deceptive due to the fact that issues discovered in this phase hopefully are solved quite quickly to avoid that following launches bear the same issues.

However, as a root cause analysis will be performed at faulted components discovered in FVA, this data will be connected to part number as well. This data is more appropriate to upscale since a larger amount of products are gathered in the FVA and is gathered later in the launching process. The upscale will be based on the amount of discovered faults of a specific component related to the amount of mobile phones checked in FVA where the component was included. This will furthermore be related to the total amount of returned mobile phones where the component has been included. Since both Jönsson and Eskilander (2012) have confirmed the one-to-one relation between discovered faults in FVA and faults at the market an upscale of discovered faults in FVA is verified. The amount of returned mobile phones is based on the general percentage estimated by the department Customer Service, seven percent. In order to upscale the amount of faults discovered in FVA, the buyer also needs to know the amount of sold mobile phones. This information can be collected from the Customer Service department. They have information regarding amount of sold mobile phones in every project (Hagelin, 2012). For detailed information regarding these calculations see appendix 4.

The department Customer Service estimates the costs related to a return, and for the Electronic Mechanic department the cost is estimated to two hundred and thirty dollar (Hagelin, 2012). This cost is referred to a *customer return*.

Regarding the cost driver *badwill,* the costs are very hard to estimate. The estimation could have been based on theoretical assumptions regarding how many customers a company loose depending on one fault at the market. Sony Mobile is aware of the problem it causes, but is not interested in such insecure data. Badwill will thereby not be included in the Supplier Quality Performance-tool, but will on the other hand be emphasized in non-quantifiable terms. It is an important aspect to have in mind when selecting supplier, but a cost will not be connected to the aspect.

### 5.4.4 Quality Management

The cost driver *inspection* is related to the time a Supplier Quality Engineer has to spend on one discovered issue. The purpose with the inspection is *quality improvement*. The time for an issue is multiplied with the salary of the engineer in order to get the total costs for quality management when an issue occurs, see formula 5.4. The average time spent on an issue is estimated by the Supplier Quality Engineer department and is considered as reliable.

$$Issue\ cost\ SQE_{one\ issue} = Issue\ time\ SQE_{one\ issue} \times Engineer\ cost_{hour}$$

Formula 5.4. Total costs for quality management when an issue occurs. (Cost drivers: *inspection* and *quality improvement*).

Vendor visits are an additional cost, but are difficult to estimate. The difficulty lies in the fact that Sony Mobile does not have any restrictions that determines when the SQE needs to travel to the supplier. The travels are made sporadically and are mostly combined with other businesses. Strategic Buyers and Supplier Quality Engineers recommended an exclusion of the cost driver vendor visits in the tool due to the arguments above.

## 5.5 Comparison and exclusion of cost drivers

As presented above, many of the cost drivers identified in theory could be found at Sony Mobile as well. However some of the cost drivers are not available or reliable. Based on the analysis of cost drivers presented above, a comparison of the cost drivers has been made. The comparison is based on the aspects; availability, reliability and costs.

Table 5.2: Comparison of cost drivers.

| | Cost driver | Available | Verified/Reliable | Costs/comp. |
|---|---|---|---|---|
| **First point of check** | | | | |
| | Rework in IQC | Y | Y | $1,25 |
| | Replacement in online-test | N | N | - |
| | Rework in SMA-test | Y | Y | $7,5 |
| | Wasted component (1st type of scrap) | Y | Y | - |
| **Production** | | | | |
| | Rework | Y | Y | $15 |
| | Wasted component (1st type of scrap) | Y | Y | - |
| | Estimated scrap (2nd type of scrap) | Y | N | - |
| | Actual scrap (2nd type of scrap) | N | N | - |
| | Production downtime | N | N | - |
| | Safety Stock | Y | Y | Identical |
| **After-sales** | | | | |
| | Customer Return | Y | Y | $230 |
| | Badwill | N | N | |
| **Quality Mgmt (issue based)** | | | | |
| | Inspection | Y | Y | $4125 |
| | Vendor visit | N | N | - |

The cost drivers with unavailable data will automatically be excluded in the tool this time. Furthermore, the cost driver might seem important and a recommendation of future registration can be necessary. These recommendations are presented in chapter 6. The excluded cost drivers are consequently the second type of scrap in production, production downtime, safety stock, badwill and vendor visits.

Next substantial variable regards the verification of data. It is crucial that the data used is verified and reliable in the development of a solid tool. To ensure the verification of it, important questions have been asked. One frequently asked question has been focusing on the insurance of the fact that registered faults are caused by suppliers. It is central that the faults discovered are caused by the supplier and not production or design.

The last column regards the costs connected to the cost drivers. These are included to illustrate the relation between these. In First Point of Check, the lowest costs are identified. In Production the cost impact is slightly higher and finally in the area regarding after-sales the cost impact is the highest. This confirms the statement by Sörqvist (1998) that costs are increasing the later in the process the faults are identified. The last area; Quality Management, is a general cost and can as mentioned occur in each of the areas. It can thereby not incriminate one specific area.

The cost drivers implemented in the Supplier Quality Performance Tool were subsequently: rework in two steps, first type of scrap, replacement, customer return and inspection including quality improvement. Connected to the identified cost drivers are time or actual costs estimated by employees at Sony Mobile.

### 5.5.1 Reports needed in order to find data connected to included cost drivers of the Supplier Quality Performance Tool

The reports needed in order to gather data to the cost drivers of the Supplier Quality Performance Tool are presented below.

#### 5.5.1.1 First Point of Check

As mentioned above, a sample is checked in the Incoming Quality Check (IQC). The faulted components are registered in an IQC-report that is sent to the responsible SQE-department on a monthly basis. The amount of discovered faults is registered and linked to the specific component and supplier. As the sample checked is statically ensured by the AQL-tool, the faults discovered in this phase can be up scaled for the whole batch. Included in the same report is the Online-yield. This ratio is sorted and it is possible to see the faults caused by supplier (Larsson and Anderberg, 2012). This report is compiled on yearly basis by Zhao at BMC and is called 'Summary on EM Monthly DPPM Performance-2011'. The problem with the IQC-registration in this report is that there is no registration regarding amount of checked components. Thereby, a report called 'IQC Inspection Data 2011' has been retrieved by the manager of Quality Controls HaiZheng at BMC.

#### 5.5.1.2 Production

The result of the quality checks within production is referred as yield. Yield is measured in several steps of the production process and is registered in a system called Insite at BMC. The top five issues are going through a root cause analysis in order to discover the source of the problem (Åberg, 2012). On these components, the source can be identified, while the remaining components only are analyzed at assembly-level (Johansson, 2012). After contacting Li, Senior of Quality Checks and Zhang, the Manager of Product Management at BMC reports including percentage of repairs have been retrieved. The percentages are connected to components for 2011 and the faults are caused by material, the report is called 'Repair-percentage 2011'.

#### 5.5.1.3 After-sales

Two tests exist on the after market. Today an RCA-database exists where Global RCA-reports can be retrieved. The data is connected to the component's part number and not the supplier (Ekman, 2012). As mentioned above, Sony Mobile has started to perform a root cause analysis on the mobile phones collected in FVA. In addition to this initiative, a database where both the FVA and the Global RCA-data are gathered is developed. The new database is called Sereena and will be launched in July 2012 (Olsson, 2012). According to both Olsson and Eskilander (2012) the new database will function as the RCA-database and include the same sorting variables.

#### 5.5.1.4 Quality Management

The responsible Supplier Quality Engineer (SQE) gets information regarding Deviated Parts Per Million (DPPM)-performance every month. The faults are registered in DPPM related to the DPPM-target. The result is illustrated in a graph that shows the relation between DPPM-level and DPPM-target. Depending on the relation between these, different actions are taken. Actions are especially taken when the DPPM-level is high compared to the DPPM-target (Larsson, 2012). As mentioned above, DPPM-performance includes faults discovered in both IQC and production and that are caused by material, design and production. The report is called 'DPPM-report', but is not included in the table below since it is not a quality check and is not applicable to the other variables.

The reports gathered from the various areas are summarized in the table below. Table 5.3 illustrates where the quality check is performed, the name of the quality check, the amount of checked components, the unit the faults are registered in, whether the data is connected to supplier and where to gather the reports from.

Table 5.3: Quality checks and reports

| Where the quality check is performed | Type of quality check | Amount of checked components | Connected to part number | Connected to supplier | Gathering of report |
|---|---|---|---|---|---|
| Incoming products | IQC | Sample size determined by AQL-tool | Yes | Yes | Excel sheet from BMC |
| Production process | Online – Yield | All components | Yes | Yes | Excel sheet from BMC |
| Production process | Total – Yield | All components | Yes | No | Excel sheet from BMC |
| After sales | RCA | 300-400 components/year | Yes | No | Database – Sereena |
| After sales | FVA | 6000 components/year | Yes | No | Database - Sereena |

## 5.6 Development of the Supplier Quality Performance Tool

The process of development of The Supplier Quality Performance Tool has followed the theoretical tool presented in paragraph 3.4. The cost drivers at Sony Mobile are similar to some of the cost drivers identified in theory regarding Total Cost of Ownership.

Furthermore, the structure of the Supplier Quality Performance Tool is following the same structure as Cost-ratio plan emphasizes. A complement to the tool is an instruction document developed by the authors, where a description of the cost drivers is given as well as how the data is gathered.

Regarding the categories of Cost of Quality presented by Sörqvist (1998) three of four categories are integrated in the Supplier Quality Performance Tool. Inspection and quality improvement is embraced under appraisal cost. Rework and replacement is included in the category Internal failure costs and finally customer return is comprised within external failure costs, see figure 5.1. The categorization as below is not a requirement in the usage of the Supplier Quality Performance Tool, but it can serve as enlightenment regarding where the Costs of Quality are spend in the organization.

| **Prevention cost** | **Appraisal cost** |
|---|---|
| <br><br><br>**Prevention cost** $(\boldsymbol{P_i})$ $\sum \$$ | **Quality Management**<br>Inspection cost \$<br>Quality improvement \$<br>**Appraisal cost** $(\boldsymbol{A_i})$ $\sum \$$ |
| **Internal failure cost** | **External failure cost** |
| **First Point of Check**<br>Replacement \$<br>Rework x 2 \$<br>Scrap (1st type) \$<br><br>**Production**<br>Rework \$<br>Scrap (1st type) \$<br>**Internal failure cost**$(\boldsymbol{I_i})$ $\sum \$$ | **After-sales**<br>Customer return \$<br><br>**External failure cost** $(\boldsymbol{E_i})$ $\sum \$$ |

Figure 5.1: Cost drivers included in the Supplier Quality Performance Tool applied to the theoretical tool.

In order to apply the costs to the theoretical framework; Cost-ratio plan, the costs related to the specific cost driver first need to be retrieved by the user from the related report and summarized into a total Cost of Quality as the formula 5.5 and 5.6 shows. What formula to use depends on whether the analysis is at component or supplier level.

$$TCoQ_c = \sum_{i=1}^{i=tot\ comp} P_{ci} + A_{ci} + I_{ci} + E_{ci}$$

$$c = the\ supplier\ c$$

$$i = the\ component\ i$$

Formula 5.5: Total Cost of Quality (component).

$$TCoQ_c = \sum_{k=1}^{k=tot\ comp\ types} \sum_{i=1}^{i=tot\ comp} P_{cik} + A_{cik} + I_{cik} + E_{cik}$$

$$c = the\ supplier\ c$$

$$k = type\ of\ component$$

$$i = the\ component\ i$$

Formula 5.6: Total Cost of Quality (supplier).

The total Cost of Quality is subsequently divided by the total amount of purchased components and finally added to the purchase price, see formula 5.7. The new purchase price is a more correct purchase price.

$$TCoQ\ for\ one\ component = \frac{TCoQ_c}{Historical\ amount\ of\ purchased\ components}$$

Formula 5.7: Total Cost of Quality for one component purchased from one supplier.

$$New\ purchase\ price_c = purchase\ price_c + TCoQ_{C,one\ component}$$

Formula 5.8: The new purchase price for one component when including the Cost of Quality.

The cost drivers and the formulas above are included in the Supplier Quality Performance Tool. The tool is developed in excel and contains two sheets; one where the Strategic Buyer registers the amount of faulted components connected to either the specific component or the supplier and one where costs and time estimations is stated. The numbers on the second sheet are fairly constant no matter component, but are still possible to change and will probably be changed over time. The Supplier Quality Performance Tool is further described in chapter 6.

## 5.7 Testing of the Supplier Quality Performance Tool

Ljung and Glad (1991) emphasizes the importance of comparing the result of the tool with the real outcome. To be able to perform a test according to theory, Sony Mobile need to know the real Costs of Quality associated to a component or supplier. This information is obviously not available since the aim with the thesis is to identify Costs of Quality connected to component or supplier. A test closely related to what is emphasized in theory is to perform a test where the result of the tool is compared with the comprehensions of supplier quality performance within Sony Mobile. This has been performed and is described below.

As the cost drivers were determined and a first draft of the tool was developed a demonstration of it was made in order to gain feedback of the included cost drivers and how they are related. The result of the demonstration was positive and the buyers were satisfied with the achievement that far. However, one major feedback was given and that was that it would be of great value if the tool could handle analysis at supplier level as well. The first draft was developed to only include analysis at component level.

The feedback was turned into actions and a few adjustments were performed to enable analysis at supplier level as well. The actions taken mostly regarded additional instructions of how to gather data connected to supplier instead. The indata to the tool is differing between analysis at component level and analysis at supplier level at specific cost drivers, further described in appendix 4. The tool was developed align with the buyers wish and a test session was planned. Two Strategic Buyers were invited and were asked to determine two suppliers they wanted to analyze during the testing session.

In the beginning of the test the buyers presented the two selected suppliers and discussed their comprehension of the suppliers. They discussed the general view associated to Supplier A, which were that the supplier had delivered a lot of components with poor quality. However, the buyers had an apprehension that the general view at Sony Mobile regarding the supplier was exaggerated. Regarding Supplier B, the general view was that this supplier delivers components with good quality in the majority of orders. The buyers' apprehension was that this supplier delivers components with slightly better quality than Supplier A.

The test started by analyzing Supplier A and during the test information regarding what information the buyers have and does not have was comprehended. The result of the test showed that the purchase price was ten percent higher when the Costs of Quality were included. The result was lower then the buyers had expected, but confirmed the thought that the Costs of Quality are high for this supplier. It also confirmed their apprehension of the general view being exaggerated.

Regarding Supplier B, the Strategic Buyer had a feeling that the supplier delivers components with higher quality than Supplier A. The result of the test showed that the purchase price was five percent higher when the Costs of Quality were included. Thereby, the Costs of Quality are lower for Supplier B than Supplier A and the intuition of the buyers were confirmed.

The major insights gained from the test session were that the Supplier Quality Performance Tool confirmed the buyers' intentions regarding the suppliers. Moreover, it gave insights to the development of the instruction document since the authors got to learn what aspects the buyer really knows him/herself and what he/she needs to ask for.

# 6. The Supplier Quality Performance Tool

*The chapter starts by an introduction to The Supplier Quality Performance Tool and the included cost drivers. Furthermore, each area; First Point of Check, Production, After-sales and Quality management are deeper described. Assumptions, weaknesses of the tool and the excluded cost drivers are presented. Reflections regarding the tool and future recommendations to Sony Mobile are following including possible adjustments of the tool. This is continued by a presentation of the theoretical and empirical contribution. General reflections are given and finally future research of the subject is stated.*

## 6.1 Description of the Supplier Quality Performance Tool

The purpose of developing a tool that integrates historical data of suppliers' quality performances into future supplier selections with a cost focus has been fulfilled through the development of the tool called Supplier Quality Performance Tool. The Supplier Quality Performance Tool is based on cost drivers identified at Sony Mobile. These cost drivers have been analyzed and the availability and reliability of them have decided whether to include or exclude the cost driver in the Supplier Quality Performance Tool. The ones that were available and reliable are included in the tool.

The Supplier Quality Performance Tool is constructed to include data from past year and can either be applied to analyses at component level or supplier level. Moreover, it is possible to analyze the performance of one specific component and supplier as well as it is possible to analyze historical performance of a supplier. If the analysis is at supplier-level, many components can be included. The disadvantage with this type of analysis is that one supplier can be the supplier of components with various complexities.

The user needs to collect historical data from various documents and register the number in the correct cell of the tool. In appendix 4 an instruction of how to use the tool and how to gather important reports needed to register correct data is specified. The tool consists of two excel sheets. In the first sheet the Strategic Buyer registers data in the yellow cells, see figure 6.1. The data can be connected to specific component or to supplier. In the second sheet, the time-estimations and costs related to a faulted component are stated, see figure 6.2. These numbers are fairly constant no matter component, still it is possible to change the parameters and will probably need to be changed over time.

The first parameter in figure 6.1 regards the total amount of components ordered past year of the specific component or from the supplier. The cell called *Component price (history)* regards the historical price paid for the specific component. This cell needs to be filled when the costs of wasted component shall be included in the costs regarding repair in Online-yield and production. If the analysis is at supplier-level it is possible to calculate an average price for the included components. This cell is referred as the cost driver scrap.

| | | Unit |
|---|---|---|
| **Total amount of components (past year)** | 0 | Pieces |
| **Component price (history)** | 0 | Dollar |
| | | |
| **First Point of Check** | | |
| Amount of checked components in IQC (sample size) | 0 | Pieces |
| Amount of faulted components in IQC | 0 | Pieces |
| Amount of checked components in Online | 0 | Pieces |
| Amount of faulted components in Online | 0 | Pieces |
| ***Total First Point of Check Costs*** | 0 | Dollar |
| | | |
| **Production** | | |
| Amount of ordered components | 0 | Pieces |
| Amount of faulted components | 0 | Pieces |
| ***Total costs Production*** | 0 | Dollar |
| | | |
| **After-sales** | | |
| Amount of faulted components in Global RCA | 0 | Pieces |
| Amount of faulted components in FVA | 0 | Pieces |
| Amount of  mobile phones checked in FVA in involved projects | 0 | Pieces |
| Amount of sold mobile phones in involved projects | 0 | Pieces |
| Global RCA-costs | 0 | Dollar |
| FVA-costs | 0 | Dollar |
| ***Total costs After-sales*** | 0 | Dollar |
| | | |
| **Quality Management** | | |
| Amount of Issues with component | 0 | Times |
| ***Total costs Quality Management*** | 0 | Dollar |
| | | |
| ***Total Cost of Quality*** | 0 | Dollar |
| | | |
| ***Cost of Quality per unit*** | 0 | Dollar |
| | | |
| Purchase price of component | 0 | Dollar |
| ***New purchase price*** | 0 | Dollar |

Figure 6.1: First sheet of the Supplier Quality Performance Tool.

### 6.1.1. First Point of Check

In the First Point of Check data can be gathered either from Incoming Quality Check (IQC) or the quality check named Online. If the analysis is at supplier level it might be that some components shall be registered in the cells regarding IQC and others in the cells regarding Online. If the analysis is at component level, it is only possible to complete one of the two. The data is gathered from dissimilar reports.

The first cost driver regards the amount of faults found in the quality check IQC. This cost driver is connected to the time it takes to sort out a faulted component and perform an extra check. The cost connected to the time is the salary for one employee at the production site per hour. For the components where an IQC is not performed, the Strategic Buyers fill the next cell that regards the Online-yield. The Online-yield is registered as the amount of components with faults discovered in this phase. The Online-yield is connected to the same type of variables as the IQC-parameter. The variable is the time it takes to repair the faulted component. This time is also connected to the cost of having a production employee for one hour.

*Amount of checked components in IQC (sample size)* regards the total amount of components that has been checked in the IQC. *Amount of faulted components in IQC* refers to the discovered faults in IQC. *Amount of checked components in Online* regards the amount of components that are controlled in the Online-yield. *Amount of faulted components in Online* concerns the amount of discovered faults Online.

### 6.1.2 Production

To avoid that faults registered in Online-yield are double-counted the components that have been registered in the Online-yield above will not be registered in this phase as well. For the other components a repair percentage is registered in this phase. The connected variables are the time it takes to perform a repair-loop. The costs regard the salary for an operator in production per hour. An additional cost driver is scrap, the scrap cost refers to the costs of a wasted component when a repair-loop needs to be completed.

*Amount of ordered components* refer to the amount of components that have been purchased past year. *Amount of faulted components* concern the discovered faults in production.

### 6.1.3 After-sales

In the After-sales phase, two parameters need to be completed by the buyer. These are Global Root Cause Analysis (RCA) and Fault Verification Analysis (FVA). When the tool was developed, only Global RCA-data was available in the RCA-database. In the near future data of both Global RCA and FVA can be gathered from a database called Seerena (Olsson, 2012). Since they will function the same the instructions in appendix 4 follow the structure of the RCA-database.

The number of faults registered in Global RCA is gathered from the RCA-database and registered in the cell *Amount of faulted components in Global RCA* in the Supplier Quality Performance Tool. According to a senior quality analyst and the senior manager at after-sales a one-to-one correlation between the amounts of faults discovered in FVA and at the market exist. Thereby, the amount of faults discovered in the FVA can be up scaled to all returned mobile phones. For further description regarding the upscale of FVA and related formula see appendix 3 and 4. The costs connected to the amount of returns are the average cost for a return estimated by the department Customer Service.

### 6.1.4 Quality Management

The cost driver called issue time regards the amount of time a Supplier Quality Engineer (SQE) has to spend on an issue. An issue occurs when a lot of problems appear with a specific component or supplier. There is not a specific limit for when it is stated as an issue; thereby the Strategic Buyer needs to ask the SQE how many issues that have occurred due to one component or supplier past year. This number is filled in the yellow cell named *Amount of issues with component*.

### 6.1.5 Total Cost of Quality

When the cells above have been completed, a total Cost of Quality is summarized and the Cost of Quality per unit is computed. This follows the structure of the theoretical tool and especially the structure of the theory; Cost-ratio plan. Finally, the buyer can register the latest purchase price from the supplier and a new total price for the component is computed. If the analysis is at supplier level it is recommended that the purchase price is an average price of the components delivered by the supplier.

### 6.1.6 Costs and time estimations

In the second sheet, see figure 6.2, all costs and time estimations are connected to one component except for issue cost. These parameters need to be updated occasionally and the latest update for electro-mechanic components was May 2012. The red cells refer to the costs related to one discovered fault in each of the area, based on amount of hours and cost per hour.

| **Estimated time** | **Time** | **Unit** | **Fixed costs** | **Costs** | **Unit** |
|---|---|---|---|---|---|
| IQC (min) | 10 | Min | Production operator | 15 | Dollar |
| Rework in Online (min) | 30 | Min | Engineer (cost/h) | 165 | Dollar |
| Rework in Production (min) | 60 | Min | Customer return cost | 230 | Dollar |
| Issue time for SQE (h) | 25 | Hour | | | |
| | | | **Calculated costs for one component** | | |
| **Customer returns from market** | **Percentage** | **Unit** | IQC cost | 2,5 | Dollar |
| Percentage of faulted components | 7% | Percent | Online-Yield cost | 7,5 | Dollar |
| | | | Production cost | 15 | Dollar |
| | | | Return Rate Cost | 230 | Dollar |
| | | | Issue cost for SQE | 4125 | Dollar |

Figure 6.2: The second sheet of the Supplier Quality Performance Tool.

## 6.2 Assumptions regarding data included in the tool

For the components that do not have a yield, the amount of faults discovered in Incoming Quality Check (IQC) shall be up scaled due to the fact that the sample checked in IQC is statistically ensured by an AQL-tool. Thereby, an assumption is taken that the faults discovered in the sample would be comparable to the whole ordered volume. However, this scenario is not very common. The reason why components checked in the IQC not are up scaled are due to the assumption that the remaining faults will be discovered in the production process. If the faults discovered in the sample test of IQC would be up scaled, the total amount of faults would according to this assumption be double counted.

Regarding the components registered in Online-yield, only one yield is taken into account. This is due to the fact that one hundred percent is checked in the Online-test and the Service Mount Assembly (SMA)-test and if a total yield would be taken into

consideration the faults would be double counted. However, the tests in the production are not one hundred percent ensured and customer returns are thereby included.
A Senior Quality Analyst and the Senior Manager at After-sales have confirmed the assumption regarding customer returns and the up scaling of identified faults in Fault Verification Analysis (FVA). The two employees are responsible within the certain area and a market study has furthermore been initiated to strengthen the statement. The tool is thereby developed to handle an upscale of FVA.

According to the Senior Quality Analyst and the Senior Manager of After-sales the new database Seerena will function the same as the RCA-database. Thereby, the tool and the complementary instructions have been developed align with this statement. Since the database is not developed, the authors are not certain whether the formulas are completely correct.

## 6.3 Weaknesses of implemented data and the tool in general

Regarding faults discovered in production, the employees in production have an incentive of blaming the supplier for the fault and not their own production. At the same time, the supplier has incentive to take responsibility for as small amount of faults as possible. This can be confirmed by the fact that the supplier bears the costs in twenty-five percent of the cases. However, data registered at BMC are used in the tool. This data is used since Sony Mobile has stated that they need to prerequisite that data registered at BMC is correct. The prerequisite is due to the fact that the production site is owned by fifty percent by Sony Mobile. If Sony Mobile would start suspect and assume that data registered at BMC is unreliable a conflict within the organization would be started. However, it is an interesting aspect and might be a weakness in the data of the tool.

The data that is implemented in the tool needs a lot of manual work. Thereby, there is a risk of incorrect data when it reaches the Strategic Buyers at BMC. This risk would be decreasing if integrated databases were implemented.

The tool needs to be updated manually and the Strategic Buyer needs to gather the data manually. This will take a bit of time and mistakes can be made during the manual update. The time is estimated to approximately twenty minutes the first time the buyer uses it and ten minutes when the buyer is comfortable with the process.

## 6.4 Excluded cost drivers and future actions related to them

Important to mention is that the developed Supplier Quality Performance Tool only covers parts of the total Cost of Quality at Sony Mobile. Some cost drivers were excluded in the process of development of the tool and this was either due to the data not being available or that it was unverified. To include such data in the tool would go against the purpose of creating a reliable tool based on monetary terms. The excluded cost drivers were the second type of scrap in production, production downtime, safety stock, badwill and vendor visits.

Regarding production downtime, in compliance to the information received from Sony Mobile, the authors don't see reason enough to start register the production downtime. This is due to the fact that it happens very seldom and according to Supplier Quality Engineers (SQE) it is almost impossible that a production stop should be due to one specific component. This is due to the fact that the volume ordered always is very large and that all of these components should be faulted is very rare (Larsson, 2012). However, the costs related to a production stop are very high and further analysis of when a production stop occurs can be made.

Vendor visits is a cost driver that is difficult to refer to a specific component. As emphasized, vendor visits are often taken in combination with other business trips and are made sporadically. Furthermore, the recommendation from the buyers and SQE:s to not include this cost driver in the tool was taken. Since it is the responsible SQE that takes the visits, the information regarding difficulties to refer to a specific component or to quality issues caused by supplier seems verified and trustful. If someone can estimate the cost or the amount of vendor visits due to a specific component, it should be the Supplier Quality Engineer.

The second type of scrap was excluded due to the fact that no registration exist today regarding the amount of money spend on this cost driver. Estimations are performed in the presence of a project, but the estimations are never verified. The authors recommend Sony Mobile to start register the costs related to scrap. The cost is varying a lot between components, but this is not a problem for the Supplier Quality Performance Tool to handle. So, a registration of costs related to the components that need to be wasted due to a fault with another component should be registered from now.

The last excluded cost driver is badwill that refers to the lost customers due to one unsatisfied customer. Purchasing managers, Strategic Buyers and Project Managers at Sony Mobile is not interested of having this cost driver specified in monetary terms but are rather interested in paying attention to this cost driver in non-quantifiable terms. The authors feel confortable with this idea since the cost in quantifiable terms would be unverified and unsecure.

One excluded cost driver that could have been analyzed more thoroughly is safety stock. This was questioned to one Strategic Buyer who meant that this does not make any difference to the tool since it represents the same volume no matter supplier that delivers the same type of component. A safety stock is always ordered since the company counts on wasted components. Thereby, the volume of the safety stock does not differ from various suppliers. The Strategic Buyer stated that the cost driver should not be included in the tool. The authors could have performed additional interviews to verify this information since it might be differing to other commodities. Other commodities might order a larger amount of safety stock due to a feeling of one supplier delivering poor quality. This can be further analysed.

An additional cost driver that has been excluded throughout the process is something called screening activity. This cost driver was firstly discussed during the final presentation of the tool and has thereby not been analyzed in this thesis. Thereby, Sony Mobile needs to look further into this activity and if it is available and reliable connect it to appropriate costs.

## 6.5 Reflections of validity of the tool

During the process of creating a Supplier Quality Performance Tool focus has been to verify the identified cost drivers and to ensure that the data is correct and connected to faults caused by suppliers. The cost drivers that are included in the final Supplier Quality Performance are the ones that are available and verified. The costs related to the cost drivers have gone through the same validation. This makes the included cost drivers and related costs reliable. The cost drivers scrap and badwill are excluded in the tool and this gives an indication to that the Cost of Quality rather being understated than exaggerated.

Since the reports with relevant data have been retrieved for the first time during this thesis a risk of misunderstandings regarding variables exist. However, the authors have several times emphasized which variables that are needed to ensure that the responsible persons have understood it the same way.

In order to use the Supplier Quality Performance tool, data needs to be gathered from various reports. The data is gathered manually and there is a risk connected to the manual work of the user. The user can make mistakes during the process, consequently it is important that the user is precise in the registration.

## 6.6 General reflections of the tool

The categorization of cost drivers into Costs of Quality is an optional step. On the other hand, usage of it can be of great value to the company. It can give an indication to where resources are spent regarding Costs of Quality. This can initiate a redistribution of Costs of Quality. The company can invest more money in prevention costs and hopefully decrease the costs of the remaining categories.

The identification of cost drivers can be seen as the basis for the development of the tool. There might be additional cost drivers at Sony Mobile that could have been included and there might even be cost drivers that the employees don't know of.

In chapter 1, Introduction, it was emphasized that Sony Mobile has focused too much on purchase price, which has generated less focus on other variables. The implementation of the tool might contribute to increased focus on quality in the organization. Furthermore, the result of the tool is a total Cost of Quality, which was what the buyers wanted in order to motivate a selection of a supplier with higher purchase price, but lower Costs of Quality.

Moreover, the tool is simple to use and update. It is especially simple when using the complement; the instruction document.

## 6.7 Further work that can be performed at Sony Mobile

As emphasized in chapter 1, Sony Mobile does not have a way to integrate historical supplier performance into future supplier selections. Thereby, the company does not have a structured way to register historical performance that easily can be used in future supplier selections. Consequently, the authors had to ask for reports at BMC that have not been retrieved before. The data has been registered but the reports generated to Sony Mobile have not been sorted on the variables needed for the Supplier Quality Performance Tool. The reports asked for has been sent by e-mail from BMC. Integrated databases, with possibilities to sort on optional variables, where the reports easily can be retrieved would facilitate this work. It would also decrease the risk of misunderstanding of what variables to sort on. Databases would be needed for the areas First Point of Check and Production. The database called Seerena is soon developed and it will include Global Root Cause Analysis and Fault Verification Analysis. The same problem is emphasized in theory regarding barriers to implement Total Cost of Ownership (Ellram, 1995). Theory highlights that the main reason for not using Total Cost of Ownership is due to lack of appropriate reporting systems. This means that the data needs to be gathered manually.

A development of these databases will probably take time and for the time being Sony Mobile needs to identify appropriate employees to be responsible for the gathering of reports and the updating of the tool.

The authors recommend Sony Mobile to start a registration of scrap-costs since the authors believe it is a significant cost driver. Waste of other components due to a fault with another component generates a lot of costs. Sony Mobile estimates a scrap cost today and it would be of interest to see whether the estimations correspond to the real cost. The registration needs to be performed at BMC.

The employees at Sony Mobile claim that Production downtime happens very seldom and are thereby not a major cost driver. However, the authors think it would be of interest to actually register the production stops and register the source to the stop. As emphasized in 6.4 the cost driver safety stock can be analyzed once again in order to verify the gathered information.

The usage of the Supplier Quality Performance Tool is today a bit complex, especially in the gathering of data. The major aspect that makes it complicated is that all data is not registered at supplier level. If this would be performed it would facilitate the work for the user. Furthermore, it would be easier to apply the tool to the area Electronics. This is further described in next paragraph.

The authors have identified that the major cost drivers can be found in the After-sales. A customer return costs a lot as well as the effects from a customer return, such as lost customers. The authors think that this finding needs to be emphasized to a larger extent at Sony Mobile. Some employees have the same opinion, while others don't seem to be aware of the costs caused by poor quality in this phase.

## 6.8 Adjustments needed to make the tool applicable in other areas

In order to apply the tool to the areas Mechanics and Electronics adjustments of the tool need to be performed. Regarding Mechanics, the tool will not be applicable due to the fact that the purchase of their components differs from the ones within Electronics and Electro-Mechanics. The Mechanical area is working more closely with their suppliers and already evaluates the suppliers based on the yield factor they offer during the supplier selection. According to the Senior Supplier Engineer within Mechanics they have great control of their suppliers and the cost drivers included in the Supplier Quality Performance Tool is not of great relevance for them. This is due to the fact that they have control of the deliveries of the suppliers and what the quality issues cost.

The major difference between Electronics and Electro-Mechanics is that Electronics purchases standard components and thereby has several suppliers connected to one part number. Electro-Mechanics mostly purchases unique components where one supplier normally is connected to one part number. The reports gathered in Production and After-sales can today only be sorted at part number and not supplier. For Electro-Mechanics' components this works but not for Electronics. Thereby, the registration of faults needs to be changed and include the supplier as well. To be able to apply the tool to include the commodities within Electronics it is rather the indata to the tool that needs to be adjusted.

Regarding generalizability outside Sony Mobile, it can be made with some adjustments. The tool together with the instructions is developed in line with Sony Mobiles' processes and registrations. Thereby, it is difficult to apply it directly to other companies. However, the tool uses formulas that are easy to adjust and can thereby be applied to other companies. The theoretical tool can be applied to other companies.

## 6.9 Theoretical contribution

The theoretical contribution is the established theoretical tool. In the tool the three frameworks; Costs of Quality, Total Cost of Ownership and Cost ratio-plan have been combined. The theoretical tool presents a new way to grasp where resources due to faults of quality are spent and where they are not spent. This is performed by categorizing the cost drivers into Sörqvist's (1998) four areas; prevention costs, appraisal costs, internal failure costs and external failure costs. A categorization gives the company an understanding of where they spend their resources. In cases where little resources are spend on prevention costs, the three other areas are probably larger. It can be interested for a company to see how much they save if investing more in prevention costs and thereby decreasing the size of the other categories of costs. This is created in order to give the company an indication of resources spent. Moreover, the tool shows a new way to integrate costs of faults of quality into future supplier selection. The cost drivers included in the four categories are summarized and added to the new purchase price aligned with the purpose of the theoretical framework Cost-ratio plan. This result in a new more correct purchase price.

As emphasized in the literature study, difficulties in identifying literature that integrates Costs of Quality into future supplier selections have been noticed. This thesis contributes to this and gives the reader one perspective of how to integrate historical supplier performance into future supplier selections.

## 6.10 Contribution to Sony Mobile

Sony Mobile has during the entire process emphasized the fact that any result is better than what they have today, since no Costs of Quality are integrated into the supplier selection. The purpose of developing a tool that integrates historical data of suppliers' quality performances into future supplier selections with a cost focus has been fulfilled and the authors have found a way to integrate historical supplier quality performance into future supplier selections at Sony Mobile. The instruction document is needed as a complement to the tool in order to understand the usage of it.

The first part of the theoretical tool, the categorization of cost drivers into Costs of Quality, will give Sony Mobile indications to where they spend their quality resources. Today, it is obvious that a lot of resources are spent during the processes within a mobile phone project and not before the processes actually start. The company does not invest in prevention costs. However, the Supplier Quality Performance Tool is a first attempt to invest in prevention costs. An interesting aspect to analyze is whether the remaining categories of costs; appraisal, internal and external are decreasing subsequent to the implementation of the tool.

Due to the size of the organization, there is no one that has the whole picture of the processes within a project, the included quality checks nor where to gather the data. A lot of information is gathered in this thesis regarding these areas. The thesis does obviously not include everything, but a general picture of it. Thereby, the thesis is contributing with a mapping of the processes within a mobile phone project, the quality checks and where to gather data from.

## 6.11 General reflections

The subject of the thesis has been very interesting and exciting to work with. This has partly been due to the fact that the subject is very relevant and employees at management-level are interested in the result of the thesis. The interest of the subject has also been obvious during the held interviews. The employees have showed a lot of engagement and interest since they consider the subject to be very relevant and necessary.

Regarding gathering of data, difficulties have been identified in the process of finding the appropriate employees to talk to regarding suitable areas. This is probably due to the size of the organization. A related aspect is that a lot of data is registered at general levels, which means that the registered faults can be caused by design, production or material. The authors thereby had to be distinct in the communication and emphasize that the data regarding discovered faulted components should be caused by supplier.
The process of gathering of data during the thesis has been interesting. To start with information was given regarding key ratios at Sony Mobile that could be used in order to analyze quality aspects. As the authors dug deeper into the ratios, realizations regarding invalidity and unreliability of them were discovered.

## 6.12 Future research connected to the subject

Throughout the process of the thesis problems with gathering of data has occurred. Further research is suggested to try to investigate how large companies can implement guidelines for how to gather information regarding costs of fault in quality.

When developing the Supplier Quality Performance Tool the authors combined the three theories Total Cost of Ownership, Cost-ratio plan and Cost of Quality. These theories have worked as a good base for this tool but the authors emphasize the possibility to use other theories to combine for developing a Supplier Quality Performance Tool. Further research to find other theories that will be used for the same purpose and developing a tool is suggested. This could be to use the theory Analytic Hierarchy Process.

Another aspect not included in the Supplier Quality Performance Tool is the cost of badwill. The authors suggest further research regarding this cost driver in order to investigate a possible implementation of it into future Supplier Quality Performance Tools.

# References

**Written sources**

Axsäter S. (2006). *Inventory Control.* Springer, Vol. 2.

Benyoceuf, B., Hongwei, D., Xiaolan, X. (2003). ”Supplier selection problem: selection criteria and methods”. *Institut National de Recherche en Informatique et en Automatique (INRIA*).

Burt, D.W. (2003). *World Class Supply Management - The Key to Supply Chain Management.* The McGraw-Hill , p. 492, 495.

Campanella, J. (1999). “Principles of quality costs: Principles, Implementation and Use”. *ASQ Quality Press,* p. 3-5.

Cooper, R. , Kaplan, R. S. (1992). *Acitivity based systems: Measuring the costs of resource usage.* Accounting Horizons.

Degraeve, Z. & Roodhoft, F. (1999a). “Effectively selecting suppliers using Total Cost of Ownership”, published in Arlbjørn J.S, Zachariassen F. (2009). *Total Cost of Ownership: A differentiated Approach*. Department of Entrepreneurship and Relationship Management, University of Southern Denmark.

Ellram, L. (1993). “A Framework for Total Cost of Ownership”. *The International Journal of Logistics Management,* Vol. 4 No.2, p. 49-59.

Ellram, L. (1995). “Total Cost of Ownership, An analysis approach for purchasing”. *International Journal of Physical Distribution & Logistics*, Vol. 25 No. 8, p. 4-23.

Ellram, L. , Siferd, S.P. (1993). “Purchasing: The cornerstone of the Total Cost of Ownership concept”. *Journal of Business Logistics*, Vol. 14 No.1, p. 163-184.

Ellram, L. (1994). “A taxonomy of Total Cost of Ownership models”. *Journal of Business Logistics*, p. 171-191.

Ferrin, B.G., Plank, R.E. (2002). "Total Cost of Ownership models: An exploratory study". *The journal of Supply Chain Management*, p. 18-29.

Hoque, Z. (2003). *Strategic Management Accounting.* Pearson Prentice Hall, p. 179.

Hansen, D.R., Mowen, M.M. (1997). *Cost accounting; Activity-based accounting; Managerial accounting.* South Western College Pub.

Humphreys, P., Mak, K.L., Yeung, C.M. (1998). "A just-in-time evaluation strategy for international procurement".

Höst, B.R. (2006). *Att genomföra examensarbete.* Lund: Studentlitteratur, p. 29-42.

Kumar, S.A., Suresh, N. (2009). *Operations Management.* New Age International (P) Limited, Publishers, p. 180.

Levary, R.R. (2007). "Ranking foreign suppliers based on supply risk"*. Supply Chain Management: An International Journal*, Vol. 12 No. 6, p. 392 - 394

Ljung, L., Glad, T. (1991). *Modellbygge och simulering*. Studentlitteratur.

Lukka, K. (2003). "The Constructive Approach, in Ojala, L. and Hilmola, O-P. (2003). Case Study Research in Logistics". *Publications of The Turku School of Economics and Business Administration*, Serie B 1, p. 83-100.

Saaty, T.L. (2008). "Decision making with the analytic hierarchy process". *International Journal Services Sciences*, Vol. 1 No. 1, p. 83-98.

Sánchez-Rodriguez, C., Hemsworth, D., Martinez-Lorente, A.R. (2004), *Quality Management Practices in Purchasing and its Effect on Purchasing's Operational Performance and Internal Customer Satisfaction*. International Journal of Logistic: Research and Applications, Vol. 7 No 4, p. 325-344.

Saunders, M. (2009). *Research Methods for Business Students*. Pearson.

Svensson, B.S.G. (1994). *Kvalitativ metod och vetenskapsteori.* Lund: Studentlitteratur.

Sörqvist, L. (1998). *Kvalitetsbristkostnader, Ett hjälpmedel för verksamhetsutveckling.* Lund: Studentlitteratur, p. 19-20, 38-41.

Tsai, W.H. (1998). "Quality cost measurement under activity-based costing". *International Journal of Quality & Reliability Management* , Vol. 15 No 7, p. 719-752.

van Weele, A.J. (2010). *Purchasing and Supply Chain Management.* South-Western Cengage Learning, p. 238-239, 241-242.

Wei-Ning, P. (2005). "Supplier evaluation and selection using Taguchi loss functions". *International Journal Adv Manuf Technol*, p. 155-160.

Xinxing, L., Chong, W., Rosenberg, D., Barnes, D. (2009). "Supplier selection in agile supply chains: An information-processing model and an illustration". *Journal of Purchasing & Supply Management,* Vol. 14, p. 249-262.

**Electronic Sources**

Accocunting For Management. *Definition and explanation of Quality costs.*
http://www.accounting4management.com/quality_costs.htm (2012-04-25)

Business Dictionary. *Replacement*.
http://www.businessdictionary.com/definition/replacement.html (2012-04-25)

Business Dictionary. *Inspection.*
http://www.businessdictionary.com/definition/inspection.html (2012-04-25)

Business Dictionary. *Rework.*
http://www.businessdictionary.com/definition/rework.html#ixzz1t7wtTyEA
(2012-04-25)

Business Dictionary. *Quality Improvement.*
http://www.businessdictionary.com/definition/quality-improvement.html (2012-04-25)

Business Dictionary. *Downtime.*
http://www.businessdictionary.com/definition/downtime.html#ixzz1t81efFqP (2012-04-25)

Citeman. *The Cost-ratio plan.*
http://www.citeman.com/7382-the-cost-ratio-plan.html (2012-02-24)

Encyclopedia Britannica Facts Matter. *Auditing.*
http://www.britannica.com/EBchecked/topic/42575/auditing/255572/Standardization-of-audit-procedures?anchor=ref891828 (2012-05-03)

Event Sales Inc. *Customer returns.*
http://www.eventsale.com/Customer-Returns.asp (2012-05-03)

NE. *Kalibrering.*
http://www.ne.se/kalibrering (2012-04-25)

NE. *Badwill.*
http://www.ne.se/badwill (2012-04-25)

Merriam Webster. *Scrap.*
http://www.merriam-webster.com/dictionary/scrap (2012-04-27)

**Internal Sources**

Anderberg, Stefan. *Senior Sourcing Engineer.*
Berglund, Andreas. *Supplier Quality Engineer*.
Blom, Johan. *Strategic Buyer.*
Bognäs, Mattias. *Staff Manufacturing Engineer.*
Bontidean, Alin. *Senior Repair Development Engineer.*
Castensson, Per. *Senior Manager Manufacturing.*
Dong, Xiufang. *Senior Factory Product Quality Manager at BMC.*
Ekberg, Peter. *Director Sourcing Mechanics Electronics*.
Ekman, Markus. *Senior Supplier Quality Engineer.*
Ericsson, Johan. *Global Commodity Manager.*
Eskilander, Stephan*. Senior Manager.*
Gustafsson, Henrik. *Staff Manufacturing Engineer.*

Hagelin, Olle. *Senior Manager Quality Feedback.*
HaiZheng, Zhang. *Manager, Quality Control at BMC*.
Johansson, Carl-Johan. *Staff Engineer, Industrialization & Production.*
Johansson, Henrik. *Senior Quality Manager.*
Jönsson, Anders. *Senior Quality Analyst Project Manager.*
Larsson, Johan*. Senior Supply Quality Engineer*.
Larson, Mattias. *Staff Project Manager.*
Li, Jing. *Senior Trouble Shooter at BMC.*
Liu, XinYing. *Quality Control Engineer at BMC.*
Lindkvist, Peter. *Director Supplier Quality Assurance.*
Nayar, Malini. *Staff Project Manager.*
Nygren, Magnus. *Staff Project Manager.*
Olsson, Lars. *Senior Business Analyst.*
Olsson, Mattias. *FVA PM.*
Pernstam, Anna. *IQC Manager.*
Pålsson, Johan. *Strategic Buyer*.
Rosander, Torbjörn. *Staff Project Manager*.
Stjernberger, Johan. *Senior Project Manager.*
Thelander, Anders. *Performance Manager.*
Walle, Erik. *Staff Project Manager.*
Wolff, Martin. *Manager Mechanical Design.*
Åberg, Peter, *Senior Project Manager.*

**External Sources**

Nilsson, Bertil. *Adjunct Assistant Professor, Department of Industrial Management and Logistics, Lund Institute of Technology.*

# Appendix 1 – Interviews at Sony Mobile sorted by date

| Interview persons | Position | Date | Purpose/Outcome |
|---|---|---|---|
| Johan Pålsson | Strategic Buyer | 23th of January | Purchasing process. |
| Johan Larsson | Senior Supplier Quality Engineer | 25th of January 13:00-14:00 | Production process, especially IQC, RR for his commodities. |
| Martin Wolff | Manager, Mechanical Design 3 | 6th of February 13:00-14:00 | Purchasing process, especially the technical part in an order. |
| Peter Åberg | Senior Project Manager | 8th of February 09.00-10.00 | Production process. |
| Torbjörn Rosander | Staff Project Manager | 9th of February 13.00-14.00 | Production process and BMC contacts. |
| Per Castensson | Senior Manager, Manufacturing G&S | 10th of February 13:00-13:30 | Production process and BMC. |
| Mattias Larson | Staff Project Manager | 13th of February 13:00-14:30 | Production process and the databases: Insite, and QI-tool. |
| Anna Pernstam | IPQM Manager | 13th of February 13:00-14:30 | Production process and the databases: Insite, and QI-tool. |
| Anders Thelander | Performance Manager | 15th of February 10:00-11:00 | OBA and Yield. Provided contacts at BMC (Wang Lin). |
| Henrik Johansson | Senior Quality manager | 15th of February 10:00-11:00 | OBA and Yield. Provided contacts at BMC (Wang Lin). |
| Alin Bontidean | Senior Repair Development Engineer | 15th of February 14:00-15:00 | Customer feedback and the average cost of one return. |
| Olle Hagelin | Senior Manager, Quality Feedback | 15th of February 14:00-15:00 | Customer feedback and the average cost of one return. |
| Peter Lindkvist | Director, Supplier Quality Assurance | 15th of February 15:30-16:00 | Data of faults of quality in previous projects. |

| | | | |
|---|---|---|---|
| Stephan Eskilander | Senior Manager | 15th of February 16:15-17:00 | Returns connected to specific component and RCA. |
| Johan Larsson | Senior, Supplier Quality Engineer | 16th of February 13:30-14:15 | Access to registered amount of faults of quality in IQC. |
| Erik Walle | Staff Project Manager | 16th of February 13:30-14:15 | Project regarding purchasing process and quality issues. |
| Johan Ericsson | Global Commodity Manager | 29th of February 09:00-09:30 | Purchasing process and gave input to how further work. |
| Henrik Gustafsson | Staff Manufacturing Engineer | 5th of March 13:00-14:00 | Scrapcost-estimations in new projects. |
| Mattias Bognäs | Staff Manufacturing Engineer | 5th of March 13:00-14:00 | Scrapcost-estimations in new projects. |
| Peter Lindkvist | Director, Supplier Quality Assurance | 7th of March 10:00-11:00 | Production process and delimitations in the thesis. |
| Peter Ekberg | Director, Sourcing Mechanics Electromech | 16th of March 10:00-11:00 | Scope of the tool and presentation of a first prototype. |
| Markus Ekman | Senior, Supplier Quality Engineer | 20th of March 13:00-14:00 | Available data at Markus department called Electronics. |
| Andreas Berglund | Supplier Quality Engineer | 20th of March 14:00-15:00 | Andreas presented the tool he has created. |
| Johan Larsson | Senior, Supplier Quality Engineer | 21th of March 13:00-14:00 | Description of time estimations. |
| Stefan Anderberg | Senior Sourcing Engineer | 2nd of April 10:00-11:00 | Discussion regarding Mechanics and their need of a tool. |
| Mattias Olsson | FVA PM | 2nd of April 13:00-14:00 | Discussion regarding RCA and FVA at the after market. |
| Carl-Johan Johansson | Staff Engineer, Industrialization & Production | 3rd of April 09:00-10:00 | Carl-Johan showed us a prototype of a production line. |
| Malini Nayar | Staff Project Manager | 11th of April 13:00-13:30 | Access to the RCA-database and instructions. |
| Henrik Johansson | Senior Quality manager | 17th of April 15:00-16:00 | Yield connected to component and supplier. |
| Peter Åberg | Senior Project Manager | 18th of April 15:30-16:00 | Yield connected to component and supplier. |

| | | | |
|---|---|---|---|
| Johan Pålsson | Strategic Buyer | 19th of April 10:00-11:00 | First draft of the Supplier Quality Performance Tool. |
| Magnus Nygren | Staff Project Manager | 19th of April 11:15-12:00 | DCL-report. |
| Johan Stjernberger | Senior Project Manager | 19th of April 15:30-16:00 | Build Issue List, Material Issue List and DCL-reports. |
| Henrik Johansson | Senior Quality manager | 19th of April 16:00-17:00 | Repair percentage. |
| Johan Pålsson | Strategic Buyers | 27th of April 12:00-15:00 | Testing of the Supplier Quality Performance Tool. |
| Johan Blom | Strategic Buyers | 27th of April 12:00-15:00 | Testing of the Supplier Quality Performance Tool. |

# Appendix 2 – Interview guide

Employees from various departments at Sony Mobile have been interviewed. The questions for the interviews have been developed iteratively. In the beginning, the questions were asked from a broad perspective since the authors wanted to acquire as much understanding of the organization as possible. Subsequently, the questions were more specified due to the fact that the authors had better comprehension of what positions the interviewers had. The interviews have followed an open process, which means that relatively broad questions are asked. The interviewed person can then answer the questions from his/her perspective. Additional questions were often needed in order to clarify the answer.

**Interview 1**

Name: Johan Pålsson
Position: Strategic Buyer
Date: 23 th of January

*What is your role at Sony?*
*Can you describe the purchasing process?*
*Do you want the tool to focus on mainly quantitative data?*
*Where is the amount of faults of quality registered?*

**Interview 2**

Name: Johan Larsson
Position: Senior Supplier Quality Engineer
Date: 25th of January

*What is your role at Sony?*
*Can you describe the production process?*
*How is the DPPM-goal determined?*
*Do you have contact information to other employees with the same position as you, but for other commodities?*

**Interview 3**

Name: Martin Wolf
Position: Manager, Mechanical Design
Date: 6th of February

*What is your role at Sony?*
*Were in the process do you work?*
*How does the purchasing process works according to you?*
*How do you specify the requirements of the components?*
*How do you get information about defect of quality?*
*What kind of defect in quality do you register?*
*What cost could be related to defect of quality?*
*How do you work together with other departments, for example the purchasing department?*
*How many components are standard components and how many have a unique design?*

**Interview 4**

Name: Peter Åberg
Position: Senior Project Manager
Date: 8th of February

*What is your role at Sony?*
How does this process works?
*Do you estimate costs related to discovered defects of quality?*
*Can you describe the production process and the controls of this process?*
*How do you work together with other departments?*
*Are there any goals connected to YIELD and how is the goal determined?*
*Do you have contact information to other employees for further information about the production process?*

**Interview 5**

Name: Torbjörn Rosander
Position: Staff Project Manager
Date: 9th of February

*What is your role at Sony?*
*Where are faults of quality registered in the production process?*

**Interview 6**

Name: Per Castensson
Position: Senior Manager
Date: 10th of February

*What is your role at Sony?*
*Can you describe Yield and the goals connected to it?*

**Interview 7**

Name: Mattias Larsson
Position: Staff project manager
Name Anna Pernstam
Position: IPQM manager
Date: 13th of February

*What is your role at Sony?*
*Can you describe the production process?*
*Where and how is the reporting done?*
*Are products sent out to the market even though you have had a lot of problems with it in the production process?*
*Are there any components that have more faults than other?*
*Do you have systems that keep track of the products in the production process?*
*Do you know if any problems are registered in IQC, even if it occurs in the production process?*
*How many components are checked in IQC?*
*Can you estimate the associated costs to the problems that occur?*
*Do you know anyone who has information about scrap estimations?*

**Interview 8**

Name: Anders Thelander
Position: Performance Manager
Name: Henrik Johansson

Position: Senior Quality Manager
Date: 15th of February

*What is your role at Sony?*
*What type of information regarding faults of quality do you have and what does BMC have?*
*How is Yield and OBA registered?*
*What is OBA?*
*If a fault is discovered in OBA, what are the consecutive actions?*
*How is OBA registered?*
*How is Yield registered?*
*What actions are taken when a low yield or high OBA is discovered?*
*How can we get access to the registered data regarding faults of quality?*
*Do you have an idea of costs related to discovered faults of quality?*
*Do you have contact with purchasing department in your daily work?*
*Do you know if the faults discovered in return rate could be connected to specific supplier?*

**Interview 9**

Name: Alin Bontidean
Position: Senior Repair Development Engineer
Name: Olle Hagelin
Position: Senior Manager Quality Feedback
Date: 15th of February

*What is your role at Sony?*
*How is the process for registration of faults on the After-sales?*
*Do you have other key ratios than return rate?*
*Are return rate connected to specific supplier?*
*Do you know the costs connected to a return rate?*
*Can you tell us about the process when a mobile phone is returned to Sony?*
*How do you work with other departments?*
*When a fault is discovered, is this presented to production or purchasing department?*
*How and where are the faults registered?*

**Interview 10**

Name: Peter Lindkvist
Position: Director, Supplier Quality Assurance
Date: 15th of February

*What is your role at Sony?*
*Where in the process do you consider that the defects of quality are discovered?*
*How do you work with BMC?*
*What is your comprehension of the commodity connectors and switches?*

**Interview 11**

Name: Stephan Eskilander
Position: Manager
Date: 15th of February

*We heard from Olle Hagelin and Alin Bontidean that you have information regarding return rate connected to supplier, is it correct?*
*Do you have an idea of appropriate categorization of components?*

**Interview 12**

Name: Johan Larsson
Position: Senior Supplier Quality Engineer
Date: 16th of February

*We have understood that DPPM-goal is determined depending on complexity of component. Is this correct?*
*During past meeting, you mentioned that you have information regarding time for RCA?*
*Can you recommend someone with the same position as you, but within electronics and mechanics?*

**Interview 13**

Name: Erik Walle
Position: Staff Project Manager
Date: 16th of February

*Erik described various working processes at Sony Mobile.*

**Interview 14**

Name: Johan Ericsson
Position: Global Commodity Manager
Date: 29th of February

*What is your role at Sony?*
*How does the purchasing process look like for the two commodities?*
*What parameters are included in the template?*

**Interview 15**

Name: Henrik Gustafsson
Position: Staff Manufacturing Engineer
Name: Mattias Bognäs
Position: Staff Manufacturing Engineer
Date: 5th of March

*What is your role at Sony?*
*How do you define costs related to scrap?*
*How do you estimate repair costs?*
*Are your estimations followed-up? If yes, how is the real outcome compared to your estimations?*

**Interview 16**

Name: Peter Lindkvist
Position: Director, Supplier Quality Assurance
Date: 7th of March

*How does the testing process differ between components at different commodities?*
*Do you have any idea of which KPIs we shall analyze further in the production?*
Do you know how we can get the information regarding scrap and RCA?

**Interview 17**

Name: Peter Ekberg
Position: Director, Sourcing Mechanics Electromech
Name: Johan Pålsson
Position: Strategic Buyer (the supervisor of the thesis)
Date: 16th of March

*What is your role at Sony?*
*We started by presenting our work so far and how we have interpreted some of the information. We emphasized the fact regarding differing data depending on commodity and even depending on component at times. Furthermore, we pointed out the problem regarding scope of the tool. Is the major purpose that we shall deliver a generic tool, with a risk that the data is not as accurate as it could be or is the purpose that we shall create a specific tool for each commodity with more accurate data? The risk with a specific tool is that the complexity of updating it is so high that it won't be done and the tool will furthermore not be used.*

**Interview 18**

Name: Markus Ekman
Position: Senior Supplier Quality Engineer
Name: Andreas Berglund
Position: Supplier Quality Engineer
Date: 20th of March

*What is your role at Sony?*
*How is your area; Electronic different from the other two areas?*
*Do you have an idea of how many of the discovered issues that can be related to the supplier?*
*How do you measure quality issues connected to supplier at the after market?*

During the conversation, Markus comes to think about one of his SQE that has done a similar tool for Total Cost of Ownership. Markus calls him and tells him to join the meeting.
*Can you tell us about the tool you have developed?*

*Return rate is not included in the tool, according to our research we found this parameter the largest cost driver, have you looked at it?*

**Interview 19**

Name: Johan Larsson
Position: Senior Supplier Quality Engineer
Date: 21th of March

*The meeting started by an illustration of the tool Andreas has developed. Johan gave his feedback.*
*How do you think we shall move forward with this model?*
*Do you have any suggestions of whom we can contact for this workshop?*

**Interview 20**

Name: Stefan Anderberg
Position: Senior Sourcing Engineer
Date: 2nd of April

*What is your role at Sony Mobile?*
*Is the key ratio return rate important for Mechanics?*
*What parameters do you consider necessary in the development of the Supplier Quality Performance Tool?*
*Is it possible to make similar estimations as electronic and Electro-Mechanics has made regarding repair time and issue time?*
*What type of evaluation of the supplier do you use?*
*Is scrap important for your area?*

**Interview 21**

Name: Mattias Olsson
Position: FVA PM
Date: 2nd of April

*What is your role at Sony Mobile?*
*Can you explain FVA?*
*How confident is the FVA-data?*

*How do you get the information? In other words, what databases do you use?*

**Interview 22**

Name: Carl-Johan Johansson
Position: Staff Engineer, Industrialization and Production
Date: 3rd of April

Carl-Johan showed us the production prototype at Sony Mobile. He told us about the three areas; Service Mount Assembly, Core Unit and Sales Item and their tests. He also showed us how a repair is made.

**Interview 23**

Name: Malini Nayar
Position: Staff Project Manager
Date: 11th of April

*We are looking for the amount of returns connected to specific supplier and component. The return shall furthermore be due to material issues. Where can we find this data?*

**Interview 24**

Name: Henrik Johansson
Position: Senior Quality Manager
Date: 17th of April

*We are looking for a yield-factor connected to specific component and supplier.*
*Do you know if all components are checked in the Online-yield?*
*Do you know the time it takes to repair one component?*

**Interview 25**

Name: Peter Åberg
Position: Senior Project Manager
Date: 18th of April

*We are looking for a yield-factor connected to specific component and supplier. Do you know where we can find that type of data?*

**Interview 25**

Name: Johan Pålsson
Position: Strategic Buyer
Date: 19th of April

A meeting regarding the master thesis was held. Discussions regarding data in production had major focus during this meeting.

**Interview 26**

Name: Magnus Nygren
Position: Staff Project Manager
Date: 19th of April

*We are looking for a yield-factor connected to specific component and supplier. Do you know where we can find that type of data?*

**Interview 27**

Name: Johan Stjernberger
Position: Senior Project Manager
Date: 19th of April

*We are looking for a yield-factor connected to specific component and supplier.*
*Can we say that issues registered in Material Issue List will be included in the DCL as well?*

**Interview 28**

Name: Henrik Johansson
Position: Senior Quality Manager
Date: 19th of April

*Johan Stjernberger mentioned the QI-tool. Is this something we can have use of?*

# Appendix 3 - Formulas included in the Supplier Quality Performance tool

The tool includes several calculations, which are described in sequence of each other below.

The following calculations represent the cost for one component or one issue.

$$\boldsymbol{IQC\ cost_{one\ component} = IQC\ time_{one\ component} \times Production\ operator\ cost_{hour}}$$

Formula 1. The cost of one faulted component in IQC

$$\boldsymbol{Online\ cost_{one\ component} = Time\ rework\ SMA_{one\ component} \times Production\ operator\ cost_{hour} + 0{,}75 \times Component\ price_{scrap}}$$

Formula 2. The cost of one faulted component in online

$$\boldsymbol{Production\ cost_{one\ component} = Time\ rework\ production_{one\ component} \times Production\ operator\ cost_{hour} + 0{,}75 \times Component\ price_{scrap}}$$

Formula 3. The cost of one faulted component in production

$$Issue\ cost\ SQE_{one\ issue} = Issue\ time\ SQE_{one\ issue} \times Engineer\ cost_{hour}$$

Formula 4. The cost for one issue for an SQE

Furthermore, the total costs are calculated for the amount of faulted components found in the areas First Point of Check, Production, After-sales and Quality Management. The formulas are presented below.

$$\begin{aligned} Total\ costs_{First\ Point\ of\ Check} &= Amount\ of\ default\ components_{IQC} \times IQC\ cost_{one\ component} \\ &+ Amount\ of\ default\ components_{Online} \\ &\times OnlineYield\ cost_{one\ component} \end{aligned}$$

Formula 5. The total Cost of Quality in First Point of Check

$$\begin{aligned} Total\ costs_{Production} &= Amount\ of\ default\ components_{Production} \\ &\times\ Production\ cost_{one\ component} \end{aligned}$$

Formula 6. The total Cost of Quality in Production

$$\begin{aligned} Total\ costs_{Global\ RCA} &= Amount\ of\ default\ components_{Global\ RCA} \\ &\times Return\ Rate\ cost_{one\ component} \end{aligned}$$

Formula 7. The total Cost of Quality in Global RCA

$$\textit{Total costs}_{FVA} = \frac{\textit{Amount of default components}_{FVA}}{\textit{Amount of mobile phones checked in FVA in involved projects}} \times \textit{Amount of sold mobile phones for involved projects} \times \textit{Retun Rate cost}_{one\ component} \times \textit{Percent of return phones from market}$$

Formula 8. The total Cost of Quality in FVA

$$\textit{Total costs}_{After-sales} = \textit{Total costs}_{FVA} + \textit{Total costs}_{Global\ RCA}$$

Formula 9. The total Cost of Quality in After-sales

$$\textit{Total costs}_{Quality\ Management} = \textit{Amount of Issues}_{SQE} \times \textit{Issue cost SQE}_{one\ issue}$$

Formula 10. The total Cost of Quality in Quality Management

$$\textit{Total Cost of Quality} = \textit{Total costs}_{First\ Point\ of\ Check} + \textit{Total costs}_{Production} + \textit{Total costs}_{After-sales} + \textit{Total costs}_{Quality\ Management}$$

Formula 11. The Total Cost of Quality

$$\textit{Total Cost of Quality}_{one\ component} = \frac{\textit{Total Cost of Quality}}{\textit{Total amount of components}}$$

Formula 12. The Total Cost of Quality for one component

# Appendix - 4 Instruction document to the Supplier Quality Performance Tool

## Description of the Supplier Quality Performance Tool

The Supplier Quality Performance Tool is based on data registered from past year and can be applied to analysis at component or supplier-level. Furthermore, the tool is divided into several cost drivers related to four areas; First Point of Check, Production, After-sales and Quality Management.

The user needs to collect data from various reports and register the number in the correct cell of the tool. The tool consists of two excel sheets. In the first sheet the Strategic Buyer registers data in the yellow cells, see figure 1. The data can be connected to specific component or to supplier. In the second sheet, the time-estimations and costs related to a faulted component are stated, see figure 2.

| | | Unit |
|---|---|---|
| **Total amount of components (past year)** | 0 | Pieces |
| **Component price (history)** | 0 | Dollar |
| | | |
| **First Point of Check** | | |
| Amount of checked components in IQC (sample size) | 0 | Pieces |
| Amount of faulted components in IQC | 0 | Pieces |
| Amount of checked components in Online | 0 | Pieces |
| Amount of faulted components in Online | 0 | Pieces |
| ***Total First Point of Check Costs*** | 0 | Dollar |
| | | |
| **Production** | | |
| Amount of ordered components | 0 | Pieces |
| Amount of faulted components | 0 | Pieces |
| ***Total costs Production*** | 0 | Dollar |
| | | |
| **After-sales** | | |
| Amount of faulted components in Global RCA | 0 | Pieces |
| Amount of faulted components in FVA | 0 | Pieces |
| Amount of mobile phones checked in FVA in involved projects | 0 | Pieces |
| Amount of sold mobile phones in involved projects | 0 | Pieces |
| Global RCA-costs | 0 | Dollar |
| FVA-costs | 0 | Dollar |
| ***Total costs After-sales*** | 0 | Dollar |
| | | |
| **Quality Management** | | |
| Amount of Issues with component | 0 | Times |
| ***Total costs Quality Management*** | 0 | Dollar |
| | | |
| ***Total Cost of Quality*** | 0 | Dollar |
| | | |
| ***Cost of Quality per unit*** | 0 | Dollar |
| | | |
| Purchase price of component | 0 | Dollar |
| ***New purchase price*** | 0 | Dollar |

Figure 1: First sheet of the Supplier Quality Performance Tool

**Description of included parameters (Yellow cells)**

*Total amount of components* regards the total amount of components ordered past year of the specific component or from the supplier.

*Component price (history)* represents the price paid for the specific component. NOTE! This cell needs to be completed when the costs of wasted component (scrap) shall be included in the costs regarding repair in online and production.

**First point of check**

**1. Analysis at component level**
NOTE! Only one of the parameters below shall be completed.

**Incoming Quality Check (IQC)**
*Amount of checked components in IQC (sample size)* regards the total amount of components that has been checked in IQC of the specific component.
*Amount of faulted components in IQC* regards the components that are checked in IQC.

**Online-yield**
*Amount of checked components in Online* regards the amount of components that are checked in the Online.
*Amount of faulted components in Online* regards the components that are registered in Online-yield.

**2. Analysis at supplier level**
NOTE! Some components can be registered in the cells regarding IQC and others in the cells regarding Online-yield depending on where the component's First Point of Check is.

**Incoming Quality Check (IQC)**
*Amount of checked components in IQC (sample size)* regards the total amount of components that has been checked in IQC of the specific component.
*Amount of faulted components in IQC* regards the components that are checked in IQC.

**Online-yield**
*Amount of checked components in Online* regards the amount of components that are checked in the Online.
*Amount of faulted components in Online* regards the components that are registered in Online-yield.

**Production**

NOTE! This shall not be completed for the components registered in Online-yield.

*Amount of ordered components* refer to the amount of components that have been purchased past year.
*Amount of faulted components* concern the discovered faults in production.

**After-sales**

Regarding returns in after-sales, the only data available at the time the tool was developed was RCA that is registered in an RCA-database. In the near future data of both Global RCA and FVA can be gathered from the database; Seerena. An assumption is that the RCA-database and Seerena will function similarly. Thereby, the instructions follow the structure of the RCA-database.

*Amount of faulted components in Global RCA* refers to the amount of discovered faults in Global RCA.
*Amount of faulted components in FVA* refers to the amount of faulted components in the involved projects for the specific component or supplier.
*Amount of mobile phones checked in FVA in involved projects* regards the amount of mobile phones that have been analyzed in FVA in the projects where the specific component or supplier is included.
*Amount of sold mobile phones in involved projects* regards the amount of mobile phones in the involved projects that have been sold. This information is gathered from Customer Service.

**Quality Management**

*Amount of issues* regards the amount of issues the Supplier Quality Engineer department has been involved in during past year with the component or supplier. This data is gathered from the responsible SQE.

**Total Cost of Quality**

A total Cost of Quality will appear and the Cost of Quality per unit.

*Purchase price* regards the price of the component offered by the supplier. If the analysis is at supplier level the *Purchase price* can be an average of the components delivered by the supplier. Finally a new purchase price for the component is calculated.

**Second sheet of the tool**

In the second sheet all costs are connected to one component except for issue cost that is referred to an issue. These costs need to be updated occasionally and the latest update for electro-mechanic component was May 2012. The red cells refer to the costs related to one discovered fault in each of the area, based on amount of hours and cost per hour.

| Estimated time | Time | Unit | Fixed costs | Costs | Unit |
|---|---|---|---|---|---|
| IQC (min) | 10 | Min | Production operator | 15 | Dollar |
| Rework in Online (min) | 30 | Min | Engineer (cost/h) | 165 | Dollar |
| Rework in Production (min) | 60 | Min | Customer return cost | 230 | Dollar |
| Issue time for SQE (h) | 25 | Hour | | | |
| | | | **Calculated costs for one component** | | |
| **Customer returns from market** | **Percentage** | **Unit** | IQC cost | 2,5 | Dollar |
| Percentage of faulted components | 7% | Percent | Online-Yield cost | 7,5 | Dollar |
| | | | Production cost | 15 | Dollar |
| | | | Return Rate Cost | 230 | Dollar |
| | | | Issue cost for SQE | 4125 | Dollar |

Figure 2: Second sheet of the Supplier Quality Performance Tool.

## Gathering of data

As mentioned, several documents exist for the gathering of data. The collecting of data is performed differently depending on if the analysis is based on component or supplier level.

**First point of check**

The report called 'IQC inspection report' is used in this phase.

**IQC**

**Component**

1. Go to column E (Part No.) and sort out the specific part number of the component.

2. The report now shows all components that have gone through the IQC. In order to summarize, mark column J (Receipt qty) and register the sum in the cell *Total amount of checked components* in the Supplier Quality Performance Tool.

3. Go to column N (Insp Res) in order to find the amount of rejected batches. Sort on ‘rejected’.

4. Column J (Receipt qty) shows the amount included in the rejected batch. Summarize the column and register the amount in the cell named *Amount of faulted components in IQC.*

**Supplier**

1. Go to column H (Supplier) and choose the supplier you want to evaluate.

2. The report now shows all components that have gone through the IQC. In order to summarize, mark column J (Receipt qty) and register the sum in the cell *Total amount of checked components* in the Supplier Quality Performance Tool.

3. Go to column N (Insp Res) in order to find the amount of rejected batches. Sort on ‘rejected’.

4. Column J (Receipt qty) shows the amount included in the rejected batch. Summarize the column and register the amount in the cell named *Amount of faulted components in IQC.*

**Online-yield**

In the collection of Online data the report ‘Summary on EM monthly DPPM performance-2011’ is used.

**Component**

1. Go to column H (SEMC Part Number) and select the part number of your component.

2. Go to column P (Defect from on line) and remove “0” and “Blanks”.

3. Mark column P (Defect from on line) and summarize the defected components and register the amount in the cell called *Amount of faulted components in Online.*

4. Go back to the excel sheet and go to column L (Input Quantity (Monthly)).

5. Mark this column and summarize all the input quantity. Register this amount into the tool under the cell called *Amount of components in Online.*

**Supplier**

1. Go to column J (Supplier Name) and select the supplier you want to evaluate.

2. Go to column P (Defect from on line) and remove "0" and "Blanks".

3. Mark column P (Defect from on line) and summarize the defected components and register the amount in the cell called *Amount of faulted components in Online.*

4. Go back to the excel sheet and go to column L (Input Quantity (Monthly)).

5. Mark this column and summarize all the input quantity. Register this amount into the tool under the cell called *Amount of components in Online.*

**Production**

The report used in this phase is called 'Repair-percentage'.
NOTE! To be able to sort at supplier-level in this phase, the user needs to know the part number of the components the supplier is delivering. Thereby, it is only possible to have one source delivering the component.

**Component**

1. Go to column C (Part No.) and sort out the specific part number.

2. Go to column G (Volume of 2011) and the total volume checked is exposed. Register this in the cell called *Amount of checked components*.

3. Go to column F (Failure number of) and the amount of faulted components is illustrated. The amount of faulted components is registered in the cell named *Total amount of faulted components* in the Supplier Quality Performance Tool.

**Supplier**

1. Go to column C (Part No.) and sort out the part numbers the specific supplier is delivering.

2. Go to column G (Volume of 2011) and the total volume checked is exposed. Register this in the cell called *Amount of checked components*.

3. Go to column F (Failure number of) and the amount of faulted components is illustrated. The amount of faulted components is registered in the cell named *Total amount of faulted components* in the Supplier Quality Performance Tool.

**After-sales**

In the compilation of Global RCA data and FVA data several steps need to be performed.

NOTE! Regarding analysis of supplier, the user needs to know the part number of the components the supplier is delivering. Thereby, it is only possible to have one source delivering the component.

NOTE! The user needs to know what projects the component/components have been involved in.

NOTE! The user needs to know how many mobile phones that have been sold in the involved projects. This amount is gathered from Customer Service department and is registered in the cell called *Total amount of sold mobile phones for the projects.*

1. Go to column F (Issue ID) and remove “-1”.
2. Go to column Q (RCA Main Fault Category) and select Supplier Elmeck.
4. Go to column C (Project) and select the projects the component/components have been involved in. Summarize the amount of mobile phones that have gone through an FVA for the involved projects. Register in *Amount of mobile phones checked in FVA in involved projects.*
5. Sort on the specific component/components and summarize the amount of faults discovered in FVA of the specific component/components. Go to column J (No of Connected Phones), mark the column and get the total amount of phones. The amount

regards the amount of faults analyzed in FVA connected to the project/projects. Register the amount in the cell called *Total amount of faulted components for projects FVA.*

7. Go back into the Global RCA and FVA excel sheet and remove all filters except for column F.

3. Go to column G (Real Fault) and select the part number/numbers you want to evaluate.

6. Go to column J (No of Connected Phones), the amount of connected phones are showed. Register this amount in the cell called *Amount of faults in RCA respectively FVA.*

## Gathering of reports

### First point of check

The 'IQC inspection report' is retrieved by the manager of Quality Controls at BMC. The report regarding Online-yield called 'Summary on EM monthly DPPM performance 2011' is retrieved by a Quality Control Engineer at BMC.

### Production

The report called 'Repair-percentage' is retrieved by the Senior of Quality Checks and the Manager of Product Management at BMC.

### After-sales

Regarding after-sales phase a new database is soon developed. For now the instructions are based on the RCA database. To start with, the user needs access to the RCA database.

1. Go to RCA-Reports.
2. Click on Line RCA.
3. Click on RCA review Report Status.
4. Click on RCA Review Report by Source.

A new window appears, which shows several alternatives to choose from.

6. Choose Platform and click "select all", Portfolio year and select the wanted year and Project click "select all".
7. Click at "View Report".
8. Click "Export to excel".