Supplier Selection Process Improvement through Six-Sigma DMAIC

“A case of Lafarge Pakistan Cement Limited”

Degree Project Advanced Level - Business Administration

15 ECTS Credits

Business Process and Supply Chain Management, 4FE02E, Spring 2010

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We dedicate this thesis in the honour of our parents who have been the source of inspiration and motivation all lifelong....
Acknowledgement

Working on this thesis provided us with the opportunity to explore our concepts profoundly as regard to supplier selection process. This work has extensively developed our understanding and allowed us to spread out on modern-day perspectives of the subject. We shall take this opportunity to show our gratitude for all those who helped us getting this task done in time.

First of all, we are reciprocally thankful to our families back home who have been the sources of continuous encouragement and support all the way long. Their paramount encouragement and confidence always pushed us to go one step further in doing this task brilliantly to meet our degree requirements. Second, we are greatly indebted to our tutor Petra Andersson who helped us a lot in the completion of this thesis and without her guidance we would not be able to write this thesis. Her critical judgement and review shaped this thesis up to the mark of being a quality manuscript. Third, we are particularly thankful to our opposition group for their valuable comments and suggestions on our script. They have been competently helpful and we owe them our sincere appreciation. Moreover, we also owe a favour to our examiner Åsa Gustavsson for her understanding and feedback throughout the seminars. Finally, we are single handedly thankful to each other in a group to stand committed and cooperative in completing our thesis.

Last but not the least; we are whole heartedly like to thank Mr. Attique Aslam (Head Supply Chain, LPCL) and Mr Naveed Ijaz (Plant Manager, LPCL) for their confidence encouragement throughout the entire thesis of ours. They have been supportive enough to in time provision of relevant data and information whenever we asked for. Their continuous review of the work helped us to secure scientific credibility of our thesis. Moreover, we are also obliged to thank purchasing managers at LPCL for their precious time.

Kamonmarn Jaenglom  Ahmed Nawaz Shaikh  Zaheer Tariq
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M. Rizwan ul Haque
____________________
Summary

Degree Project Advanced Level - Business Administration, Linnaeus Business School at Linnaeus University, Business Process and Supply Chain Management, 4FE02E, Spring 2010.

Authors: Muhammad Rizwan ul Haque, Ahmed Nawaz Shaikh, Kamonmarn Jaenglom, Zaheer Tariq

Tutor: Petra Andersson

Title: Supplier Selection Process Improvement through Six-Sigma DMAIC (A case of Lafarge Pakistan Cement Limited)

Background: Cement industry is considered to be an intensive supplier base industry. Cement manufacturing involves several types of suppliers ranging from general utilities to large plant equipments. Also, supply chain performance is significant topic in many cement organisations. The supply chain department at Lafarge Pakistan Cement Limited (LPCL) wants to inspect and improve their supplier selection process. The intended objective of this inspection is two folded. First, LPCL wants to develop a competitive supplier base out of bulk suppliers available in the market that would result in competitive advantage over its competitors. Second, they want to improve their supplier selection process so that there would be low variance and exclusion of unnecessary activities that would ultimately help in achieving the cost, quality and service enhancement objectives.

Research question:
How can the existing supplier selection process at Lafarge Pakistan Cement Limited (LPCL) be improved by applying Six-Sigma DMAIC?

Methodology:
This thesis is a descriptive case study and was conducted with a deductive approach. Data was collected through interviews, discussions and questionnaire. The scientific credibility of this thesis was secured by using many sources, avoidance of assumptions, studying a common process and following standardized steps of supplier selection.
Conclusion:
The existing process of supplier selection at LPCL was defined and mapped to understand the process characteristics and capabilities. The existing process was then analysed to identify problem areas, variations and unnecessary activities. Corrective actions were recommended to deal with problem areas and an improved supplier selection process for LPCL was suggested with process coordination and control measures.

Suggestions for future research:
Based on the findings of this thesis, we suggest that the further research for LPCL could be done in the area of sourcing and suppliers relationship management. Sourcing; a study could examine the sourcing policy at LPCL on purchasing practises of products. It would also be interesting to focus more on this area which leads to excellent cost reduction. Using scenario method could compare and analyse regional, national and worldwide sourcing. Supplier Relationship Management; a study could investigate supplier relationship management that leads to creating a competitive advantage for LPCL through the development of supplier performance monitoring and supplier development programme. More details could continuously move towards cost reduction, increased reliability and risk mitigation, transparency of supplier costs and quality, and enhanced efficiency of sourcing process.
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5.2 Measure: How does the process work?

5.3 Analyse: What are the problems?

5.4 Improve: What can be improved?

5.5 Control: How the processed is controlled?

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List of Abbreviation

C3A  Calcium Triode
DET  Ability of controls to prevent or detect
DP   Direct Purchase
DMAIC Define, Measure, Analyze, Improve, Control
EOI  Expression of Interest
ERP  Enterprise Resource Planning
ELIN Electronic Library Information Navigator
FMEA Failure Mode and Effect Analysis
ISM  Institute for Supply Management
JIT  Just in Time
LIT  Limited Invitation of Tender
LPCL Lafarge Pakistan Cement Limited
LOI  Letter of Intent
L/C  Letter of Credit
MBO  Management By Objectives
OCC  Frequency of occurrence
OCI  Orascom Construction Industries
OPC EN Ordinary Portland Cement (European Standard)
PO   Purchase Order
PR   Purchase Request
PAKCEM Pakistan Cement
RFI  Request for Information
RFQ  Request for Quotation
RPN  Risk Priority Number
SRC  Sulphate Resistant Cement
SAQ  Self-Assessment Questionnaire
SEV  Severity of effects
SS   Single Source
SPSS Statistical Package for the Social Science
TCO  Total Cost of Ownership
TE   Tender Enquiry
TQM  Total Quality Management
5W1H Why, What, Where, Who, When and How
1. Introduction

In this first chapter, reader will be introduced to the subject. The background will provide reader with an overview to subject area of this thesis. Further on the problem discussion will be presented which will then be translated into research question for this thesis. Finally, the objective of this thesis will be devised.

1.1 Background

A basic part of business management is the purchasing function which has the prime responsibility of supplier selection. This is valid for both types of business enterprises, manufacturing and service firms, and for the acquisition of all types of products and services, including major materials and equipment. In highly competitive global operating environment, it is impossible to produce low cost and high quality products successfully without competent suppliers. (Weber et al., 1991)

The selection of competent suppliers has long been regarded as one of the most important functions to be performed by a purchasing department. For example, in one of the earliest purchasing texts, Lewis (1943) stated that among all those responsibilities which belong to purchasing officer - selection of proper source is likely to be more important responsibility and in his views in some cases it is the most significant factor in purchasing.

The current competitive environment in global marketplace is continuously changing. To be successful in this uncertain environment, all the players in supply chain should respond quickly to the market demand. A supplier plays an important role in supply chain in term of production cost and product quality. Consequently, supplier selection becomes even more critical for most organisations to develop a closer and long term relationship with their supplier to build an effective supply chain. (Xiao Xia et al., 2008)

In current business environment, organisations are relying heavily on suppliers for products and services. With this increased dependence on suppliers and the growing complexity of products & services, an extended supply chain raises the importance of having an effective supplier selection process. With the millions of suppliers in the world, an effective supplier selection process is needed to gather intelligence on potential suppliers and select the best suppliers. When developing partnerships with suppliers and maintaining relationship with them, an effective supplier selection process is essential. This effective process helps
organisation improve process capability, improve delivery schedules, eliminate avoidable costs and improve overall efficiency. (Zeng et al., 2008)

According to Wu et al. (2008), supplier selection process is like **Figure 1**. Enterprises analyse market condition first. Then they ascertain supplier target that can be selected. Supplier selection guideline is made next. Enterprise evaluates and selects excellent supplier according to suppliers’ target and selection guideline. At last the supply chain cooperation is established between enterprise and supplier to actualise working relationship. The supplier’s evaluation and selection information can also feedback to market and resultantly by having this kind of feedback suppliers can improve their capabilities/abilities. In supplier selection process, enterprise must determine starting point of every step because every step is a dynamic procedure to improve the business.

![Figure 1: Supplier Selection Process (Wu et al., 2008)](image)

The purchasing function has been receiving increasing importance as a critical supply chain management component. This is mainly due to the significant impact of material costs on profits, increased investments in advanced manufacturing and information technologies, and a growing emphasis on Just-In-Time (JIT) production. The critical objectives of purchasing department include obtaining the product; at the right cost, in the right quantity, with the right
quality, at the right time and from the right source. So, executing effective decisions concerning supplier selection is single handily critical part of purchasing function. (Sarkis and Talluri, 2002)

Today, the uncertainty creates a drag on supply chain performance involving all processes. Thus, Six-Sigma has become useful methodology to improve the quality of all supply chain processes intended to cost reduction, improved resource utilization, and improved process efficiency (Wang et al., 2004). Conceptually, Six-Sigma is focused on variation reduction. If companies can understand and reduce variation in their processes, then they can implement improvement initiatives that will stabilise the process and ensure accuracy and reliability according to the expectations (Goldsby and Martichenko, 2005).

1.2 Problem Discussion
Cement industry is considered as an intensive supplier based industry. Cement manufacturing involves several types of suppliers ranging from general utilities to large plant equipments. Supply chain performance is also a significant topic in many cement organisations. The supply chain department at Lafarge Pakistan Cement Limited (LPCL) wants to inspect and improve their supplier selection process. The intended objective of this inspection is two folded. First, LPCL wants to develop a competitive supplier base out of bulk suppliers available in the market that will result in competitive advantage over its competitors. Second, they want to improve their supplier selection process so that there would be low variance and exclusion of unnecessary activities which will ultimately help in achieving the cost, quality and service enhancement objectives.

An effective supplier selection process assures the success of organisation in a highly competitive environment. To upgrade their supply chain performance and competitiveness, organisations are seeking the ways to deal with suppliers. Supplier selection and relationship strategies have become part of a well-managed supply chain and affect the competitiveness of the entire supply chain. Hence, the supplier selection has become a very important matter for effective supply chain functions of any organisation. (Xiao Xia et al., 2008)

Six-Sigma DMAIC methods can improve supplier selection process by identifying weak areas, take corrective actions and improve continuously. This methodology is very helpful to
improve the supplier selection process in order to have competitive advantage. Moreover, applying DMAIC methods to supplier selection process is one way to improve supplier base as regard to quality, cost and service function. It will be more effective if organisations spread Six-Sigma DMAIC methods throughout supply chain functions that have a direct upshot on organisation’s performance. (Coronado and Antony, 2002)

1.3 Research Question
After the problem discussion and motivation of carrying out this inspection initiative, research question for this thesis is devised as;

“How can the existing supplier selection process at Lafarge Pakistan Cement Limited (LPCL) be improved by applying Six-Sigma DMAIC?”

1.4 Purpose
The purpose of this thesis is to study and evaluate the supplier selection process at LPCL, and give suggestions for improvements to develop a competitive supplier base in order to get competitive advantage in the long run. Process improvement objectives of LPCL are matching to the rationale of Six-Sigma DMAIC process improvement methods. So, the LPCL supplier selection process improvement by applying Six-Sigma DMAIC methods is set to be the objective of carrying out this thesis.

1.5 Thesis Disposition
Figure 2 below shows the disposition of this thesis;
### 1.6 Time Schedule

*Figure 3* below shows the time schedule to carry out this thesis;

<table>
<thead>
<tr>
<th>TASK</th>
<th>WEEK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>11</td>
</tr>
<tr>
<td>Methodology</td>
<td>12</td>
</tr>
<tr>
<td>Theoretical</td>
<td>13</td>
</tr>
<tr>
<td>Framework</td>
<td>14</td>
</tr>
<tr>
<td>Empirics</td>
<td>15</td>
</tr>
<tr>
<td>Empirical Analysis</td>
<td>16</td>
</tr>
<tr>
<td>Conclusion</td>
<td>17</td>
</tr>
</tbody>
</table>

**Figure 3: Time Schedule of Thesis**
2. Methodology

In this chapter, methodological choices for this research will be presented and motivated. The research strategy will be discussed. The scientific perspective, approach and method for thesis will be discussed in details. Further on the data collection methodologies will be presented and finally the scientific credibility of thesis will be discussed in details.

According to Jonker and Pennink (2010), methodology is, broadly speaking, the way in which a researcher conducts research. The researcher has to consider the way in which he is going to organise and establish his overall research approach, by choosing how he wishes to conduct the research. The researcher may decide to create a questionnaire and send it to people in the organisation. He can also opt to work in the organisation in order to be able to observe the organisation as he collects data. The method he selects depends both on the nature of the question, and on the view of what he considers to be a good research.

There are two clear categories as suggested by Jonker and Pennink (2010):

- The first researcher conducts research in the organisation by means of a well defined research question. This question often appears to have a closed character. This form of research is characterized by research activities that are accomplished in a definite order of rank.

- The second researcher conducts research ‘with’ the organisation, often based on an open question. What needs to be examined exactly, let alone how it should be done, is not determined in advance. The most important element of research based on an open question is the ‘search behaviour’ of the researcher. Research questions are used as ‘road signs’ leading from one place to the next.

2.1 Research Strategy: Case Study

According to Yin (2003), the case study method has a distinct advantage in situations when a "how" or "why" question is being asked about a contemporary set of events, over which the investigator has little or no control and when the focus is on contemporary phenomenon within some real-life context.
Case studies are found even in economics, in which the structure of a given industry may be investigated by using the case study method. The case study, like other research strategies, is a way of investigating an empirical topic by following a set of pre-specified procedures (Yin, 2003).

**Case Study of Thesis**

In today’s highly competitive environment, an effective supplier selection process is very important. Under this situation, LPCL wants to improve quality of its supplier selection process to develop a competitive supplier base in order to achieve continuous improvement and service enhancement of supply chain department at LPCL.

This thesis contains interviews with different people from different position concerning supplier selection process at LPCL. The case study method is a way to investigate supplier selection process to understand the current process in depth. Further, the thesis figure out how to deal with problems in this process and provide process improvements that company needs to follow.

**2.2 Scientific Perspective: Positivistic**

In view of Thomas (2004), there are two major orientations in scientific perspective; positivism and hermeneutics. However, there are several key differences in main idea within each orientation. According to Jonker and Pennink (2010), a specific research methodology explains the behaviour of the researcher. Therefore, the affinity will be determined in drawing up a research.

The Positivism approach is commonly used in science. The researchers express relationship between elements or variables, and then relate them to theory (Neville, 2005). This approach is aimed to build general theories and provide solution in practice. Researchers deal with problems by following three steps; diagnose a clear problem definition, design the solution and implement the solution (Thomas, 2004). Practically, the result of development and implementation come with numerous techniques. The researchers attribute these tools and techniques during implementation approach and lead the project in a methodologically correct way for specific situation (Jonker and Pennink, 2010).
Chapter 2: Methodology

The Hermeneutics approach, according to Neville (2005), intends to understand human behaviour; however, it is not easy to generalise in the natural sciences regarding to inner thought processes. In this perspective, researcher places his/her own thought on events and perform action in unpredictable ways. According to the human stage, there are a wide range of variables. This approach relates to the understanding behaviour from the participants reference and tries to describe and explain events from behaviour.

**Scientific Perspective of Thesis**

This thesis has mainly a positivism approach by using general theories such as Six-Sigma DMAIC for supplier selection process at LPCL. The information used was collected from interviews and historical/current data from LPCL. Further, this thesis analyses the current supplier selection process with the application of Six-Sigma DMAIC methods for ultimately achieving process improvement objectives.

**2.3 Scientific Approach: Deductive**

There are two aspects of scientific research, one is deduction method and the other is induction method (Perry and Jensen, 2001). Inductive and deductive methods are more or less presumed as learning style issue (Grumbine et al., 2005).

Deductive approach can be used in a systematic way on the basis of established ideas (Neville, 2005). Generally deductive method is used by researchers who want to have general principles identified and try to get the results out of them (Grumbine et al., 2005). The deduction method prevails in marketing research (Perry and Jensen, 2001). Pre-existing frameworks to the data are involved in deductive methods (Fook, 2002).

Induction method is also used in qualitative data analysis (Thomas, 2003). The involvement of induction method is used to develop a theory form the data. For qualitative research inductive approach is commonly used, but it is suggested to use both types (Fook, 2002). If researcher wants to have a fresh way of looking at the subject in terms of reward he might use inductive approach (Neville, 2005). For management and sociology research, induction method is widely used (Perry and Jensen, 2001).
The following **Figure 4** summarises difference between the two scientific approaches;

<table>
<thead>
<tr>
<th>Deductive</th>
<th>Inductive</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Theory</td>
<td>• Observation</td>
</tr>
<tr>
<td></td>
<td>• Hypothesis</td>
</tr>
<tr>
<td></td>
<td>• Observation</td>
</tr>
<tr>
<td></td>
<td>• Rejection/Confirmation</td>
</tr>
<tr>
<td></td>
<td>• Pattern</td>
</tr>
<tr>
<td></td>
<td>• Tentative Hypothesis</td>
</tr>
<tr>
<td></td>
<td>• Theory</td>
</tr>
</tbody>
</table>

**Figure 4: Difference between Scientific Approaches (Skinner, 2010)**

**Scientific Approach of Thesis**

Deductive approach is used for our thesis because it is a theory based research leading towards the findings. It is a “top-down” approach and the theory part will support the findings that we will conclude in the end. Definitely our findings will suggest LPCL a new way to look at the supplier selection process. Empirical studies were done in collaboration with the staff of supply chain department at LPCL Plant “Kallar Kahar” and LPCL Head Office “Islamabad”, Pakistan.

**2.4 Scientific Method: Qualitative**

As cited by Sogunro (2001), a quantitative research can be defined as “an inquiry into a social or human problem, based on testing a theory composed of variables, measured with numbers, and analysed with statistical procedures, in order to determine whether the predictive generalisations of the theory hold true” and a qualitative research as “an inquiry process of understanding a social or human problem, based on building a complex, holistic picture, formed with words, reporting detailed views of informants, and conducted in a natural setting”.

In a very simplistic form, Punch (1998) noted quantitative research as, “an empirical research where the data are in the form of numbers” and qualitative research as, “an empirical
research”. Table 1 represents differing characteristics summary of both research methods, as garnered from the literature (Sogunro, 2001).

<table>
<thead>
<tr>
<th>Factor</th>
<th>Qualitative</th>
<th>Quantitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Collected</td>
<td>Soft data</td>
<td>Hard data</td>
</tr>
<tr>
<td>Data Collection Techniques</td>
<td>Active interaction with sample population (Observation by active participation)</td>
<td>Passive interaction through questionnaire and/or experimental design</td>
</tr>
<tr>
<td>Sample Population</td>
<td>Small population</td>
<td>Large population</td>
</tr>
<tr>
<td>Research Variables</td>
<td>Large number</td>
<td>Small number</td>
</tr>
<tr>
<td>Data Collection</td>
<td>On-going observation and interview</td>
<td>Before and after training or experiment</td>
</tr>
<tr>
<td>Relationship</td>
<td>Intense and long term Subjects</td>
<td>Distant and short term</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>Content/interpretive analysis through themes, patterns, and narrative synthesis, using coding and descriptive statistics, including ranking, frequency, percentages, etc.</td>
<td>Statistical analyses (e.g., descriptive, inferential statistics) using specific procedures, such as the Statistical Package for the Social Science (SPSS)</td>
</tr>
<tr>
<td>Research Context</td>
<td>Uncontrolled</td>
<td>Controlled</td>
</tr>
<tr>
<td>Research Findings</td>
<td>Inductive through creativity and critical reflection</td>
<td>Deductive through inferences from data</td>
</tr>
<tr>
<td>Research Instruments/Tools</td>
<td>Researcher as instrument, interview guide, computer, type writer, etc.</td>
<td>Questionnaires, computer, calculator, etc.</td>
</tr>
<tr>
<td>Interpretation of Results</td>
<td>Subjective/Nature of Inquiry</td>
<td>Objective, Interpretive, Positivism</td>
</tr>
<tr>
<td>Research Tradition</td>
<td>Hermeneutics, case studies, etc.</td>
<td>Descriptive, co-relational, experimental, etc.</td>
</tr>
</tbody>
</table>

Table 1: Differing Characteristics of Qualitative and Quantitative Research Methods (Sogunro, 2001)
Scientific Method of Thesis

In this thesis, the qualitative research method is used in order to understand the current process in depth. For example, the approach was to investigate the current supplier selection process at LPCL and suggest improvements after identifying the variations, unnecessary activities and problems. The information was collected from interviews. The thesis will be expected to clarify the LPCL’s current supplier selection process about what kind of problems there are in the current process; furthermore, create an improved process map in order to continuous improvement and service enhancement objectives at LPCL.

2.5 Data Collection: Primary and Secondary

Two major types of data have dominated debate in methodology research i.e., primary data and secondary data. The primary data is facts and information collected by researchers for specific purpose (Rabianski, 2003). The methods for primary data involve interviews, observation and questionnaire. Interview techniques can be used in different forms such as personal direct contact, phone, e-mail or other communication media. The interviews consist of three main types: structured interviews, semi-structured interviews and unstructured interviews. Structured Interviews are the use of questions based on specific set of queries read out by a researcher. For Semi-structured interviews, the interviewer will have a list of some standardised questions but the interviewer may add or omit some questions depending on the situation. Unstructured interviews are informal discussions. The researcher will have a range of topics to handle the discussion. (Neville, 2005)

The process of observation is the way of gathering data by researcher and sharing the experiences in any situation. The observers will see a true fact while being observed. Observation takes place at the same place and same time when the action occurs. During the observation, the observer risks loss of information concerning to forgetfulness, disorganisation, or mismanagement of the facts. The questioning process can provide information through the set of question. However, the collected information might be inaccurate due to misunderstood question and fabricated answer. Primary data can lead to error or less accuracy, therefore secondary data is considered for more accurate information. (Rabianski, 2003)
Secondary data is the facts and information from secondary source including published and unpublished work based on research of primary data (Rabianski, 2003). The greater use of secondary data is freely available without limitation. Everyone can access to data and get benefit from the shared research data. The researcher may add value by analysis of impartial secondary source. Secondary data can be found in all written material such as books, articles, and reports. However, the researchers commonly use more than one sources; primary data and secondary data, to arise their knowledge of the subject. (Nicholson and Bennett, 2009)

**Data collection of this thesis**

In this thesis, both primary and secondary data were collected. The primary data was gathered through interviews and discussions. The process of interviews was principally semi-structured interviews to gain a wider answer about the topic. The interviews were mostly held by video conferencing and e-mail contact, to picture current supplier selection process at LPCL. *Table 2* shows the schedule of interview and discussion sessions;

<table>
<thead>
<tr>
<th>Name</th>
<th>Designation</th>
<th>Mode</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Attique Aslam</td>
<td>Head Supply Chain</td>
<td>Video Conferencing</td>
<td>2010-04-13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video Conferencing</td>
<td>2010-05-13</td>
</tr>
<tr>
<td>Mr. Naveed Ijaz</td>
<td>Plant Manager</td>
<td>Video Conferencing/ Email</td>
<td>2010-04-15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Questionnaire</td>
<td></td>
</tr>
<tr>
<td>Mr. Imran Burney</td>
<td>Purchasing Manager (HO)</td>
<td>Video Conferencing/ Email</td>
<td>2010-04-26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Questionnaire</td>
<td></td>
</tr>
<tr>
<td>Mr. Naveed Azfar</td>
<td>Purchasing Manager (Plant)</td>
<td>Video Conferencing/ Email</td>
<td>2010-04-28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Questionnaire</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video Conferencing</td>
<td>2010-05-04</td>
</tr>
</tbody>
</table>

*Table 2: Interview/Discussion Schedule*

The secondary data were collected from literature and scientific articles. The search engines such as ELIN, Emerald, and Business Source Premier were used to find scholarly articles and reliable information. The words as supplier selection, supplier evaluation, DMAIC process, Six-Sigma, and supply chain management were used to find relevant information and articles.
2.6 Scientific Credibility

Bocking (2004) defined scientific credibility as the range of science related to reliable information source of the world. Adams et al. (2007) identified three general criteria’s for testing and evaluating variable measurements that also assess data quality and overall precision of study results. These three criteria’s are reliability, validity and generalisation. These are considered to be very important, both in qualitative and quantitative research. These three criteria’s are commonly found in quantitative research as the findings of actual reality can be generalised. However qualitative research includes theoretical complexity and methodological rigidity therefore findings are difficult to generalise.

2.6.1 Validity and Reliability

Validity is an actual strength of our conclusions that relates the extent of our results’ truthfulness and accuracy. Every type of validity emphasises a different aspect of relationship between treatment and observed outcome. Three different kinds of validity can be considered that are construct validity, internal validity and external validity (Adams et al., 2007). These three types of validities can be defined as follows:

1. **Construct Validity:** Makes sure that objective judgments are to be made and there must be correct operational measures that eliminate subjective judgement when researchers are collecting data. (Yin, 2003)

2. **Internal Validity:** Deals with the probability that dependent variable can only be influenced with changes of the independent variable and researchers draw a right casual relationship between the programme and conclusion. (Adams et al., 2007)

3. **External Validity:** deals with the development of such domain on which researchers finding can be generalised (Yin, 2003).

Reliability provides measurement consistency or in other words it is the extent to which an instrument provides the same result each time under the same conditions with the same subjects. If researchers measure something several times and the obtained result is always the same then the output of the measurement process is reproducible without any erratic results and it is reliable. (Adams et al., 2007)
Thesis Validity and Reliability

Real world settings and human experiences are involved in our research which makes our work more qualitative oriented. The thesis has quite high validity and for construct validity we conducted detailed video conferencing interviews of all the staff involved. Moreover work was continuously reviewed by Mr. Attique Aslam (LPCL, SCM Head). Literature argued that personal perceptions affect the validity. Therefore to avoid this, we also had informal group discussion with Mr. Attique Aslam (LPCL, SCM Head) in which we had good arguments and reasoning.

Participating interviewees had extensive working experience in their respective fields and we conducted interviews by selecting the right people to have a clear and in-depth knowledge of ongoing process (that helped in comparing the different views). Therefore, interviewee’s in-depth practical knowledge with right selection of theory ensures internal validity. This work might not be generalised with respect to cement industry of Pakistan as it is specifically for LPCL and cement companies differs in their supplier section process that gives low external validity. To ensure high reliability all group members participated in conducting the interviews. Right questions were designed based on the relevant theory. Interviews were conducted in a clear and simple way to avoid any kind of misunderstandings. Therefore thesis reliability heightens with the usage of well known theory and use of reliable instruments for data collection.

<table>
<thead>
<tr>
<th>Construct Validity</th>
<th>Internal Validity</th>
<th>External Validity</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video conferencing interview sessions with the interviewees</td>
<td>Interviews of the people directly involved in the supplier selection process</td>
<td>Specifically for LPCL</td>
<td>Full participation of authors</td>
</tr>
<tr>
<td>Continuous supervision and review both by LPCL and tutor</td>
<td>Strong interviewee profile and right selection of theory for extensive focus on problem area</td>
<td>Cement manufacturing enterprises differ in their supplier selection process, so generalisation of this work to cement industry of Pakistan is not valid</td>
<td>Questionnaire designed based on relevant theory in a clear and simple way</td>
</tr>
<tr>
<td>Informal discussions sessions with Mr. Attique Aslam (Head Supply Chain, LPCL), to avoid personal opinions</td>
<td></td>
<td></td>
<td>Supervised data collection for real case insight</td>
</tr>
</tbody>
</table>

Figure 5: Scientific Credibility of Thesis
2.7 Summary
The following Figure 6 summarises the research methodology of thesis;

![Figure 6: Summary of Research Methodology](image)
Chapter 3: Company Description

3. Company Description

This chapter includes the company presentation. The organisation’s operations will be discussed. Company’s mission, vision, milestones and products will be presented. Finally, the organisational chart of supply chain department will be presented. The information presented in this chaptered is gathered directly from LPCL and its web-site.

3.1 Company Presentation

Lafarge Pakistan Cement Limited (LPCL) is a part of Lafarge, world leader of construction materials. The state-of-the-art plant commenced Commercial Operations in December 2006 with an annual cement production capacity of 2.5m tons, thus becoming the largest production line in Pakistan. LPCL is proud of its product PAKCEM which is the leader on all quality scales. PAKCEM is the first cement in Pakistan to comply with European Standards (EN 197) and Indian Standards (IS 12269) also far exceeding requirements of Pakistani Standard (PS 232). LPCL’s aim of being at the forefront in creating foundations for a prosperous tomorrow is backed by the Company’s philosophy of providing outstanding value to its customers, a safe and stimulating work environment for its employees, superior returns for its shareholders and special focus on social responsibility and environmental protection.

Lafarge Pakistan Cement Limited (LPCL) is a subsidiary of Lafarge, world leader of building materials with its corporate headquarter in Paris, France. Lafarge is world leader in Cement and Aggregates, and number three in Concrete and Gypsum. Lafarge extracts resources from the heart of the earth to make materials to bring to the heart of life. Present in 78 countries, the Group responds to the world's demand for housing and infrastructure. Lafarge is driven by the needs of its customers, shareholders, local communities and architects. The Group creates high value-added solutions which encourage creativity whilst leaving a lighter trace on the world. Lafarge believes that ongoing advances in building materials must integrate respect for people, their different needs and their environment. This strong conviction is reflected in a strategy which combine industrial know-how with performance, value creation, respect for employees and local cultures, environmental protection and conversation of natural resources and energy.
**3.2 Vision**
Strive to exceed the expectations of our stakeholders through sustainable growth and high quality performance.

**3.3 Mission**
We are committed to providing outstanding value to our customers, a safe and stimulating work environment for our employees and superior returns for our shareholders.

**3.4 Milestones**
*Table 3* presents the milestones achieved by LPCL:

<table>
<thead>
<tr>
<th>Milestones</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCI Acquisition</td>
<td>March 2005</td>
</tr>
<tr>
<td>Financial Close</td>
<td>June 17, 2005</td>
</tr>
<tr>
<td>Trial Production</td>
<td>July 18, 2006</td>
</tr>
<tr>
<td>First Dispatch</td>
<td>August 28, 2006</td>
</tr>
<tr>
<td>Commencement of Commercial Operations</td>
<td>December 18, 2006</td>
</tr>
<tr>
<td>Lafarge Acquisition (Transfer of Orascom's shares to Lafarge)</td>
<td>January 23, 2008</td>
</tr>
</tbody>
</table>

*Table 3: LPCL Milestones*

**3.5 Products**
LPCL produces two major types of products. The characteristics of these two are presented below;

**3.5.1 Ordinary Portland Cement**
Ordinary Portland Cement is produced by pulverising clinker consisting essentially of hydraulic calcium silicate and containing one or more forms of Calcium Sulphate as an inter ground addition.

**Typical Analysis and Physical Properties**
The listed tests below are typical and for information only. Analytical details of the product should be sought in writing from the Lafarge Cement, Pakistan.
Application
The product has been designed to give enhanced concrete properties in the fresh “wet” state with adequate high early strength levels upon setting and hardening.

Assured Compliance With

<table>
<thead>
<tr>
<th>European Standard</th>
<th>OPC EN 197-1 CEM I 52.5 R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian Standard</td>
<td>IS 12269 Grade 53</td>
</tr>
<tr>
<td>Pakistani Standard</td>
<td>PS 232/1983(R)</td>
</tr>
</tbody>
</table>

3.5.2 Sulphate Resistant Cement
Sulphate Resistant Cement is a dark colour Portland cement manufactured from clinker of low C3A content and undergoes grinding with a reduced proportion of Gypsum than Ordinary Portland Cement.

Typical Analysis and Physical Properties
The tests results below are typical and for information only. Analytical details of the product should be sought in writing from the Pakistan Cement Company.

Application
Use in concrete exposed to severe Sulphate action where soil or ground water have high Sulphate content.

Assured Compliance With

<table>
<thead>
<tr>
<th>European Standard</th>
<th>OPC EN 197-1 CEM I 42.5 N</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Standard</td>
<td>SRC 42.5 N BS 4027-1996</td>
</tr>
<tr>
<td>Pakistani Standard</td>
<td>SRC PS 612(R)</td>
</tr>
</tbody>
</table>
3.6 Supply Chain: Organisational Chart

Following is the organisational chart of supply chain department at LPCL:

![Organisational Chart](image-url)

Figure 7: Organisational Chart (Supply Chain, LPCL)
Chapter 4: Theoretical Framework

4. Theoretical Framework

This chapter will present theoretical references to this thesis. Initially, some reference literature about importance of supplier selection process will be presented. Further, literature references to Six-Sigma DMAIC application will be presented. This chapter will follow the structure of DMAIC model to relate its application to LPCL in the later chapters.

4.1 Supplier selection and its importance

Era of 21st century brought rapidly changing market demands and fierce global competition for manufacturing industries. Raw materials and component parts can cost up to 70% of the product cost whereas customers are demanding more products with high quality, low cost and short lead time. With this kind of state of affairs, importance of appropriate supplier selection is on the rise for manufacturers. Selecting a right supplier (having variety of competency levels) from multiple available sources is a significant task and it is a multi-criteria decision making problem (Fangqi et al., 2009).

The contemporary competition in the business world is not only the competition between companies but also the competition between supply chains. In order to improve the competitiveness of whole supply chain, companies should be very cautious when selecting suppliers. So, the research on supplier selection has always been in focus. Supplier selection is considered as an increasing critical issue of a supply chain for the success of an organisation and supplier selection process is represented as competitive strategy (Saen, 2009). In support of this Heinritz et al. (1991) argued that companies having a competitive supplier base, leads to cost-reduction possibilities, better sources for their products input and also can have collaborative planning.

In views of Mitchell (1998) initially price factor was the primary factor of supplier selection however recently companies not only consider the price factor but also select suppliers based on their capabilities/abilities with mutually (win/win) beneficial relationship. By having a supplier who offers the cheapest price does not guarantee of having a best product/service and mutually beneficial relationship. Moreover supplier selection process should be simple and there must not be any personal biasness in selecting the suppliers because whenever clients (buyer) have a strong mutual benefit with specific suppliers (with the influence of personal biasness) then errors can occur in selecting a right supplier.
Fangqi et al. (2009) explained the supplier selection process into three main stages; supplier search, feedback and negotiation adjustment.

- **Stage 1:** Analyse market condition and search right supplier to undertake.
- **Stage 2:** Gather response from supplier and evaluate supplier.
- **Stage 3:** Negotiate the criteria values of supplier and select final choice.

Monczka et al. (2009) mentioned that companies having a competitive supplier base can lead to long term relationship with suppliers. And resultantly a mechanism of long term supplier relationship management helps companies in monitoring their processes which ensures performance improvement through the strategy in term of cost, quality, delivery and time. They also suggested that process model should be clearly defined and transactions efficiency in process is generated by the suit of communication tools.

Wade (2007) presented supplier relationship management strategy in his research. He suggested that two parts are considered important in it that is supplier connectivity and their enablement with the company strategy. These two factors play an important role in e-procurement as it can guide employees in selecting the supplier and reduce costs of sending purchase orders and other messages to and from suppliers. The new channels for suppliers’ connectivity and their enablement are supplier networks and direct connections with them.
Although these have costs but it automates both buyer and supplier order process, resultantly reduce the cycle time and enhance accuracy. The following Figure 9 shows the supplier connectivity and enablement phenomenon;

![Figure 9: Suppliers Connectivity and enablement with company (Source: Wade, 2007)](image)

In a case study of “Allstate” presented in the proceedings of ISM Conference, 2002 (Institute for Supply Management Conference) a great emphasise is given for supplier relationship management. By having a successful relationship management with suppliers, companies can yield true values of strategic sourcing, demand management and operating efficiency (processing efficiency).

Supplier relationship management journey involves suppliers’ segmentation. Segmentation is essential in order to identify the gaps, allocation of resources and for appropriate action identification. Basic, Valued, Preferred and Strategic suppliers can be categorised under supplier segmentation. One of the examples mentioned in this case study is supplier segmentation according to general attributes that includes planning horizon, relationship mode and level of involvement. (Yelvington, 2002)
Chapter 4: Theoretical Framework

<table>
<thead>
<tr>
<th>Planning Horizon</th>
<th>Basic</th>
<th>Valued</th>
<th>Preferred</th>
<th>Strategic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current deal; singular operation</td>
<td>Ongoing multiple exchanges; near term planning</td>
<td>Specified endpoint; some joint strategic planning</td>
<td>Unspec. endpoint; ongoing intent to co-create value</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relationship Mode of Operation</th>
<th>Competitive bid</th>
<th>Performance incentives</th>
<th>Continuous improvement</th>
<th>Experimentation and learning, collaboration</th>
</tr>
</thead>
</table>

| Management Cost / Level of Involvement | Low – staff members | Intermediate – leadership level management | High – executive leadership | High – Sr. executive leadership |

Figure 10: Supplier segmentation based on general attributes (Source: Yelvington, 2002)

Verdecho et al. (2009) discussed about supplier selection criterions and mentioned in his paper that both tangible and intangible criterions should be considered in ranking and evaluating the potential suppliers. Though generally quantitative performance data is considered helpful but other unquantifiable data (e.g. trust, commitment and market reputation) are also essential for successful business.

Figure 11 below is the theoretical model developed for theoretical chapter which represents the relation between research question and theory presented.
4.2 Six-Sigma – DMAIC

DMAIC model has been developed within Six-Sigma. DMAIC stands for Define, Measure, Analyse, Improve and Control. It is a five steps procedure to improve process performance. This model can be applied to both sub-processes requiring small changes or the whole process makeover. (Krajewski et al., 2007)

Conceptually, the DMAIC cycle was developed by General Electric. The cycle is an advanced process of PDCA cycle: Plan, Do, Check, and Act. The DMAIC process is described as (Chase et al., 2004):

- **Define:** Investigate the point of view of supplier and customers.
  - Identify the customers and their requirements
  - Identify the critical factors that have the most impact on supply chain performance

- **Measure:** Measure current process.
  - Measure and validate the current processes
  - Identify the factors that influence on processes and measure the defects relative to those processes

- **Analyse:** Analyse contributors to poor performance and variation.
  - Determine the critical causes of defects
  - Identify the key variable to understand defects that cause process variation

- **Improve:** Define, test and validate the improvements.
  - Remove the causes of defects
  - Modify the existing process to provide a better performance

- **Control:** Ensure that changes are successful.
  - Ensure the success keys working through the modified process
  - Determine the processes maintain continuous improvement
Chapter 4: Theoretical Framework

4.3 Define
In Six-Sigma DMAIC implementation, define phase is to identify a complete description of the issue. The historical data and experiences are gathered to investigate problem (Jalali et al., 2008). In the define phase, the question “What is important” is addressed to identify the goal and scope of process. (Islam, 2006)

This phase determines the characteristics of process’s output that are critical to customer requirements. This is done by identifying process characteristics and capabilities gaps. The identified gaps become improvement targets later on. (Krajewski et al., 2007)

Many different processes build up a company. The possibility of achieving satisfying results is directly related to identification of right process with right characteristics. To achieve the improvement objectives, knowledge of process characteristics is of utmost importance. (Tang, 2007)

4.4 Measure
There are some questions which we can put in the measure phase like; if you want to know how the current process is practiced today. It is necessary that you measure your current process in a way which leads you to measure the improvement in a process as well. If you are not willing to measure the improvement you can bear some possible negative effects in the end. (Koanit, 2003)

Selected Tool: Process mapping is the tool used for the measure stage which is elaborated below.

4.4.1 Process Mapping: Purpose
To understand or improve the process, process mapping is considered at the early stages. If we want a dynamic model, we can do it by putting the activities in the picture which can be constructed through the gathered information. This communication tool is very much helpful to understand the process and helps to find the opportunities for improvement. (Department of Trade & Industry: DTI, n.d)
The common advantages of process mapping are common framework, discipline, language and systematic way of working. Process mapping always helps to present the complex interactions in a logical, visible and in an objective way. This common decision making framework helps teams to improve the judgment criteria about the issues which exist within the process. (DTI, n.d)

Steps to be considered while constructing a process map are following: (DTI, n.d)

- Consider all the routine activities which are performed within the scope of the process.
- Construct the activities into 4-6 main sub-processes.
- Sequence of events should be identified and join them between these sub processes.
- Visualise high level process maps and sub-process maps using different tools.

### 4.4.2 Process Mapping: Flowcharting

According to Campbell (2004), Processes can be graphically represented through flowcharts. Flowchart is a pictorial representation of the steps within the process. There are number of things which can be handled through flowchart other than the pictorial representation; like

1. The steps can be simplified within the process by using flowchart.
2. Flowchart can help employees to communicate processes.
3. By using flowchart unnecessary steps can be eliminated within the process.
4. It is a roadmap for process improvement.

Understanding the steps involved in each of the process is difficult for the companies sometimes. Companies should visualise the processes for the better understanding of their employees and make sure that everything is included. (Campbell, 2004)

Flowchart is also known as flow diagram. It is a logical flow of activities within the process from the start till the end. The starting and ending points should be considered when drawing the process flow diagram. It would help the reader to understand the steps easily. (Islam, 2006)
Flowcharting can help in understanding the basic concepts behind its methodology. Technical experts sometimes use this shared language to deal with simple and complex processes. (Nash and Poling, 2009)

It is a matter of having the easiest way to draw an accurate and self explanatory map so that all employees can understand it which sometimes becomes a challenge for them. If we talk about accuracy, time limit may exceed up to weeks to get it accurate. It is more or less a challenging job as well but people used to call it curse when time limit exceeds more than weeks. Finally, it should be presented in the logical flow of product or service (Nash and Poling, 2009). Norman and Kehoe (1997) defined flowchart in detail and suggested the process of developing a flowchart as below;

- **Identify the process:** For the process flowchart start point and end point should be identified earlier.
- **Describe the current process:** Draw the complete process which is followed currently. (i.e., lay out all the steps). There are symbols which can help to draw the process that are specified later on.
- **Search for improvement opportunities:** There may be some steps which are unnecessary or have little or no value in the process, try to answer why these steps exist in the process and which new steps should be added in the process.
- **Update your chart:** Update your new flowchart by finding the solution of the problems you have identified in the previous chart.

*Figure 12* shows the process flowcharting symbols;

![Process Flowcharting Symbols](image-url)
4.5 Analyse

Goldsby and Martichenko (2005) explained Six-Sigma and suggested that Six-Sigma DMAIC concept provides a wealth of methods and tools that assist in problem solving. Where as its main objective is to align the problem leading to analysis and solution. After having a clear statement of the problem and proper identification of its measurement, the DMAIC process moves forward with the “Analyse” step.

According to Pyzdek (2003), this stage involves two different steps:

1. **Divergent thinking:** Considering the maximum possible solutions.
2. **Convergent thinking:** Can help to identify the best solution.

For divergent thinking 5W2H can help to obtain maximum possible solutions through brainstorming and for convergent thinking cause and effect diagram is opted to come up with the best possible solution.

In the Analyse phase of Six-Sigma DMAIC methodology, quantifying the existing process helps to determine how best process improvement goals can be achieved. Pyzdek (2003) and Brassard *et al.* (2002) suggested there are many tools and techniques that can be used in this phase, which may include the following:

- Run charts
- Descriptive statistical analysis
- Exploratory data analysis
- Cause & Effect
- Design of Experiments
- Analytic data analysis
- Process capability analysis
- Process yield analysis
- Scatter plots
In views of Pyzdek and Keller (2010), at this stage the system is analysed in order to identify those ways that can eliminate the gap between the system’s ongoing performance and the desired goal. They suggested that following could be the key objectives of the Analyse phase:

- Identification and elimination of gap between the current and desired performance.
- Analyse the factors of variations that lead to performance gap.
- Determine those drivers that relate to the customer requirements in terms of Quality, Cost, and Schedules and have significant influence on the process.

**Selected Tools:** 5W2H and Cause and Effect diagram are the tools that are selected for the Analyse stage which are elaborated below.

### 4.5.1 5W2H

Brainstorming generates various ideas that put forward many different business problems or solutions to explore further. The purpose of the 5Ws and 2Hs method is to investigate a process or problem to gain the improvement ideas and it can help to identify the overlooked issues or causes. 5W2H is the acronym of Why, What, Where, Who, When, How and How much. 5W2H works as facilitator in completing the cause-and-effect diagram. (The UK Office of Government Commerce, 2006)

<table>
<thead>
<tr>
<th>Issue</th>
<th>5W2H Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Why: What do we use rail travel?</td>
</tr>
<tr>
<td>Activity</td>
<td>What: What are the activities involved in booking travel?</td>
</tr>
<tr>
<td>Place</td>
<td>Where: Are people doing whilst they travel?</td>
</tr>
<tr>
<td>Staff</td>
<td>Who: Who is travelling and who books the tickets?</td>
</tr>
<tr>
<td>Time</td>
<td>When: When are the rail journeys booked?</td>
</tr>
<tr>
<td>Method</td>
<td>How: How at what time are people travelling?</td>
</tr>
<tr>
<td>Cost</td>
<td>How much: What is the cost of rail travel?</td>
</tr>
</tbody>
</table>

*Figure 13: 5W2H (The UK Office of Government Commerce, 2006)*

Changqing et al. (2005) argued in their paper that the problem can be scrutinised systematically with the help of 5W1H based on 6 aspects, which are Why, What, Who, When, Where and How. 5W2H is the improved concept of 5W1H in which ‘How’ is divided into ‘How to’ and ‘How much’. In their views ‘How to’ is a way to resolve the problem and
‘How much’ is to what extent the problem can be resolved. The authors provided the meanings of 5W2H in the following Table 4.

<table>
<thead>
<tr>
<th>Problem</th>
<th>What</th>
<th>Who</th>
<th>When</th>
<th>Where</th>
<th>Why</th>
<th>How to</th>
<th>How much</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy</td>
<td>Object</td>
<td>Analysis</td>
<td>Manipulator</td>
<td>Reason</td>
<td>Way to do</td>
<td>Degree to do</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Principle</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Meanings of 5W2H (Changqing et al., 2005, pp 3)

4.5.2 Cause and Effect Diagram

Dr. Kaoru Ishikawa developed a graphical tool that is used to identify and display possible variation causes in any given process. This graphical tool is called by several names like Ishikawa diagram, the cause and effect diagram and the fishbone diagram. (Quinn, 2007)

Goldsby and Martichenko (2005) discussed that cause-and-effect diagram offers a structured approach to problem solving. The main purpose of this diagram is to come up with the discussion that is close enough for the root cause of central problem. The cause-and-effect diagram provides stream line for causal analysis brainstorming and becomes a starting point for deeper analysis. This diagram narrows down the scope for the analysis of the problem. Categories which are common for identification of potential variation sources of root cause include people, process, technology, equipment, material, and environment. These categories are generally used in manufacturing environment and its application can also be found in logistics as well. They have provided an example of customer dissatisfaction with ferry service by having a specific question, “Why is the ferry service so unreliable?” Cause-and-effect diagrams are of qualitative nature and with the help of brainstorming we can have number of possible causes for the problem.
Keller (2005) defined cause-and-effect diagram and suggested that its main twigs helps in brainstorming or sorting out the possible problems. In his views either we can adopt the 5Ms and E (that are manpower, machines, methods, material, measurement and environment) or 4Ps (policy, procedures, plant, people) to ensure that all the areas are considered in brainstorming. Cause-and-effect diagram makes sure that the possible causes are included which helps in the data collection and analysis by categorising these potential causes.

According to Brassard et al. (2002), cause-and-effect diagrams helps to explore and find out possible causes related to a problem with graphical representation that can discover its root cause(s). It enables to stay focus on the contents of the problem instead of history of the problem.

According to the views of Martin (2007), we can sum up the concept of cause-and-effect by saying that it is used to brainstorm the likely inputs of the specific effect and it is a basic problem-solving method to illuminate issues and identify root causes. Inputs are the causes that are categorised into major groups that subsequently aid data collection and analysis. While making the diagram the main problem is placed under investigation in a box on the right side, variation sources are analysed by placing on the bones and finally the bones are combined in. Considerations have to be centred to ensure causes rather than symptoms. If there are several effecting variables then these are ranked according to relative importance.
Chapter 4: Theoretical Framework

4.6 Improve

The goals of this phase are to select problem solution, recognise the risks and implement selected solution. Practically, the improvement must investigate necessary knowledge based on brainstorming to create the best solution. (Jalali et al., 2008)

Selected Tool: Failure Mode and Effect Analysis: FMEA is selected for the Improve stage which is elaborated below.

4.6.1 Failure Mode and Effect Analysis: FMEA

Failure Mode and Effect Analysis: FMEA has been widely used as a process quality improvement technique. The purposes of FMEA are to prevent defects, enhance performance and increase satisfaction level. In addition, FMEA is the technique that identifies the failures, effects, and risks of a process, and then seeks the way to eliminate or reduce errors (McDermott et al., 2009). The ten steps of the FMEA are described following the FMEA worksheet as below: (Norman and Kehoe, 1997; McDermott et al., 2009)

- **Step 1:**
  Review the process: ensure that everyone understand the process and its flow.

- **Step 2:**
  Brainstorm potential failure modes: identify all possible failure modes by grouping into categories such as which process could fail to meet the process requirement.

- **Step 3:**
  List potential effects of each failure mode: create a potential effects list of failure that occurred.

- **Step 4:**
  Assign a severity ranking for each effect: estimate the impact of the problem when it occurs by ranking the level of serious effect for given failure mode on a scale 1 to 10.
• **Step 5:**
  Assign as occurrence ranking for each failure mode: determine the frequency of occurrence on scale of 1 to 10. 10 means the failure is for sure to occur and 1 means the failure is unlikely.

• **Step 6:**
  Assign a detection ranking for each failure mode and/or effect: identify the likelihood of detection on the scale 1 to 10. The assumption must be set that the failure has occurred.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No detection opportunity</td>
<td>No current process control: Cannot detect or is not analyzed.</td>
<td>10</td>
<td>Almost Impossible</td>
</tr>
<tr>
<td>Not likely to detect at any stage</td>
<td>Failure Mode and/or Error (Cause) is not easily detected (e.g., random audits).</td>
<td>9</td>
<td>Very Remote</td>
</tr>
<tr>
<td>Problem Detection Post Processing</td>
<td>Failure Mode detection post-processing by operator through visual/tactile/audible means.</td>
<td>8</td>
<td>Remote</td>
</tr>
<tr>
<td>Problem Detection at Source</td>
<td>Failure Mode detection in-station by operator through visual/tactile/audible means or post-processing through use of attribute gauging (go/no-go, manual torque check/clicker wrench, etc.).</td>
<td>7</td>
<td>Very Low</td>
</tr>
<tr>
<td>Problem Detection Post Processing</td>
<td>Failure Mode detection post-processing by operator through use of variable gauging or in-station by operator through use of attribute gauging (go/no-go, manual torque check/clicker wrench, etc.).</td>
<td>6</td>
<td>Low</td>
</tr>
<tr>
<td>Problem Detection at Source</td>
<td>Failure Mode or Error (Cause) detection in-station by operator through the use of variable gauging or by automated controls in-station that will detect discrepant part and notify operator (light, buzzer, etc.). Gauging performed on setup and first-piece check (for set-up causes only.)</td>
<td>5</td>
<td>Moderate</td>
</tr>
<tr>
<td>Problem Detection Post Processing</td>
<td>Failure Mode detection post-processing by automated controls that will detect discrepant part and lock part to prevent further processing.</td>
<td>4</td>
<td>Moderately High</td>
</tr>
<tr>
<td>Problem Detection at Source</td>
<td>Failure Mode detection in-station by automated controls that will detect discrepant part and automatically lock part in station to prevent further processing.</td>
<td>3</td>
<td>High</td>
</tr>
<tr>
<td>Error Detection and/or Problem Prevention</td>
<td>Error (Cause) detection in-station by automated controls that will detect error and prevent discrepant part from being made.</td>
<td>2</td>
<td>Very High</td>
</tr>
<tr>
<td>Detection not applicable Error Prevention</td>
<td>Error (Cause) prevention as a result of fixture design, machine design or part design. Discrepant parts cannot be made because item has been error-proofed by process/product design.</td>
<td>1</td>
<td>Almost Certain</td>
</tr>
</tbody>
</table>

Figure 15: Process FMEA Detection Evaluation Criteria (McDermott et al., 2009)
• **Step 7:**
  Calculate the risk priority number (RPN) for each effect: calculate RPN to compare each failure mode

\[ \text{Risk Priority Number} = \text{Severity} \times \text{Occurrence} \times \text{Detection} \]

• **Step 8:**
  Prioritise the failure modes for action: rank the failure modes for action plan from the highest risk to the lowest

• **Step 9:**
  Take action to eliminate or reduce the high-risk failure modes: design actions to eliminate or reduce the level of failure modes

• **Step 10:**
  Calculate the resulting RPN as the failure modes are reduced or eliminated: determine the product or process improvement

From 10 steps above, Failure Mode and Effects Analysis: FMEA is a disciplined technique that is used for evaluating and improving the process step by step as shown below: (Bolhouse, 2008)
4.7 Control

Control phase is the last stage and completes the DMAIC methodology. It ensures that the day to day process variations are fully controlled and the process is working in an improved state, and this process becomes standard once it is integrated in routine practices. (Hwang, 2004)

To sustain the Six-Sigma initiative, the objective must be to control the improved process once the improvement is realised in the improve phase of DMAIC. The Six-Sigma initiative must be alive throughout the DMAIC on the continual basis to meet the challenges. Organisations have divided their working territories in each of the functional area where each manager is responsible to improve his/her own functions on continual basis to keep Six-Sigma initiative alive. (Gupta, 2004)

Being the last and important phase of Six-Sigma DMAIC, progress is monitored and maintained against the actions performed in the prior phases (Bolhouse, 2008). The methods which are used to solve the problem become standards that should be sustained and improved time by time (Hambleton, 2008). It depends on the process which control method should be used to control the variations in the process. Chosen control method can help a lot to control the process effectively. Improvements and change in process should be communicated throughout the organisation appropriately. There is an opportunity that these results could be implemented on the other areas of the business. (Breyfogle, 2003)

After communicating the bigger picture to the users/employees, make sure that the employees have linked it into small and actionable goals in their respective areas appropriately to ensure the success on continual basis. You need to have an effective communication plan to share the learned lessons and sustain your Six-Sigma success. Things like monthly newsletters, quarterly company meetings, press releases, company intranet updates and video presentations should be communicated regularly to the intended people inside or outside the organisations. (Brue, 2002)
### 4.8 Chapter Summary

The following *Figure 17* summarises the theory chapter:

<table>
<thead>
<tr>
<th><strong>Supplier selection and its importance</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Six-Sigma DMAIC</strong></td>
</tr>
<tr>
<td>• This is the model structure that is followed to form theoretical framework</td>
</tr>
<tr>
<td>• Presents the concept of DMAIC in brief</td>
</tr>
<tr>
<td><strong>Define</strong></td>
</tr>
<tr>
<td>• Characteristics and capabilities of process</td>
</tr>
<tr>
<td>• Identification and determination of focus</td>
</tr>
<tr>
<td><strong>Measure</strong></td>
</tr>
<tr>
<td>• Process Mapping</td>
</tr>
<tr>
<td>• Flowcharting</td>
</tr>
<tr>
<td><strong>Analyse</strong></td>
</tr>
<tr>
<td>• 5W2H</td>
</tr>
<tr>
<td>• Cause and effect diagram</td>
</tr>
<tr>
<td><strong>Improve</strong></td>
</tr>
<tr>
<td>• Failure Mode and Effect Analysis</td>
</tr>
<tr>
<td><strong>Control</strong></td>
</tr>
<tr>
<td>• Process improvements control</td>
</tr>
<tr>
<td>• Communication and coordination</td>
</tr>
</tbody>
</table>

*Figure 17: Summary of Theoretical Framework*
5. Empirical Findings

In this chapter, all the empirical materials will be presented that were gathered through interviews and questions. Empirical findings will be presented in clear connections to theoretical model devised to answer research question.

All the empirical information for this thesis was gathered through video conferencing interview sessions conducted according to the schedule given in chapter 2. Furthermore, a structured questionnaire (see Appendix A) was also provided to the interviewees for more insight. Empirical findings for this chapter would follow the conceptual model shown in Figure 18 that represents the clear connection of data collection to research question and theoretical model.

![Figure 18: Empirical Model](image-url)
5.1 Define: What is the scope/focus of process?

In order to set our focus for supplier selection process, first we needed to determine a product family. The scope of supplier selection process was then defined in relation to a specific product family. **Figure 19** below provides percentages of purchasing in relation to different product families;

![Figure 19: LPCL Purchasing from Product Family Standpoint](image)

To determine the scope, capabilities and characteristics of supplier selection process in “Definition” phase of DMAIC, we selected plant and equipment (5%) suppliers to focus while gathering empirical information about the whole supplier selection process. **Figure 20** below depicts the whole process starting from PR generation to PO issuance and presents the scope of our focus to define capabilities and characteristics of process in Define phase of DMAIC.

![Figure 20: Procurement Process of LPCL](image)
This focus can further be characterised in details as follows;

**Quotations / Bidding:**
- Performing competitive bidding consists in having several suppliers competing (minimum 3).
- Competitive bidding is mandatory.
- Competitive bidding has to be finalised before PO.
- If an agreement exists with suppliers (e.g.: frame-agreement, investment contract …), the PR should be transformed into PO directly without any additional competitive bidding.
- Competitive bidding is performed by a team (Requester and Purchaser). In most cases and in any case above a defined threshold, purchasing professionals have to lead the bidding process, including the final negotiations with suppliers.
- In all cases, the following rules have to be applied:
  - Ensure each supplier is treated equally and is provided with the same information to support his proposal and quotation. In case of changes in requirements, all suppliers must be given equal chance to adjust their bids.
  - Allow sufficient time for the supplier to respond to a bid or quotation request.
  - Selection criteria have to be defined before the receipt of tender by the potential suppliers.
  - Quoted information is confidential and is not to be shared with other suppliers.

**Supplier Qualification / Evaluation:**
- Prior to be invited to a tender, and in any case before signature of the first contract, the supplier’s ability to meet LPCL criteria/expectations is to be assessed.
- Only “qualified” suppliers can receive orders from LPCL.
- Suppliers qualification is based on his ability of being technical responsive, financially lowest and matching the general qualification. Numbers of factors are considered in these three main qualification aspects ranging from quality, cost, and delivery to his social and environmental responsibility.
Negotiations / Contracting:

- Before approval of a Supplier Agreement, the formal comparison of offers, approved by the team (Requester / Purchaser) will be the base for the final choice for a supplier. This choice will be made according to delegation of authority; the evidence of this formal comparison of offers will be kept available in database.
- Major contracts should be reviewed by Legal Advisor.
- Contracts must be communicated to the relevant Buyers so they can enforce them when they are changing Purchase Requests into Purchase Orders.
- Contracts and Purchase Orders in foreign currency have to be communicated to Treasury department and managed as per CFO instructions.

5.2 Measure: How does the process work?

Based on the above mentioned scope and characteristics, current supplier selection process is mapped in the following Figure 21.
LPCL has implemented Oracle E-business Suite since March, 2007. Associated characteristics of the whole “Procure to Pay” purchasing process in Oracle E-business Suite are depicted below in Figure 22:

![Figure 22: Procure to Pay Process in Oracle E-business Suite](image)

The supplier module in Oracle E-business Suite is depicted below in Figure 23 with all of its associated characteristics:

![Figure 23: Suppliers Module in Oracle E-business Suite](image)
5.3 Analyse: What are the problems?

After detailed discussions and interview feedback on how the current process works, the problems identified are discussed below in relation to each procurement step that ultimately affects supplier selection.

- Regarding the issues of material planning, sometimes technical department is unable to generate proper forecast regarding required material and normal need becomes urgent. Hence, this leads to deviations in many procurement procedures resultantly affecting supplier selection.

- Technical department has to get budget approval for Purchasing Request from the finance department which is time consuming activity.

- Technical department when develop the technical selection criteria for supplier selection often generates a very rigid additional criterion that drop out many cost effective and reliable suppliers, if selected. This thing is explained with many examples that include extensive working experience (sometimes 20 years), audited reports and requirement of previous seven years supply records which is unnecessary in many cases and does not influence in reality.

- Technical department sometimes changes delivery times after publishing the purchasing request / indent and in response to this procurement team has to reduce the quote submission time for quick response from the suppliers and therefore many potential suppliers drop their bids.

- Sometimes technical department is biased and personal influences are involved towards supplier selection which is difficult to eliminate because procurement team is not allowed to made comments or question technical aspects of the case despite having the technical expertise. And justifications given by technical team for single source sometime are not fully justified that also shows personal biasness and influence the supplier selection.
• Procurement is only made from preferred suppliers because of the previous experience with the supplier and technical teams are to some extent biased towards these suppliers and criterions for preferred suppliers are not continuously evaluated.

• Preferred suppliers are also required to submit bid bond that increases the administrative work.

• Market Intelligence is not fully analyzing the market resources and not giving the real input for updating the suppliers’ database. This thing is explained in the general discussion that though Market Intelligence team has mentioned RFI, self assessment questionnaires, 3rd party assessments as mode of suppliers search but in reality only those suppliers who approach LPCL directly get registered in their database.

• Expression of interest is not obtained from preferred suppliers before request for quotation that sometimes causes delay in process.

• Request for quotation is advised to suppliers through only ordinary mail that is time consuming.

• Often technical team takes more time than usual for technical evaluation, leaving very less margin for bid validity and resultantly it affects suppliers bid validity.

• No personal meetings with suppliers are arranged during negotiations.

• After finalising negotiations the Letter of Intent is sent to suppliers, rather than a straight contract.

• Purchase order is issued through fax and ordinary mail which are duplication of work activities.

• Direct purchases sometimes skip transaction recording in ERP suite and heave transparency issues.
• Company is not maintaining any kind of Supplier Portal that can provide access to suppliers to view general supply chain information from LPCL, and suppliers individual information related to their contracts and payments.

5.4 Improve: What can be improved?

In relation to the problem identified in the Analyse phase, the improvement areas are determined as regard to the empirical information gathered through discussions and interviews.

• Forecasting material requirements is not properly done at LPCL. Resultantly, normal needs become urgent, and on the same continuum it creates stocking issues. Proper check on available stock and required stock in future may answer these types of issues.

• For budget check, the PR has to route from technical department to finance department. It is only an excessive exercise while the technical department has previously been allotted annual budget. Here the unity of command may resolve the issue.

• There are some of the criteria’s which are necessary to follow when evaluating the technical perspective of the supplier. But additional criterions being rigid need to be overlooked in some cases.

• Due to urgent change in delivery time by the technical department during the pre-defined stages of purchasing process may lose some of the good suppliers. Again lack of calculating incorrect time for the forecasted need leads in the reduction of pre-defined number of days in delivery time.

• Personal relations influence the supplier selection process used by technical department and this is the area where technical team always has some issues with procurement team.
• Preferred suppliers in database always come into consideration when fulfilling the need but LPCL does not consider in great deal the potentially good suppliers registered in the new category of database.

• Submission of bid bond in case of preferred suppliers is an excessive activity.

• Although, market intelligence measures are specified but not effectively exercised.

• The inclusion of EOI may help LPCL to reduce the complexity of interested suppliers.

• The reach of advanced technology increases the use of technology which needs to be adopted more rigorously by LPCL. There are some procedures like sending request for quotation through ordinary mail which is one of the examples of outdated procedures followed by LPCL.

• Supplier’s technical evaluation period is not properly adhered by the technical department.

• In person negotiation meetings with suppliers at the workplace or outside the workplace are hardly exercised which in some cases impacts the supplier selection in great deal.

• Letter of intent is a document which compiles the negotiations and all other matters in one document and is issued before the contract. Contract is also the same document in which everything is mentioned. It is duplication of activities.

• The mode of sending documents to the supplier like purchase order or other documents should be updated to cater complains from the supplier like unreadable fax and delay in delivery of ordinary mail.

• Direct Purchase is used to fulfil the urgent need, this type of transaction is recorded after the purchase is made which is against the existing procedure at LPCL and in some cases the transparency is questionable.
• Supplier’s access to LPCL general information is not practiced electronically these days. Suppliers do face many problems in gathering information regarding contracts and payments.

5.5 Control: How the processed is controlled?
Considering the feedbacks from previous phases that provide a picture of process and discussions with LPCL Supply Chain Head, current supplier selection process at LPCL seems to have less control on overall process. While problem arises more often in managing the process, the delay in the process was found simultaneously.

The procurement complexity creates the need of communication channels with high information processing capabilities to encourage fast response when problem occurs. Open channels of communication should willingly share responsibility for process integrity and reliability. Moreover, coordination of work is an important dimension. Effective coordination between different levels of management and across functional areas is not widely apparent to adhere to any quality and reliability measures thorough supplier selection process.
6. Empirical Analysis

In this chapter, the empirical findings are going to be discussed and analysed together with the theoretical framework. The analysis will be connected to the same structural approach as of theoretical and empirical models presented earlier. Lastly, the analysis will provide the answer to our research question to conclude this thesis.

The theory of Six-Sigma DMAIC provides a five step procedure which is applied to process improvement objectives. The purpose of this thesis is to investigate the supplier selection process at LPCL with Six-Sigma DMAIC methodology, and give suggestions for improvements to develop a competitive supplier base in order to get competitive advantage in the long run. So, the recommended implementation of Six-Sigma DMAIC will be useful to improve supplier selection process. Figure 24 represents the analysis model which is connected to our empirical model presented in chapter 5, and it will ultimately lead us to answering the research question in our conclusion chapter.

![Figure 24: Analysis Model](image-url)
6.1 Define and Measure
The first 2 phases of DMAIC process improvement methodology correlate to investigating the current process. It includes defining the process scope, characteristics and capabilities. Further, it relates to measuring and mapping the current process to describe and understand the current process in details. This has already been done in empiric’s chapter 5.1 & 5.2, and the existing process map is once again being presented here for reader’s ease;

Figure 25: Existing Supplier Selection Process Map of LPCL

6.2 Analyse
During this stage we identified the problem areas in the current supplier selection process of LPCL. Finding problem areas in the supplier selection process helped us to ascertain how the process is actually working right now and what improvements opportunities there are to make it more effective.
6.2.1 5W2H

Mitchell (1998) in her paper discussed that previously vendors were primarily selected on the price factor but now a day supplier’s capabilities/abilities and win/win relationship are considered more important. Suppliers who offer the lowest prices for their product/service does not always mean that they can provide the best product/service and nor it guarantees a mutually beneficial buyer/supplier relationship.

Many researchers use 5W2H framework which is a supportive tool in different situations and can help to understand the structure in more depth that is why while collecting empirics’ authors kept this structure/strategy in their mind for data collection. 5W2H described below includes Why, What, Where, Who, When, How and How much for LPCL supplier selection process.

**Why: Purpose – Why is it a problem?**

LPCL wants to improve their current supplier selection process because of the following:

- To develop a competitive supplier base
- To reduce the complexity & eliminate unnecessary activities in supplier selection process
- To make the process more transparent while minimizing the human interventions
- To develop the suite of communication channel to achieve the efficiency in supplier selection process

**What: Symptoms – What’s wrong in it?**

In views of LPCL supply chain authorities the following symptoms create an urge for improvement in their supplier selection process.

- Lack of market intelligence
- Unnecessary activities are found in the process
- Technical team biasness influences on supplier selection
- Delay in current process because of ineffective tools of communication
Where: Place – Where the problem takes place?

After analysing the current process map of LPCL supplier selection process the above discussed problems arise at the following stages in the process.

- **Purchasing Request + Bidding + Evaluation (TCO + Market Intelligence)**
  At the time of Purchasing Request estimation cost is wrongly stated without considering the total cost of ownership, evaluation criteria is not mutually formulised and mode of procurement is suggested based on only preferred suppliers. Bidding stage lacks full utilisation of market resources. Only preferred suppliers from internal suppliers’ database are considered, other recourses like 3<sup>rd</sup> party assessments, suppliers’ plant visits and external assessment including trade exhibitions, supplier referrals are not considered. In the evaluation stage problems arise due to the non-involvement of procurement team in supplier evaluations.

- **Purchasing Request + Evaluation Criteria (Long Term Relationship)**
  As discussed above at the stage of Purchasing Request and Evaluation LPCL technical selection team sometimes develops a very rigid criterion for selection and evaluation that leads to less suppliers’ participation that is considered important in long term. Moreover technical selection team only considers quantitative factors (like price, quality and delivery time) where as qualitative factors (like financial health, operational performance, business process & practices, risk factors and cultural factors) are not considered.

- **Bidding (D.P., & EOI) + Negotiations & Contracts (LOI) (Process Complexity)**
  Process complexities can be found at the stage of Bidding and Negotiations & Contracts stage. Like during bidding stage no expression of interest is sent to suppliers that can be effective in terms of knowing how many suppliers are interested and will send their quotations. Direct purchases make the process complex with the transparency issues and manual transactions. Further at the stage of negotiations with suppliers and after finalising it, LPCL sends letter of intent to finally selected supplier which is duplication of activity as direct contract with purchase order can be issued to save the time.
Chapter 6: Empirical Analysis

• **Purchasing Request + Bidding (Mode of procurement) + Evaluation (technical matters) (Human Intervention)**

Human interventions that are biasness of technical selection team can be found during the formulisation of *Purchasing Request, Bidding and Evaluation* stages. Procurement team is not allowed to comment during development of technical criteria and technical evaluation despite having the technical expertise. Similarly procurement team has to go for the bidding process under that procurement mode which is advised by the technical team, especially when it comes for limited suppliers selection (limited invitation of tenders) and single source (single source/propriety) supplier selection.

• **Bidding (RFQ & D.P.) + Negotiations & Contracts (Negotiations & finalization) (Suite of Communication)**

Process delays because of ineffective tool of communication can be found at the stage of *Bidding and Negotiations & Contracts*. In bidding RFQ is obtained through ordinary mail system in order to maintain office records which take more time. In direct purchases manual transactions are carried out which can lead to process transparency issues. Only manual quotations are received and considered in the evaluation stage. Moreover during negotiation stage ordinary mail correspondence is carried out by LPCL which is ineffective tool. Personal meetings are considered as more effective however if not possible at least electronic modes of communication like video conferencing should be adopted to carried out the negotiations with suppliers.

**Who: Involvement – Who are involved?**

Generally following five departments of LPCL are involved in the supplier selection process having a major or minor influence on the process.

- Technical Team
- Financial Team
- Procurement Team
- Legal Team
- I.T. Team (Information Technology Team)
### When: Time – When was the problem found / arise?

<table>
<thead>
<tr>
<th>Problem arises at the time of:--</th>
<th>Providing estimation of cost without considering the total cost of ownership.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poor performance of Marketing Intelligence (not utilising the maximum market resources)</td>
</tr>
<tr>
<td></td>
<td>Not emphasising on General Evaluation criteria for suppliers.</td>
</tr>
<tr>
<td>Problem arises at the time of:--</td>
<td>Development of inflexible qualification and evaluation criteria for suppliers.</td>
</tr>
<tr>
<td></td>
<td>Not emphasising on General Evaluation criteria for suppliers.</td>
</tr>
<tr>
<td>Problem arises at the time of:--</td>
<td>Manual transactions for direct purchases making the process complex.</td>
</tr>
<tr>
<td></td>
<td>No expression of interest (EOI) before RFQ in Bidding stage</td>
</tr>
<tr>
<td></td>
<td>Sending the letter of intent (LOI) after contract finalisation</td>
</tr>
<tr>
<td>Problem arises at the time of:--</td>
<td>No involvement of procurement team during development of qualification and evaluation criteria.</td>
</tr>
<tr>
<td></td>
<td>Suggested mode of procurement has to be considered by procurement team whatever is advised by technical team.</td>
</tr>
<tr>
<td></td>
<td>No involvement of procurement team during Technical Evaluation</td>
</tr>
<tr>
<td>Problem arises at the time of:--</td>
<td>No EOI before RFQ in Bidding stage</td>
</tr>
<tr>
<td></td>
<td>Sending the letter of intent (LOI) after contract finalisation</td>
</tr>
<tr>
<td></td>
<td>Releasing of Purchase Order through ordinary mail.</td>
</tr>
<tr>
<td></td>
<td>Manual receiving of quotation</td>
</tr>
<tr>
<td></td>
<td>Finalising negotiations</td>
</tr>
</tbody>
</table>

**Table 5: Problem Occurrence table**
How: Method/Solution – How to improve?

Generally discussing the following points should be considered for improvement in the LPCL current supplier selection process.

- Forecasting and material planning
- Analyse all resources of market intelligence
- Evaluation criteria must be continuously evaluated with the mutual involvement of procurement and technical team
- Discouragement of Direct Purchases
- Direct issuance of contract
- There must be mutual involvement of technical & procurement team in whole supplier selection process
- Effective suite of communication tool must be adopted and used in each process of supplier selection to make it more efficient

How much / how many?

How many processes are to be improved? How many / how much improvement can be brought in current supplier selection process?

- To develop competitive supply base:
  Provide better decision making and deliver a competitive advantage particularly in cost saving and responsiveness to requirements. Heinritz et al. (1991) indicated the competitive supply base development provides cost-reduction possibilities, better sources, collaborative planning with supplier.

- To develop a long term relationship:
  This can result in a joint support concerning cost reduction, risk sharing, and supplier capabilities development. Monczka et al. (2009) mentioned that a long term supplier relationship management works as one of the most critical tools in monitoring process ensuring the performance improvement achieved thorough the strategy in term of cost, quality, delivery and time.
• **Reduce the complexity:**
Robust process and be simple use. Monczka *et al.* (2009) stated that the process model should be clearly defined and simplifying process. Different people from difference functional area involved in the process can understand a routine and process model easier including a reduction of errors in the process.

• **Human Intervention:**
Standardise evaluation and measurement process can help LPCL selects good suppliers in right products. Consequently, the good relationship between LPCL and supplier will take place. Mitchell (1998) stated that whenever clients have a strong mutual benefit with suppliers, the errors in selecting supplier will be occurs.

• **Suite of communication:**
Reduce a time-consuming process and eliminate paper work handling. Monczka *et al.* (2009) also mentioned the efficiency transactions in process were generated by the suit of communication tools.

### 6.2.2 Cause and Effect Diagram – LPCL Supplier Selection Process
Problem sources for LPCL supplier selection process were brainstormed through cause-and-effect diagram. However the process of doing this is also assisted with 5W2H framework. The problem sources are divided into six different categorizes that are People, Process, Communication, Management, Supplier and Technology. Each cause has its sub-cause which affects the selection process at LPCL. The potential reasons being found in the process are included in the cause-and-effect diagram which can be shown by the following Figure 26.
People:
Considering the factor of people (employee) who are involved in supplier selection process shows two prominent causes that includes human intervention and requester technical expertise. Human intervention is shown at the stage of developing the evaluation and selection criteria for suppliers, mode of procurement and evaluation stage (technical & general) without the genuine involvement of supply chain management department (procurement team). Supply Chain Management department has the technical expertise as the SCM head and managers have the technical background with the extensive working experience. Non-standardise criteria includes unnecessary factors that does not directly influence on the supplier selection and moreover general criterions in the evaluation stage is being overlooked many times. Second cause in this category which influences the process is
requestor technical expertise, in which practical knowledge and working experience matters a lot in the selection of right supplier. In the discussion with LPCL SCM head, we analysed that the impact of working experience and technical knowledge of the requester matters a lot while developing the specific criteria for evaluation. Because user has to analyse the received quotations and his decisions will truly base on his technical expertise.

**Process:**

Some issues connected with process have been found. The first comes regarding working of marketing intelligence which is not actually performing up to the mark. This sub team is not utilising the full market resources for supplier search. Currently only those suppliers get registered in LPCL database who themselves request LPCL to add in supplier database and send information about their businesses to them. Technical selection team is greatly inclined towards the selection of preferred suppliers (with whom they already had a business) and procurement team is not continuously doing market analysis for supplier search that might include personal referrals, trade exhibitions, yellow pages, and internet search engines, external assessments through blog and forums and third party assessments. Material planning is not actively carried out which creates a hurdle for the procurement team. With the absence of right forecasting the actual needs becomes urgent and resultantly in order to meet the desired need procurement team has to deviate from its procedures that affect the supplier selection process. In some cases technical team makes changes in the delivery time after issuing the enquiry to suppliers, resultantly with this change some potential suppliers drop their bids as they cannot make an urgent delivery. Complexity can be found in the current process with the unnecessary activities (like expression of interest is not obtained and issuance of letter of intent after finalisation of contract) and unnecessary involvement of finance department for budget approval. Technical team has to get budget approval from the finance team which is a time consuming process. However department wise budget authority can be transferred to respective department heads. Evaluation criteria issue covers inflexible criteria given by the technical team which is rigid in some cases and demands fulfilment of unnecessary requirements that do not directly influence on the selection. Supplier’s selection is greatly influenced by their technical capabilities however other intangible criterions must also considered which most of the time is overlooked. Total cost of ownership is not considered for the material estimation cost that results in huge variation when the actual price is received. Process delays can also be found under this category as its some sub-process are
time consuming. Technical team takes more time than usual while evaluating the technical bids, leaving less period for bid validity.

**Communication:**
The third problem source is named as communication. At many steps unsuitable tools of communication are adopted. Examples includes request for quotation is obtained through ordinary email, electronic quotations are not accepted and no electronic mode of communication is adopted at the stage of negotiations and contracts. Lack of coordination exists between the departments and information sharing is not free carried out. This thing can be exemplified by non-involvement of procurement team in technical selection team.

**Management:**
Different issues are connected with the management problem source. Based on the detailed discussion with authorities, we came to the point that there is a lack of strong implementation of sourcing strategy with less emphasise on material planning. Concerned department heads are validating the predefined evaluation criterions which are not continuously updating and also leading to personal influences. The other sub-cause is a power delegation of authorities from the management which is no involvement of SCM authorities in technical matters despite having the technical expertise. Another important aspect arise from the management side is the non-existence of performance base contract system. A performance base contract with suppliers ensures and fosters a successful long term working relationship.

**Supplier:**
There is no apparent problem at the supplier’s side however different issues are connected with this problem source. Supplier capabilities that affect the supplier selection in this process are their technical, financial and general capabilities. The matter of trust between the parties has been observed in the process which affects the supplier selection. Because of lack of trust LPCL demands performance bond from the supplier and/or opening of inbound L/C with them and non compliance of this can disqualify the supplier. Another important issue is the imposition of clauses from the suppliers’ side including payment term clauses. And not withdrawing the clauses by suppliers can disqualify them from the process.
Technology:
The technology as problem source in the cause-and-effect diagram that affects the supplier selection process includes lack of *electronic modes of communication* at different stages, *no supplier portal including no electronic bid submission* and *user technological knowledge*. LPCL is not managing any kind of supplier portal to manage its suppliers however its availability is mutually beneficial and because of its absence suppliers cannot submit their bids electronically. User technical knowledge affects the usage of LPCL Oracle – SCM suite. And very less training sessions are arranged for the users to accommodate them to quickly understand the newer version of Oracle; therefore resultantly users take more time to get familiar with the newer versions.

6.3 Improve
With the help of above discussed Analyse stage, we identified the problems using cause and effect diagram. In this improve stage those problems were removed and the existing process was modified to provide an improved supplier selection process for LPCL which is shown in *Figure 27*. The improvement practically provides the best possible solution and corrective actions will deliver a better performance of supplier selection process.
Figure 27: Improved Supplier Selection Process for LPCL
6.3.1 Failure Mode and Effect Analysis: FMEA

With the assistance of 5W2H and Cause-and-effect diagram in analyse stage; the errors in the process were clarified. Thorough the FMEA worksheet, the supplier selection process is categorised into failure modes. Then, brainstorming seeks the way to remove or reduce errors which affects the supplier selection process. FMEA worksheet (see Appendix B) describes errors in the supplier selection process at LPCL including recommended actions in term of process improvement.

6.3.2 Corrective actions / Recommendations

According to the risk priority number (RPN) calculation from FMEA worksheet, the priority list of the failure modes for action within supplier selection’s main process was generated as shown in following Table 6:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Supplier Selection Process (Main Steps)</th>
<th>Risk Priority Number (RPN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Purchasing Request (PR)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need Identification</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>Qualification and evaluation criteria</td>
<td>120</td>
</tr>
<tr>
<td>2.</td>
<td>Bidding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Approved PR for bidding</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Identify mode of procurement</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>Market intelligence</td>
<td>336</td>
</tr>
<tr>
<td></td>
<td>Received Quotations</td>
<td>80</td>
</tr>
<tr>
<td>3.</td>
<td>Evaluation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluation criteria</td>
<td>294</td>
</tr>
<tr>
<td>4.</td>
<td>Negotiation &amp; contracts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negotiations</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Selection of Supplier</td>
<td>40</td>
</tr>
</tbody>
</table>

Table 6: Risk Priority Numbers from FMEA
**Purchasing Request (PR)**

To reduce *high level* of total cost of ownership (TCO) and inventory, the best solution for LPCL is material planning by using information from ERP system. Basically, production and inventory forecast can identify the future need and the technical team can schedule its need. As the result, the process will prevent from the errors. The ways to gather cost information are benchmarking with competitors and updating internal cost and financial analysis. To get accurate information, LPCL should not consider only price, but also after sale package such as warranty, spare parts, maintenance cost. *Inflexible criteria* are the critical cause of dropping out many suppliers. Reviewing current criteria, then eliminate unnecessary criteria is the way to ensure that reasonable and effective criteria are used regarding qualification and evaluation criteria. Moreover, there is a *coordination gap* between technical team and procurement team at LPCL. To reduce this gap, a team has to formalise internal customer guidelines regarding to a clear communication for what exactly the internal customer wants and needs.

**Bidding**

Another cause of delay process for urgent need product is *power delegation*. Most current making decision was hold by high management level. Supplier selection process can respond shortly if LPCL provide authority to lower management for making decision. During the bidding, technical team sometimes *changes their needs* in deliverable and its time. Procurement team should give all suppliers equal change to adjust their bids and non-equality can reduce the number of supplier by dropping their bids. *Conflict of interest* influences on process delay with personal biasness. Employees who are in a position to influence purchasing transactions are required to avoid situations, relationships or perceptions where their personal interests may conflict. To prevent conflict of interest, employee must deal with supplier and other business partners in an ethical manner such as honestly, fairness and integrity. Moreover, some mode of procurement such as direct purchase provides process complexity, manual transaction and transparency issue. Adopting effective mode of procurement for each product will help team to shortcut the bidding process. Based on current *market intelligence*, it does not give the real input for updating the supplier database and use only preferred supplier. Practically, LPCL should analyse all source of market intelligence (e.g. press, articles, supplier document and visits to suppliers), and keep monitoring supplier market. Also, a team should continuously update and review the list of
supplier by structuring supplier into 3 categories; preferred, referenced and accepted. Evidently, employees have little or limited technical knowledge of market intelligence. Setting up basic training program will develop their purchasing skills that lead to a better performance. Electronic mode of communication such as Supplier Portal is meaningful for LPCL to develop their process. It is an effective communication channel that increased transparency internally and externally, gain time through more efficient interactions and real time information sharing with supplier and internal sourcing team.

**Evaluation**

Choosing the potential suppliers, criterion should be a continuous consideration. In fact, different criterion may be used for suppliers. Basically, suppliers were considered in area of cost, flexibility, quality, service and delivery. LPCL as business unit does not fully conform to group policy; therefore, management must emphasis and impose policy specially sourcing policy concerning to continuously consider general criteria by adopting different methods like employee trainings, periodic meetings with senior management and so on. In this process, inflexible criterion is also a cause. Reviewing and continuously updating are working as recommended action like above. In the existing process we identified that no mutual evaluation criteria and information sharing among teams exist therefore it leads to human intervention. LPCL should have regular meeting to increase visibility for the team and knowledge sharing. In addition to this evaluation should be performed by a team (requester, and purchaser) to ensure that a team has standardised evaluation criteria. Lastly, procurement team tend to take longer time in technical evaluation. The management should schedule the project and set up lead time for each process to provide fast response for a need.

**Negotiation & Contracts**

Negotiating for a fair and reasonable price and selecting the supplier best meeting the need are the main objectives in this process. The suitable communication channel is required for information processing capabilities. Nowadays number of new tools such as internet auctions has been adopted during negotiation stage. However, manual communication channels; face-to-face negotiation and conventional sealed bids, are still more polite than email negotiation. In some cases, electronic channels like video conference may act as a replacement. Development of long term supplier relationship thorough strong communication and information sharing helps parties in sharing a risk. It also provides successfully business
when working with the selected supplier regarding to long-range financial and value-added benefits. A true relationship can help LPCL reduce their paperwork such as inbound L/C opening and submission of performance bond. Moreover, *double paperwork* (LOI and contract) was found in this stage. A team has to review overall process and eliminate unnecessary paperwork for shorten time period and to improve the whole process.

### 6.4 Control

The control stage is the last phase of Six-Sigma DMAIC. The progress in this stage is to ensure that changes or the modified process from improve stage are successful and continuous improvement is taking place in supplier selection process.

#### 6.4.1 Process Management and Communication

Wu and Barnes (2009) mentioned that, when tools/applications are adopted for process improvement then process becomes more influential and leads to continuous improvement. To preserve continuous improvement, LPCL should work on process improvement control. By gathering meaningful information from the previous three stages, it can easily design the quality management involving process for planning and controlling the flow of work through supplier selection process as the concept of continuous improvement.

With the new flowchart, the first thing it will map the whole picture of supplier selection process at LPCL and the second thing is that few steps of overall process will prevent a team from problem occurring. By eliminated unnecessary activities and paperwork, the new flowchart will expectably be more efficient than the existing one. Moreover, it possibly guides a good plan which LPCL can perform the better process lead to the better decision making.

The management team at LPCL also plays an important role in developing strategies based on continual and effective communication. Simultaneously, the all members of team must coordinate and incorporate the best practices to deliver the better performance. The ERP system at LPCL works very well as effective computer-assisted tools in the area of planning, monitoring, control and reporting but the system is requiring the skills. LPCL has to educate their employees to preserve a better job and use a tool more efficiency.
Kist (2004) stated the need of timely, clear, effective communication is critical key affecting to process improvement. Using a variety of communication techniques will help LPCL enhance understanding, also increase involvement and collaboration, namely the motivation plan. Mitchell (2006) suggested motivation plan need to start from educating and communicating. *Customer Guidelines*, for example, are designed as a communication channel for optimising supplier selection process. They work as an assistant to identify a process in depth concerning roles, responsibilities, timeline, and documentation.

Communicate, communicate, communicate AND THEN educate, educate, educate is the communication concept that begins with the expectations of internal customer move to suppliers throughout supplier selection process. Each department participating in supplier selection process must communicate the plan to each other and make sure a team understand the process including activities and information. Then, educate internal customer purchasing skills including what deliverables they need and what the goal is. Feisell *et al* (2008) mentioned that when a team has the high level of purchasing skill, organisation will have positively performance on strategic purchasing practices.

Through communication openness and early collaboration at different levels of management and across functional areas urge the level of process maturity and a problem solving. The management team need to build closely rapport within organisation because mutual positive coordination among team members during the act of communicating provides a great enhancement in processing capabilities. Whereas this mutual positive coordination also encourages team members willingly sharing information and responsibility for work. The complexity environment in some steps of supplier selection process such as evaluation criteria create the need of effective communication channels. For LPCL, it is important to frequently use computer technology such email or small group meeting for discussion and planning for contingencies as fast response when problem occurring.
7. Conclusion

This chapter concludes the thesis. Further on own reflections about this assignment will be presented. Finally, suggestions for future research will be given as regard to the subject of this thesis.

7.1 Results

The objective of this thesis could be concluded in connection to the same structural model of DMAIC which we followed throughout this script.

The research question:

“How can the existing supplier selection process at Lafarge Pakistan Cement Limited (LPCL) be improved by applying Six-Sigma DMAIC?”

Results are presented below to serve the purpose of thesis and to answer our research question;

7.1.1 Define:

To narrow down the scope of the supplier selection process we selected the plant and equipment suppliers from the purchasing product family. Moreover in order to determine the focus and process characteristics we selected three major steps of procure-to-pay process: quotations and bidding, supplier selection and evaluation, and negotiations and contracting.

7.1.2 Measure:

In this phase we mapped the current supplier selection process at LPCL through process mapping. We used flowchart as a mapping tool to map the current supplier selection process in this stage. Flowchart is the pictorial representation of the activities within the process and by this we came to know the actual activities or steps involved in the current supplier selection process at LPCL. There are some standard symbols in flowcharting which are used to map the process.
7.1.3 **Analyse:**
At this stage using DMAIC approach of Six Sigma, we analysed the issues involved in current supplier selection process that lead to increase the gap between actual and required performance. In this phase we used the tools which are very good at identifying the problems within the activity or among the activities. The first tool is 5W2H which also works as facilitator for the second tool which is cause and effect diagram. The 5W2H is comprehensive tool for identification of the problem and gave us the platform to think for the solution. Cause and effect is used to identify the variation within the process through graphical representation. The problematic issues identified were;

- No material planning or forecasting the need.
- Poor performance of Marketing Intelligence
- Not emphasising on General Evaluation criteria for suppliers.
- Inflexible qualification and evaluation criteria for suppliers
- Unsuitied communication channel used
- No expression of interest (EOI) before RFQ in Bidding stage
- Double paperwork in some process
- No involvement between procurement team and technical team in evaluation stage.

7.1.4 **Improve:**
Based on the problems identified at the Analyse stage, we developed an improved flow chart of the existing supplier selection process. With the help of FMEA tool we characterised the problems according to risk priority numbers and based on those risk priority numbers recommended actions are given to bring improvement in the existing process. The recommended actions for supplier selection process through Failure Mode and Effect Analysis FMEA are:

- Production and Inventory forecast by defining target cost, updating internal cost and financial analysis, and benchmarking with competitors.
- Review criteria and eliminate unnecessary criteria
- Coordinate and involvement between a team
- Treat all suppliers equal in any change
- Dealing with suppliers and partners in an ethical manner
• Develop market Intelligence by updating data and analysing all sources.
• Set up training program to develop purchasing skill and impose sourcing policy.
• Adopt suited communication channels
• Build long term supplier relationship

7.1.5 Control:
To control the activities involved within the process of supplier selection process, LPCL should focus on planning of activities at the right time and communicating in the right direction. Collaboration of departments is essential to achieve the overall goal of the organisation. Six-Sigma is a continuous improvement tool that will help LPCL to control the activities on continuous basis. Process management and communication strategy is suggested to ensure continuous improvement and control objectives. Majorly effective planning and communication are two main control tools that will help LPCL to reduce the errors within the supplier selection process.

7.2 Own Reflections
In order to achieve the primary objective of the thesis (that was to inspect current supplier selection process at LPCL and suggest improvements), we found Six-Sigma DMAIC as the most relevant process quality improvement methodology. This could somehow be done with several other quality improvement methodologies available i.e. TQM, Kaizen and MBO, for in-depth comparative investigation for LPCL. Moreover as physical presence at LPCL was not possible due to long geographical distance, this thesis only relied on the electronic means of data collection through emails and video conferencing.

LPCL is unable to absorb any kind of suppliers innovation as no framework exists that encourage collaborative long term relationships with its suppliers. Moreover they do not have any strategic suppliers in their supply base. LPCL management should categorise its suppliers according to value driven segmentation in order to identify the value driven suppliers by which they can enhance their technical expertise, bring process and product improvements. Suppliers that offer value driven products can help organisation to reduce total cost of ownership. Cement industry acts as a building block in nation’s construction industry, therefore having a competitive supply base can help LPCL to capture big chunk of cement market with the help of its suppliers.
7.3 Suggestions for Future Research

Based on the findings of this thesis, we suggest that the further research for LPCL could be done in the area of sourcing and suppliers relationship management. Sourcing: A study could examine the sourcing policy at LPCL on purchasing practices of products. It would also be interesting to focus more on this area which leads to excellent cost reduction. Using scenario method could compare and analyse regional, national and worldwide sourcing. Supplier Relationship Management: A study could investigate supplier relationship management that leads to creating a competitive advantage for LPCL through the development of supplier performance monitoring and supplier development programme. More details could continuously move towards cost reduction, increased reliability and risk mitigation, transparency of supplier costs and quality, and enhanced efficiency of sourcing process.
References


Brue, G. (2002), Six Sigma for Managers, McGraw-Hill, Madison, WI.


References


References


Perry, C. and Jensen, O. (2001) “Approaches to combining induction and deduction in one research study”, paper presented at the Australian and New Zealand Marketing Academy Conference (ANZMAC), 1-5 December, Albany, Auckland, available at:


Tang, C. L. (2007), *Fortification of Six Sixma: Expanding the DMAIC Tools*, Wiley InterScience, OH.


Appendices

Appendix A: Questionnaire

Supplier Selection Process improvement through Six-Sigma DMAIC
“A case of Lafarge Pakistan Cement Limited”

Answered by: ____________________________ Date: ____________________________
Designation: ____________________________

Purpose:
This questionnaire is the data collection instrument for aforementioned topic of Master Thesis administered by Muhammad Rizwan Ul Haque, Ahmed Nawaz Shaikh, Kamonmarn Jaenglom and Zaheer Tariq students of Master Programme in Business Process & Supply Chain Management at Linnaeus University. This questionnaire is more of a descriptive nature and would take 30 minutes (approximately), so we appreciate your consideration to spare some time in advance. If you are not sure of a particular question, leave it blank or route it back to us for clarifications. We hope the respondent will do justice by providing clear and accurate answers as much as possible. The data collected is strictly for academic purposes and no public disclosure of the company will be allowed in any form whatsoever.

A. Please discuss and elaborate the current procurement process at LPCL.

B. Which LPCL teams participate in supplier selection process and how much each has the influence on it?

C. How frequently material planning is carried out at LPCL and how much it deviates from expected results?

D. What selection criterions are considered in supplier evaluation and how much flexible it is?

E. After raising the indent and its approval how often changes are made on it?
<table>
<thead>
<tr>
<th></th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Are there any biasness and personal influence involved in supplier selection? If yes then how those are reduced / eliminated?</td>
</tr>
<tr>
<td>G</td>
<td>What is the general criterion for approved suppliers and are these continuously evaluated?</td>
</tr>
<tr>
<td>H</td>
<td>What is the bid bond &amp; performance bond and who has to submit this and at which stage?</td>
</tr>
<tr>
<td>I</td>
<td>How efficient is your market intelligence and how much it contributes in obtaining suppliers information?</td>
</tr>
<tr>
<td>J</td>
<td>Which modes of communication are normally used in the whole supplier selection process?</td>
</tr>
<tr>
<td>K</td>
<td>Do you prefer face to face negotiations with suppliers or any other electronic mode of communication?</td>
</tr>
<tr>
<td>L</td>
<td>How effectively ERP system is utilized and how much user friendly it is?</td>
</tr>
<tr>
<td>M</td>
<td>How much your supplier selection process is oriented towards information technology?</td>
</tr>
<tr>
<td>N</td>
<td>Do you have any supplier portal for effective management of your suppliers?</td>
</tr>
<tr>
<td>O</td>
<td>Do you measure supplier’s processes and capabilities that can help and improve LPLC process?</td>
</tr>
<tr>
<td>P</td>
<td>Which steps in your point view are considered unnecessary during supplier selection?</td>
</tr>
<tr>
<td>Q</td>
<td>Please discuss if you think there are any loop holes in your supplier selection process?</td>
</tr>
</tbody>
</table>

Thank you for your time and patience.

“Patience is the toughest road to stay on, but the surest path to victory.” – David Weinbaum
## Appendix B: FMEA Worksheet

<table>
<thead>
<tr>
<th>No.</th>
<th>Sub-Process</th>
<th>Failure Mode</th>
<th>Effect</th>
<th>Cause</th>
<th>OCC</th>
<th>SEV</th>
<th>DET</th>
<th>RPN</th>
<th>Recommended Actions</th>
</tr>
</thead>
</table>
| 1   | Purchase Request | Need Identification | - High TCO | - Poor Material Planning | 5 | 6 | 8 | 240 | - Production and Inventory forecast.  
- Define target cost.  
- Up-to-date internal cost and financial analysis.  
- Benchmark with competitors. |
|     | Qualification and Evaluation Criteria | - Overstock | - Inflexible criteria | - Lack of coordination b/w technical team and procurement team | 4 | 5 | 6 | 120 | - Review criteria and eliminate unnecessary criteria.  
- Formalise the needs to make sure the requirement were fully understood by procurement team. |
|     | Approved PR for bidding | - Drop out many suppliers | - Inflexible criteria | 4 | 5 | 6 | 120 | - Review criteria and eliminate unnecessary criteria.  
- Formalise the needs to make sure the requirement were fully understood by procurement team. |
|     | Identify Mode of Procurement | - Delay process for Urgent need product | - Power delegation | 4 | 4 | 5 | 80 | - Provide authority to lower level management for making decision.  
- Give all supplier equal chance to adjust their bids. |
|     | Market Intelligence | - Many suppliers drop their bid | - Change in deliverable & its time | 4 | 4 | 5 | 80 | - Provide authority to lower level management for making decision.  
- Give all supplier equal chance to adjust their bids. |
|     | - Process delay with personal biasness | - Conflict of Interest | 4 | 5 | 8 | 160 | - Dealing with suppliers and other business partners in an ethical manner.  
- Adopt other effective mode of procurement to shorten the bidding process. |
|     | - Process complexity | - Direct Purchase | 4 | 5 | 8 | 160 | - Dealing with suppliers and other business partners in an ethical manner.  
- Adopt other effective mode of procurement to shorten the bidding process. |
- Adopt other effective mode of procurement to shorten the bidding process. |
|     | Market Intelligence | - Not giving the real input for updating the supplier database and use only preferred suppliers | - Poor Marketing Intelligence | 6 | 8 | 7 | 336 | - Keep update and review the list of suppliers.  
- Analyse all source of Market Intelligence and monitor supplier market.  
- Set up basic training program to develop purchasing skill. |
|     | - Little or limited technical knowledge of Market Intelligence | 6 | 8 | 7 | 336 | - Keep update and review the list of suppliers.  
- Analyse all source of Market Intelligence and monitor supplier market.  
- Set up basic training program to develop purchasing skill. |
## Appendices

<table>
<thead>
<tr>
<th>3</th>
<th>Evaluation</th>
<th>Evaluation criteria</th>
</tr>
</thead>
</table>
|   | Received Quotations | - Long time consuming process  
- Electronic Mode of communication  
- No expression of interest obtained from preferred suppliers |
|   | Evaluation criteria | - Less participation of suppliers  
- Inflexible criteria  
- Technical selection team biasness  
- No mutual evaluation criteria and information sharing btw technical team & procurement team  
- Remains less bid validity  
- Longer technical evaluation  
- Non-standardised evaluation criteria and no assessment of current evaluation criteria  
- General criteria is not considered and only tangible criteria is considered  
- Lack of compliance with group policy |
|   | Negotiations | - Delay process  
- Unsuitable communication tools  
- Inbound L/C opening and submission of performance bond  
- Trust between parties  
- Double paperwork (LOI vs Contract)  
- Unnecessary activities |
|   | Selection of supplier | - Adopt Supplier Portal  
- Review current criteria and continuously update it  
- Have regular meeting to increase visibility for the both team and knowledge sharing  
- Schedule process time and set up lead time for each step  
- Perform evaluation by a team (requester, specifier and purchaser)  
- Management must emphasis and impose sourcing policy  
- Formalise minutes of negotiation meeting  
- Build long term supplier relationship  
- Review process and eliminate unnecessary paperwork |
Appendix C: Cause & Effect Diagram

Cause and Effect Diagram – Supplier Selection Process

- People
  - Human Intervention
    - Non-standardised evaluation criteria
  - Requester technical expertise
    - Working experience
    - Practical knowledge
  - Performance based contracts
  - Power delegation
  - Predefined evaluation criteria
  - No emphasis on material planning
  - Lack of sourcing strategy implementation

- Process
  - Market intelligence
    - Market resources
    - Referrals
  - Poor material planning
    - Changes in deliverables & its time
  - Process delays
    - Longer technical evaluation
    - Long time consuming sub-process

- Communication
  - Communication channels
    - Un-suitable communication tools
  - Complexity
    - Unnecessary activities
    - Unnecessary involvement
  - Evaluation criteria
    - Inflexible criteria
    - Technical/capabilities
    - TCO
  - Lack of coordination
    - No mutual Evaluation criteria
    - Information sharing b/w functional areas

- Management
  - Trust b/w parties
    - Inbound L/C or Performance Bond

- Supplier
  - User technological knowledge
    - IT Trainings
  - Supplier portal
    - Electronic bid submission
  - Electronic mode of communication

Supplier Selection Process at LPCL