CRITICAL SUCCESS FACTORS AND BARRIERS TO SIX SIGMA PROJECT IMPLEMENTATION: EMPIRICAL EVIDENCE FROM AN ECUADORIAN COMPANY

A dissertation submitted to The University of Manchester for the degree of Master of Science in the Faculty of Humanities

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LIST OF ABBREVIATIONS

BO: Beyond Operations
BB(s): Black Belt(s)
CEO: Chief Executive Officer
CHF: Swiss Francs
CIP: Continuous Improvement Programme
CSFs: Critical Success Factors
CTQ: Critical to Quality Characteristics
DMADV: Define - Measure - Analyse - Design - Verify
DMAIC: Define - Measure - Analyse - Improve - Control
DPMO: Defects per Million Opportunities
FMEA: Failure Mode and Effects Analysis
GB(s): Green Belt(s)
IPM: Industrial Performance Manager
KPIs: Key Performance Indicators
MBB(s): Master Black Belt(s)
PI: Process Improvement
SIPOC: Supplier - Input - Process - Output - Customer
SS: Six Sigma
TQM: Total Quality Management
VOC: Voice of Customers
WB(s): White Belts(s)
ABSTRACT

Despite the popularity and wide acceptance of Six Sigma as an approach to improve quality and increase firm profitability, there is a rising concern regarding the failures of Six Sigma programmes. The purpose of this dissertation is to study the success factors and barriers to Six Sigma project implementation and how these factors are linked to specific phases of the process through which Six Sigma projects are deployed.

A single case study approach was taken to examine in-depth information regarding Six Sigma project implementation processes at an Ecuadorian food manufacturer. One manager, an external Black Belt and eight Green Belt project leaders took part in the study by providing evidence on the topic according to their experiences participating in projects.

The study found that the project leaders evidenced success factors identified in previous literature, as well as barriers that have been reported on several academic studies. However, this research found direct relationships between each success factor and the specific phases of the Define-Measure-Analyse-Improve-Control (DMAIC) process through which Six Sigma improvements are deployed. It was also found that some factors influence on others and that critical success factors inhibit the negative effects of obstructive barriers.

The project leaders agreed on several facts commonly experienced. However, no major generalisations can be made from this study since it was performed in a single company due to the purpose of collecting empirical rich in-depth data and the time available to conduct the study. Therefore, further research is suggested to validate the findings and the relationships between the factors and the DMAIC process, which can vary among different contexts and industries. Nevertheless, this research makes a useful contribution since no previous study analyses specifically these relationships described, moreover under the context of an Ecuadorian company. This study also provides interesting insights to practitioners who can make use of the findings when implementing projects, by ensuring the critical success factors and strategically avoiding or overcoming the barriers that may appear along the DMAIC process.
DECLARATION

No portion of the work referred to in the dissertation has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.
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DEDICATION

I dedicate this dissertation to my beloved parents and sisters.

ACKNOWLEDGEMENTS

I would like to express extensive gratitude to my dissertation supervisor Dr. Claire Moxham, for her valuable support and constructive feedback during the entire process of conducting this research.

I also thank my parents for their constant emotional support and for inspiring and encouraging me to pursue new goals with their example of commitment and perseverance.

Finally, but not least important, I thank God for giving me the strength, patience and courage to perform my daily work.
1. INTRODUCTION

1.1. Research Background

Quality management approaches have been utilised by companies since the 1930s (Dahlgaard-Park, 2011). Built on the work of Shewart and Deming, and the Total Quality Management (TQM) approach (Proudlove et al., 2008), Six Sigma emerged in the 1980s as a system that involves the rigorous pursuit of learning, problem-solving and process improvement (Easton and Rosenzweig, 2012) which produces highly significant benefits to firm profitability (Swink and Jacobs, 2012). Six Sigma has been defined as “an organised, parallel-meso structure to reduce variation in organisational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives” (Schroeder et al., 2008, p.540). This approach has similarities to the ideas and philosophies of quality programs of the past which have been taught for years, but differs in scope and complexity due to its practical method followed to achieve these ideas and philosophies (Kumar et al., 2008). This practical and rigorous method for managing Six Sigma improvement activities is known as the Define - Measure - Analyse - Improve - Control (DMAIC) process (Linderman et al., 2003).

Some of the key reasons why companies decide to implement Six Sigma, as outlined by Henderson and Evans (2000), include: (a) to be responsive to and focused on the customer base; (b) to improve product and service performance; (c) to improve financial performance and profitability; (d) to be able to quantify their quality programs; and, (e) to be considered as suppliers for a business. Many global organisations have developed Six Sigma programmes of their own (Andersson et al., 2006), and Six Sigma is now being applied in a vast number of different types of industries from both manufacturing and service sectors (Kwak and Anbari, 2004). Starting at Motorola (Breyfogle, 1999), Six Sigma has been adopted by leading companies such as General Electric, 3M, AlliedSignal and Sony (Coronado and Antony, 2002). After implementing Six Sigma and applying its methodologies and practices, Motorola reported savings of
approximately $2.2 billion within four years (Nair et al., 2011). Moreover, this methodology has also proven to be applicable and generate successful results on small and medium enterprises (Antony et al., 2005; Antony, 2008a; Deshmukh and Chavan, 2012). However, not all companies can claim to have achieved the same benefits, as it is the case of 3M (Chakravorty, 2009). These contrasting results demonstrate the complexity of Six Sigma implementation, where critical success factors must be recognised.

Despite the enormous popularity and the widespread adoption of Six Sigma, there is a rising concern regarding the failures of Six Sigma programmes (Chakravorty, 2009). As any other system, the success of Six Sigma project implementation is conditioned by the existence of several factors and the control or elimination of barriers to it. Taking into consideration these factors can ensure companies’ a successful implementation; it may prevent companies from failing on doing so and, moreover, from incurring into financial losses. Therefore, given the high acceptance of Six Sigma in industry and the interest of companies on looking for ways to confront the challenges of implementing this approach, it has also been stated that it is important to continue to study in-depth the Six Sigma phenomenon from the academic perspective (Nonthaleerak and Hendry, 2008; Schroeder et al., 2008; Tjahjono et al., 2010). Additionally, much of the research until now has focused on success factors, but there has been a lower amount of research targeting the obstructive role of barriers to Six Sigma implementation and the impact of organisational factors on these barriers, particularly in a developing country context (Aboelmaged, 2011). Moreover, only few of these papers identify the relationship between success factors, barriers and the DMAIC process through which Six Sigma is implemented (Aboelmaged, 2011). Identifying these relationships may allow companies to prevent failures on their Six Sigma implementations by being strategically prepared to overcome issues or prevent them to happen when possible.
1.2. Research Aim, Objectives and Questions

Taken into consideration the previous statements, the aim of this research is to study the success factors and barriers to Six Sigma project implementation in a developing country context, and how these factors are related to specific phases of the process through which Six Sigma projects are deployed. In order to achieve this aim, the following objectives are outlined:

- Identify which are the success factors and barriers to Six Sigma project implementation experienced by project leaders.
- Identify whether there is an existing relationship between each Six Sigma success factor and specific phases of the DMAIC process through which Six Sigma projects are developed.
- Identify if there is an existing relationship between each barrier to Six Sigma project implementation and specific phases of the DMAIC implementation process.
- Assess the impact of specific success factors and obstacles on projects with high, moderate and low success.

Based on the described background that details the importance of further studies on this topic and the aim and the objectives of this research, the following research questions are established:

- **RQ 1.** How are the identified success factors for Six Sigma project implementation related to each phase of the DMAIC process?

- **RQ 2.** How are the identified barriers to Six Sigma project implementation related to each phase of the DMAIC process?

To answer these questions, a rigorous procedure was conducted as described in the following section, where the overview of the dissertation structure is provided.
1.3. Overview of the Dissertation Structure

This dissertation is structured as detailed in Figure 1.1. Following the present Chapter One, Chapter Two presents the existing literature on Six Sigma relevant to this study, including Six Sigma main features, the methodology for Six Sigma project deployment, the success factors and barriers to Six Sigma project implementation identified by previous authors, and the literature gaps identified on the existing academic literature that justify this research. Chapter Three starts outlining the research questions that were defined based on these identified gaps. Additionally, the case study methodology performed in an Ecuadorian company to conduct this research is described, including the data collection and analysis methods. Chapter Four presents the findings obtained from the case study conducted. Chapter Five discusses the findings from Chapter Four and contrasts them with the previous existing literature contained in Chapter Two. Finally, Chapter Six concludes with a review of the research aim and objectives, the contributions provided by this dissertation, some practical implications and limitations of this study and recommendations for future research.
2. LITERATURE REVIEW

2.1. Introduction

This chapter presents and critically analyses the existing literature on Six Sigma relevant to this research. First, a brief description of Six Sigma definitions and its main features is provided. Second, the methodology utilised for Six Sigma project deployment is presented, outlining and explaining the different phases of the method. Further, a literature review on success factors and barriers to Six Sigma project implementation is developed. Finally, the last section of this chapter summarises the justification and focus of this research.

2.2. Six Sigma: Definition and Main Features

Six Sigma (SS) is defined by Pande et al. (2000, p.XI) as a “comprehensive and flexible system for achieving, sustaining and maximising business success”, uniquely driven by close understanding of customer needs, disciplined use of data and statistical analysis, and diligent attention to managing, improving, and reinventing business processes. The authors state that the types of business success a company may achieve are broad since the proven benefits of the SS system are diverse, including: cost reduction, productivity improvement, market-share growth, customer retention, cycle-time reduction, defect reduction, culture change, product/service development, and so on. The main functionality of SS projects is to reduce cost of poor quality or increase operational efficiency and effectiveness in general (de Mast, 2006). Sis Sigma is thought to provide a structure and promote a culture that promotes problem/opportunity identification, process analysis, and the creation of sustained improvements (Swink and Jacobs, 2012). Researchers argue that SS differs from other process management approaches, being distinguished by its organisational structures, methods, and emphasis on customer-oriented metrics (Linderman et al., 2003; Sinha and Van de Ven, 2005; Schroeder et al., 2008 as cited by
Swink and Jacobs, 2012). As stated by Chowdhury (2003), the power of SS is the combination of people power with process power.

There are many factors that contribute to the potential of SS, of which the critical ones, as enlisted by Goh (2002), are presented in Figure 2.1.

![SIX SIGMA Characteristics](image)

<table>
<thead>
<tr>
<th>SIX SIGMA Characteristics (Goh, 2002)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top down initiation of a serious quality journey (not a book-keeping exercise)</td>
</tr>
<tr>
<td>Hierarchy of expertise and execution</td>
</tr>
<tr>
<td>Structured deployment of tools</td>
</tr>
<tr>
<td>Customer focus (in contrast to inward-looking standardisation)</td>
</tr>
<tr>
<td>Clear performance metrics (sigma levels; defects per million opportunities (DPMO))</td>
</tr>
<tr>
<td>Fact-based decisions (not procedure or judgment based)</td>
</tr>
<tr>
<td>Application of statistics (analytical, not will power)</td>
</tr>
<tr>
<td>Service as well as engineering applications</td>
</tr>
<tr>
<td>Recognised time effects in process analysis (with explicit provisions for short-term and long-term variations)</td>
</tr>
<tr>
<td>Result oriented (project by project; three to six months project duration makes progress tangible)</td>
</tr>
<tr>
<td>Business oriented (achievements often required to be expressed in financial terms)</td>
</tr>
<tr>
<td>Good timing (coming at a time when personal computing hardware and statistical software packages had become widely available, making pervasive implementation possible)</td>
</tr>
</tbody>
</table>

In statistical terms, six sigma means 3.4 defects per million opportunities (DPMO), where sigma is the term used to represent the variation about the average of a process (Coronado and Antony, 2002). Six Sigma mainly seeks to reduce defects in business processes by applying several tools and techniques under a methodological and disciplined structure (Kumar et al. 2008). This
structured approach for managing improvement activities is represented by the methodology Define - Measure - Analyse - Improve - Control (DMAIC) used in process improvement, or Define - Measure - Analyse - Design - Verify (DMADV) used in product/service design improvement (Linderman et al., 2003). The following section provides description of the SS DMAIC methodology.

2.3. The DMAIC Methodology

In SS, the structured method DMAIC provides a ‘metaroutine’ that organisational members follow to solve problems and improve processes, ensuring an adequate search for alternative solutions to a problem and with this, avoiding early jumping to conclusions (Schroeder et al., 2008). Using this SS method and tools provide a mechanism for improvement teams to achieve their goals, especially for challenging projects (Linderman et al., 2006). The five steps of the SS DMAIC framework are described in Figure 2.2 (Henderson and Evans, 2000; Senapati, 2004).

1. Define Phase: Who are the customers and what are their priorities?

- A Six Sigma project team identifies a project suitable for Six Sigma efforts based on business objectives as well as customer needs and feedback.
- As part of the definition phase, the team identifies those attributes, called CTQs (critical to quality characteristics), that the customer considers having the most impact on quality.
- Project plans are developed and the relevant processes are identified. The Supplier-Input-Process-Output-Customer (SIPOC) mapping exercise can be used effectively to describe the process.

2. Measure Phase: How is the process measured and how is it performing?

- The team identifies the key internal processes that influence CTQs and measures the defects currently generated relative to those processes.
- The process variables are measured through data quality checks, repeatability and reproducibility studies, and process stability is addressed.

Figure 2.2: Six Sigma DMAIC process (Adapted from Henderson and Evans, 2000; Senapati, 2004) (continued)
2.4. Six Sigma Hierarchical Structure

Six Sigma goals are achieved by a variety of improvement specialists, referred to as Black Belt (BB), Master Black Belt (MBB), Green Belt (GB) and Project Champion (Linderman et al., 2003). The mentioned specialists have different roles and responsibilities. They receive intensive differentiated training that is tailored for their ranks and is designed to improve their knowledge and skills in statistical methods, project management, process design, problem-solving techniques, leadership skill, and other managerial skills (Zu et al., 2008).

The DMAIC method involves different organisational members at different steps in the method. Champions play an active role in the Define step but a supporting role in the remaining steps; Process Owners take a much more active role in the Control step but a supporting role in the other steps; GBs tend
to take a more active role in the Measure, Analyse, and Improve steps; and, finally, BBs serve as project leaders and are active in all steps of the process (Schroeder et al., 2008). GBs can also perform a project leading role as it is further explained. In SS methodology, belts are required to have both technical and managerial skills, ability to understand and implement the tools and techniques and be able to coach the team about the same (Gijo and Rao, 2005). Thus, selection of these belts plays a vital role in successful SS implementation (Gijo and Rao, 2005). Table 2.1 summarises the description of the different roles in a SS organisation, as outlined by Pyzdek and Keller (2010).

<table>
<thead>
<tr>
<th>Responsible Entity</th>
<th>Roles</th>
<th>Responsibilities</th>
</tr>
</thead>
</table>
| Executive SS Council | Strategic leadership | • Ensures SS goals are linked to enterprise goals  
• Develops new policies as required  
• Aligns process excellence efforts across the organisation  
• Suggests high-impact projects  
• Approves project selection strategy |
|                      | Ensures progress | • Provides resources  
• Racks and controls progress toward goals  
• Reviews improvement teams’ results (BB, GB, other)  
• Reviews effectiveness of SS deployment |
| Cultural transformation |                 | • Communicates vision  
• Removes formal and informal barriers  
• Commissions modification of compensation, system, reward and recognition systems |
| Director, SS | Manages SS infrastructure and resources | • SS champion  
• Develops enterprise SS deployment  
• Owns the SS project selection and prioritisation process  
• Ensures SS strategies and projects are linked through quality function deployment  
• Among others |

Table 2.1: Six Sigma Roles and Responsibilities  
(Adapted from Pyzdek and Keller, 2010)  
(continued)
<table>
<thead>
<tr>
<th>Responsible Entity</th>
<th>Roles</th>
<th>Responsibilities</th>
</tr>
</thead>
</table>
| SS Certification Board | Certifies BBs Board representatives include MBBs and key SS leaders | • Works with local units to customise BB and GB requirements to fit business needs  
• Develops and implements systems for certifying BBs and GBs  
• Certifies BBs |
| SS Core Team | Cross-functional SS team Part-time change agent | • Provides input into policies and procedures for successful implementation of SS  
• Facilitates SS activities such as training, special recognition events, BB testing, etc. |
| Master Black Belt | Enterprise SS expert Permanent full-time change agent Certified BB with additional specialised skills or experience especially useful in deployment of SS across the enterprise | • Highly proficient in using SS methodology to achieve tangible business results  
• Technical expert beyond BB level on one or more aspects of process improvement (e.g., advanced statistical analysis, project management, among others)  
• Identifies high-leverage opportunities for applying the SS approach across the enterprise  
• Basic BB training  
• GB training  
• Coach/Mentor BBs  
• Participates on the SS Certification Board to certify BBs and GBs |
| Black Belt | SS technical expert Temporary, full-time change agent (will return to other duties after completing a two to three year tour of duty as BB) *In some companies the BB is external | • Leads business process improvement projects where SS approach is indicated  
• Successfully completes high-impact projects that result in tangible benefits to the enterprise  
• Demonstrated mastery of BB body of knowledge  
• Demonstrated proficiency at achieving results through the application of the SS approach  
• Internal Process Improvement Consultant for functional areas  
• Coach/mentor GBs  
• Recommends GBs for certification |
| Green Belt | SS project originator/leader Part-time SS change agent Performs normal duties while participating on SS project teams SS champion in local area | • Demonstrated mastery of GB body of knowledge  
• Demonstrated proficiency at achieving results through the application of the SS approach  
• Recommends SS projects  
• Teaches local teams  
• Successful implementation of at least one SS project every 12 months to maintain their GB certification |

Table 2.1: Six Sigma Roles and Responsibilities  
(Adapted from Pyzdek and Keller, 2010)  
(continued)
Table 2.1: Six Sigma Roles and Responsibilities  
(Adapted from Pyzdek and Keller, 2010)

<table>
<thead>
<tr>
<th>Responsible Entity</th>
<th>Roles</th>
<th>Responsibilities</th>
</tr>
</thead>
</table>
| SS Improvement Team         | Primary vehicle for achieving SS improvements | • Completes chartered SS projects that deliver tangible results  
• Identifies SS project candidates |
| Leaders and Managers        | Champions for SS                            | • Ensures flow-down and follow-through on goals and strategies within their organisations  
• Plans improvement projects  
• Charters or champions chartering projects  
• Identifies teams or individuals required to facilitate SS deployment  
• Integrates SS with performance appraisal process  
• Identifies, sponsors and directs SS projects  
• Holds regular projects reviews  
• Among others |
| Project Sponsor             | Charters and supports SS project teams      | • Ultimately responsible for the success of sponsored projects  
• Actively participates in projects  
• Ensures adequate resources are provided for project  
• Personal review of progress  
• Identifies and overcomes barriers and issues  
• Evaluates and accepts deliverable |
| SS Improvement Team Member  | Learns and applies SS tools to projects     | • Actively participates in team tasks  
• Communicates well with other team members  
• Demonstrates basic improvement tool knowledge  
• Accepts and executes assignments as determined by team |

2.5. Measuring Success of Six Sigma Projects

As aforementioned, many documented success cases have recorded millions of monetary savings due to implementing SS and its DMAIC methodology. Industries from diverse sectors have reported the benefits of implementing this approach (Kwak and Anbari, 2004): manufacturing sector, financial sector, healthcare sector, engineering and construction sector, research and development sector, among others. However, there have also been SS
programme failures when deployment has been weak and when there has been insufficient focus on setting achievable goals and/or training employees in the use of proper problem-solving techniques (Breyfogle III, 1999). Hence, understanding the critical success factors and barriers to SS project implementation is crucial, since it can prevent companies from suffering failures or from investing large amount of resources and effort on coping with issues emerging during the implementation processes.

Before studying the success factors and barriers to SS project implementation, it is important to determine how to measure whether a Six Sigma project is successful or not. According to Pyzdek (2003), project success is possible to measure by defining metrics for each project deliverable based on customer or sponsor requirements, in order to keep the project focused on its goals and objectives. Additionally, to accurately measure project success it is necessary to keep track of how the resources consumed by the project are used (Pyzdek, 2003). Considering that what makes SS stand out from previous quality management initiatives is its focus on improving business performance in terms of increasing profits (Swink and Jacobs, 2012), success SS is also measured in terms of the amount of financial savings obtained from the projects. According to Morris and Pinto (2004), project success can be measured at three levels, as shown in Table 2.1.

<table>
<thead>
<tr>
<th>1. Project Management Success – Was the project done right?</th>
<th>2. Project Success – Was the right project done?</th>
<th>3. Consistent Project Success – Where the right projects done right, time after time?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• This level is regarding to managing time, cost and quality. The principle is that the goal is to deliver the project so that it meets the objectives within the constraints.</td>
<td>• This is the level of most interest to the owner or sponsor of the project. It is a measure of “value for money” in its broader sense. The assumption is that the project will be successful only if it successfully delivers the benefits that were envisaged by the people and organisations (i.e., the stakeholders) that agreed to undertake the project in the first place.</td>
<td>• The focus moves from project management success, through project success to consistent project success. Projects are the means by which all organisations accomplish business change, as well as the means by which some organisations deliver profits to their shareholders.</td>
</tr>
</tbody>
</table>

Table 2.2: Levels of project success (Adapted from Morris and Pinto, 2004)
Six Sigma project success can be measured in a similar way, since the aim is to select strategic projects and obtain the expected financial savings for the company, by utilising effectively the resources available and ensuring the sustainability of the improvements. As an example, Nonthaleerak and Hendry (2008) measured the level of success of the SS projects developed at the companies that they studied by analysing the financial evidence obtained from the projects together with perceived success of SS implementation. They defined three levels of success as shown in Figure 2.3.

<table>
<thead>
<tr>
<th>Low success:</th>
<th>Moderate success:</th>
<th>High success:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined as having no financial evidence or insignificant financial savings from six sigma project(s) and no perceived success</td>
<td>Defined as having no financial evidence or a moderate amount of financial savings from six sigma project(s) and some perceived success</td>
<td>Defined as having a significant amount of financial savings from six sigma project(s) and with high-perceived success</td>
</tr>
</tbody>
</table>

Figure 2.3: Levels of SS Success (From Nonthaleerak and Hendry, 2008)

As it is possible to note, the perception of success is very subjective, but the authors justified it in each case using evidence related to key performance indicators, such as improving customer satisfaction or productivity (Nonthaleerak and Hendry, 2008). However, aspects such as time management (Morris and Pinto, 2004) or sustainability can also be included when measuring project success.

### 2.6. Success Factors on Six Sigma Project Implementation

Several authors have described the factors influencing successful SS implementation. For instance, Coronado and Antony (2002) state that SS implementation is a complex and central process, where critical success factors (CSFs) in its implementation must be recognised. Some of the factors identified...
by them are management involvement and commitment, cultural change, communication, organisation infrastructure, training, linking SS to business strategy, linking SS to customer, among others. Other authors such as Kwak and Anbari (2006), based on literature reviews and discussions with SS leaders from various organisations, note four key elements of successful SS applications: management involvement and organisational commitment, project management and control skills, cultural change and continuous training. Additionally, Van Iwaarden et al. (2008), state that a successful SS implementation has to build on experiences with earlier quality management programmes and a quality maturity. According to Dale et al. (2007) SS’s success also depends on adherence of SS to a whole philosophy (not treated as a stand-alone activity).

In addition to the previous contributions and findings on success factors, Nonthaleerak and Hendry (2008) identify as three implementation aspects that influence the success of SS implementation a pattern of full-time or part-time BBs, belts reporting structure and the inclusion of a team of technical support. Furthermore, Nonthaleerak and Hendry (2008) provide evidence on CSFs previously cited such as the effectiveness of SS training and the nature of management involvement.

Many of these mentioned authors agree on several success factors and have provided evidence to their positive influence. It is important to note that some of these success factors, such as adherence of SS to a whole philosophy or cultural change, apply to a SS programme implementation across a company. However, success factors specific to individual project implementation can be enlisted. In this sense, Table 2.3 presents the success factors identified by several authors that positively influence on SS project implementation process during the development of the DMAIC stages.
<table>
<thead>
<tr>
<th>Success Factors for SS Project Implementation</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB / Technical support</td>
<td>Nonthaleerak and Hendry (2008)</td>
</tr>
<tr>
<td>Supportive team / Effective team work</td>
<td>Proudlove et al. (2008)</td>
</tr>
<tr>
<td>Link of the project to the business strategy</td>
<td>Antony and Banuelas (2002), Brun (2011), Coronado and Antony (2002), Snee (2001), Ho et al. (2008)</td>
</tr>
<tr>
<td>Link of the project to customer (customer focus)</td>
<td>Antony and Banuelas (2002), Coronado and Antony (2002), Dale et al. (2007), (Goh, 2002), Ho et al. (2008), Kumar et al. (2009)</td>
</tr>
<tr>
<td>Link of Six Sigma to human resources (i.e. rewards and compensations)</td>
<td>Antony and Banuelas (2002), Coronado and Antony (2002), Henderson and Evans (2000), Ho et al. (2008)</td>
</tr>
</tbody>
</table>

**Table 2.3: Success Factors for SS Project Implementation (various sources)**
In order to provide a clear understanding of the SS project implementation success factors from Table 2.3. that have been studied in more depth, a description of findings from previous literature is provided in the following section:

- **Strategic Selection of SS projects:**
  Six Sigma is deployed by carrying out a series of improvement projects. According to Pande et al. (2000), SS improvement projects require at least three basic qualifications: (1) having an existing gap between current and desired/needed performance; (2) the cause of the problem is not clearly understood; and, (3) the solution is not predetermined nor is the optimal solution apparent. To select between projects, it is essential to prioritise projects which provide maximum financial benefits to the organisation (Coronado and Antony, 2002; Corbett, 2011). Unlike many quality initiatives, the implementation of SS is top down, starting with upper management (Coronado and Antony, 2002; Raisinghani et al., 2005; Pyzdek and Keller, 2010). The decision rights to initiate a project are allocated to senior management (Schroeder et al., 2008). An established methodology needs to ensure that the project selection criteria are aligned to the company’s goals rather than being merely based on short-term financial targets and that appropriate large scale projects are selected (Nonthaleerak and Hendry, 2008; Corbett, 2011). Additionally, it has been noted that regardless of the project complexity, strategic project selection enables clarity of metrics associated with the process improvement project (Nair et al., 2011). Zimmerman and Weiss (2005) argue that unclear project objectives and selecting wrong SS projects result on failures.

- **Strong Leadership and Managerial Commitment/Involvement/Support:**
  Many authors argue that committed leadership of top management is crucial to the success of SS implementation. Quality is not a responsibility that can be solely delegated. Management is responsible for leading a SS transformation process (Breyfogle III, 1999) and SS success demands commitment even from the highest corporate executives (Henderson and
Evans, 2000). Additionally, management sponsors require providing the management interface necessary to ensure the project remains on course relative to its objectives, or to change objectives if necessary given new information found by the project team (Pyzdek and Keller, 2010). Pyzdek and Keller (2010) identify effective management support strategies such as mentoring, identification of informal leaders and their support, finding of legitimate ways around people, procedures, resource constraints and other roadblocks.

It is important to note that managerial interest and involvement in the projects are not only evidenced when a project is highly beneficial in financial terms. As Nonthaleerak and Hendry (2008) determined in their study, management can also be involved when non-financial targets, which are from high interest of managers, are selected.

- **Effective Training:**
  
  As previously described, SS is implemented by improvement specialists (BBs, MBBs, GBs and Project Champions) which require intensive differentiated training (Zu *et al.*, 2008). Training is required to cover both qualitative and quantitative measures and metrics, leadership, and appropriate project management practices and skills. There are almost no key management skills that do not play a role at some point in building a SS organisation (Pande *et al.*, 2000). It is critical that people involved in the projects acquire the knowledge of the method, tools, and techniques of SS, and that they are able to communicate effectively with actual data and meaningful analysis (Kwak and Anbari, 2004).

- **Black Belt and Technical Support:**
  
  Companies argue that less experienced belts need more support from BBs to guide them in executing the project and choosing appropriate tools (Nonthaleerak and Hendry, 2008). According to Pyzdek and Keller (2010), since a GB is not trained in all the tools needed in the DMAIC cycle, when they lead projects they must be actively supported by a BB. Support from the higher levels of specialists in SS is crucial during the entire implementation processes (Pyzdek and Keller, 2010).
• **Appropriate Understanding, Selection and Use of Quality Tools and Techniques:**

There is a wealth and variety of tools and techniques that are utilised within the DMAIC approach (see Pyzdek and Keller, 2010; Tjahjono *et al.*, 2010; Raisinghani *et al.*, 2005) which provide employees with the capabilities of adopting and developing the SS DMAIC methodology (Coronado and Antony, 2002). However, in some occasions there is confusion as to which tools work best for specific business requirements (Tjahjono *et al.*, 2010), especially if there is not an appropriate guiding from, for example, experienced BBs. Moreover, Nonthaleerak and Hendry (2008) note that the perception of tools’ complexity very much depends upon the team member’s educational background. Companies identify that less experienced belts need more support from a MBB to guide them in executing the project and choosing appropriate tools, in order to avoid unnecessary project delays (Nonthaleerak and Hendry, 2008). Even though tools and techniques vary, it is essential to apply the right tool in the right situation in order to achieve successful results (Tjahjono *et al.*, 2010).

• **Supportive Organisational Culture:**

Key to the success of SS is acceptance, which requires everyone in a company, from the Chief Executive Officer (CEO) to the factory workers, to understand and appreciate the power and benefits of SS (Chowdhury, 2003). Six Sigma is considered a breakthrough management strategy, since it involves adjustments to the firm’s values and culture for its introduction and substantial change in the organisation structure and infrastructure (Coronado and Antony, 2002). People facing organisational change and cultural challenges due to implementation of SS require to understand the nature and aim of the change, which involves having a clear communication plan and channels, motivating individuals to overcome resistance, and educating senior managers, employees, and customers on the benefits of SS (Kwak and Anbari, 2004).
• **Team effectiveness:**
  Authors such as Proudlove *et al.* (2008), mention that team effectiveness can be related to project progress in terms of both speed and quality of work. According to their findings, team working can be considered key to effective improvement in GB projects.

• **Effective Communication and Reporting Structure:**
  In order to implement SS within any organisation, some organisational characteristics are fundamental elements that need to be already in place, such as team work, communication skills and long-term focus/strategy (Coronado and Antony, 2002). A communication plan is crucial factor on SS project implementation (Henderson and Evans, 2000) and it enhances the involvement of the personnel with the SS initiative. It is important to establish a communication program to propagate the business strategy of the organisation and, after implementation of SS projects, publish results (Coronado and Antony, 2002). Additionally, SS projects are process-oriented and most processes that have significant impact on quality cut across several different departments. Thus, cross-functional collaboration is required and good communication is crucial, either if it is formal or informal, which determines the project manager (Pyzdek and Keller, 2010).

• **Link of the Project to the Business Strategy:**
  SS requires adherence to a whole philosophy and SS projects must be targeted for process and product improvements that have a direct impact on both financial and operational goals (Coronado and Antony, 2002). Pyzdek and Keller (2010) suggest the development of strategy deployment plans, aimed to identify the linkage between stakeholder satisfaction, strategies, and metrics.

• **Link of the Project to the Customer:**
  Six Sigma projects are required to begin with the determination of customer requirements, in order to seek the reduction of the gap between the company’s expected and actual performance, especially in terms of delivery time, reliability and customer satisfaction (Coronado and Antony, 2002).
• **Link of SS to Human Resources:**
  Human resources-based actions are required to be put into effect in order to promote desired behaviour and results, such as rewards and compensations to encourage successful selection and completion of SS projects (Coronado and Antony, 2002). Human resource functions need good harmonisation with the SS approach leading to a general involvement within the organisation (Tjahjono *et al.*, 2010).

• **Project Management and Control Skills:**
  Hoerl (2001) mentions that Black Belts in most cases are leaders of a team that is working together on a SS project, and while possessing the ability to apply statistical tools to solve real problems they also require organisational effectiveness skills such as team and project leadership (Hoerl, 2001). Project leaders require having several basic management skills to prevent projects from failing, such as setting agendas, rules, responsibilities and meetings (Coronado and Antony, 2002).

2.7. **Barriers to Six Sigma Project Implementation**

Despite the numerous benefits obtained from SS, successful implementation of SS projects is not easily achieved. Conversely, challenges emerge during project implementation process which, if not managed appropriately, can constitute barriers to the project deployment. SS project implementation can fail due to several factors. For instance, Snee (2001) identifies as barriers to SS project team success the lack of support by management, too large project scope, insufficient time to work in the project, and lack of a link between the project and the organisation’s strategic goals. Other authors such as Proudlove *et al.* (2008) provide an evaluation of SS implementation in a specific service industry, where several barriers such as difficulty on identification of customers and processes, deviations from the structured rigorous DMAIC process, lack of emphasis on the soft/people/cultural factors and a limited BB support, among others are identified. Further, authors such as Kumar *et al.* (2009) found as reasons for SS project failure: low emphasis on the voice of customers (VOC),
focus on short-term savings, over-emphasis on quick fix and selection of too big and complex projects with too large scope. Additionally, Aboelmaged (2011) provides a literature review on the barriers to SS implementation outlined by several authors and identifies the most influential barriers to SS implementation by performing a cross-sectional survey targeting CEOs, operations or quality managers in various organisational settings.

As described, several authors have identified numerous barriers to SS programme implementation from a managerial and also project leaders' perspective. Table 2.4 presents the barriers previously mentioned by various authors, which have proved to exert a negative influence on SS project implementation, specifically along the development of the DMAIC stages.

<table>
<thead>
<tr>
<th>Barriers to SS Project Implementation</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficient project selection (i.e. there is no structured and disciplined approach to selecting projects)</td>
<td>Antony et al. (2005), Antony and Desai (2009), Gijo and Rao (2005), Kumar et al. (2009), Snee (2001), Zimmerman and Weiss (2005)</td>
</tr>
<tr>
<td>Project scope too large</td>
<td>(Gijo and Rao, 2005), Kumar et al. (2009), Snee (2001)</td>
</tr>
<tr>
<td>Project objectives not important to the organisation / not linked to the organisation's strategic goals</td>
<td>(Gijo and Rao, 2005), Kwak and Anbari (2006), Proudlove et al. (2008), Snee (2001)</td>
</tr>
<tr>
<td>Lack of managerial support</td>
<td>Feng and Manuel (2008), Nonthaleerak and Hendry (2008), Proudlove et al. (2008), Snee (2001)</td>
</tr>
<tr>
<td>Insufficient time to work on project</td>
<td>Aboelmaged (2011), Antony et al. (2005), Antony and Desai (2009), Snee (2001)</td>
</tr>
</tbody>
</table>

Table 2.4: Barriers to SS Project Implementation (various sources)
(continued)
<table>
<thead>
<tr>
<th>Barriers to SS Project Implementation</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited Black Belt support</td>
<td>Antony et al. (2005), Proudlove et al. (2008)</td>
</tr>
<tr>
<td>No clear measure of success (deficient performance metrics defined)</td>
<td>Snee (2001)</td>
</tr>
<tr>
<td>Team too large</td>
<td>Snee (2001)</td>
</tr>
<tr>
<td>Difficulty on identification of customers and processes</td>
<td>Proudlove et al. (2008)</td>
</tr>
<tr>
<td>Difficulties selecting and applying complex SS tools and techniques</td>
<td>Chakravorty (2009), Gijo and Rao (2005), Nonthaleerak and Hendry (2008)</td>
</tr>
<tr>
<td>Difficulty in identifying process parameters</td>
<td>Aboelmaged (2011)</td>
</tr>
<tr>
<td>Difficulties collecting data</td>
<td>Feng and Manuel (2008), Gijo and Rao (2005)</td>
</tr>
<tr>
<td>Deviations from the structured DMAIC process/over-emphasis on quick fix</td>
<td>Gijo and Rao (2005), Kumar et al. (2009), Proudlove et al. (2008)</td>
</tr>
<tr>
<td>Focus on short-term savings</td>
<td>Kumar et al. (2009)</td>
</tr>
<tr>
<td>Insufficient financial resources</td>
<td>Antony et al. (2005), Antony and Desai (2009), Gijo and Rao (2005)</td>
</tr>
<tr>
<td>Insufficient resources to work in the project (i.e. computers)</td>
<td>Antony and Desai (2009), Gijo and Rao (2005)</td>
</tr>
<tr>
<td>Poor measurement of customer satisfaction</td>
<td>Aboelmaged (2011)</td>
</tr>
<tr>
<td>Low emphasis on the voice of customers</td>
<td>Kumar et al. (2009)</td>
</tr>
<tr>
<td>Unclear cost of poor quality</td>
<td>Aboelmaged (2011)</td>
</tr>
<tr>
<td>Difficulty to sustain project improvements</td>
<td>Aboelmaged (2011), Nonthaleerak and Hendry (2008)</td>
</tr>
<tr>
<td>Intangibility of the project results</td>
<td>Antony and Desai (2009)</td>
</tr>
<tr>
<td>Uncertainty of the project results</td>
<td>Aboelmaged (2011)</td>
</tr>
<tr>
<td>Difficulties with integration of different areas / coordination between functions</td>
<td>Gijo and Rao (2005), Snee (2001)</td>
</tr>
</tbody>
</table>

Table 2.4: Barriers to SS Project Implementation (various sources)
From the barriers listed in Table 2.4, some of them have been described in previous academic studies, while others are only mentioned as being identified by survey research. The following section summarises the findings from existing literature related to barriers on SS project implementation that have been discussed:

- **Deficient Project Selection:**
  Poor project selection methodology (i.e. there is no structured and disciplined approach to selecting projects) is a crucial barrier to successful SS project implementation (Antony and Desai, 2009). Some organisations place rigid expectations on belts, thus forcing them into considering everything as a SS project (Gijo and Rao, 2005) when, as aforementioned, it is essential that SS projects are selected according to their amount financial benefit to the organisation. Moreover the decisions to initiate a project are responsibility of upper management, and not solely of belts.

- **Project Scope Too Large:**
  The project scope should be for improvements that are attainable in three to six months of time frame (Snee, 2001). Too big and complex projects increases their probability of getting delayed or abandoned (Kumar et al., 2009; Gijo and Rao, 2005). According to Snee (2001), an unrealistic scope is probably the most commonly encountered cause of project failure.

- **Project Objectives Not Important to the Organisation / Not linked to the Organisation’s Strategic Goals:**
  Some organisations are unable to link their projects to their goals and objectives (Gijo and Rao, 2005), when in practice they must be tied to the bottom line in some way (Snee, 2001). Projects lacking of this linkage fall behind schedule or even fail (Brice as cited by Kumar et al., 2009).

- **Insufficient / Deficient Training:**
  As previously described, effective training is a key success factor in implementing SS. Conversely, insufficient and/or deficient training may
reflect on issues on project deployment, such as not being able to select and apply the appropriate tools.

- **Difficulties Selecting and Applying Complex SS Tools and Techniques:**
  Authors such as Nonthaleerak and Hendy (2008) evidenced that the perception of tools' complexity very much depends upon the educational background of the belts. For example, belts with engineering degrees and work in manufacturing areas may have fewer concerns than ones from non-manufacturing areas, regarding to understanding the application of statistical tools. Additionally, Nonthaleerak and Hendy (2008) identified that less experienced belts require more support from a MBB, for instance, on guiding them in executing projects and selecting appropriate tools.

- **Lack of Managerial Support:**
  As previously mentioned managerial commitment and support is critical to SS project implementation success. However, it is possible that management and leadership are not committed to the system due to, for example, a lack of link between SS projects and a wider strategic approach to improvement (Proudlove *et al.*, 2008). It also occurs that in some organisations top management may be interested in SS implementation while process owners or champions of the projects are not (Gijo and Rao, 2005).

- **Insufficient Time to Work on Project:**
  Snee (2001) mentions that BBs are recommended to work full-time, being able to spend 80 per cent of that time on a project. GBs, on the other side, are change agents who work part-time on process improvement. According to Snee (2001), GBs should be able to spend at least 20 per cent of their time on their projects. However, Pyzdek and Keller (2010) indicate that although most experts advocate that the GB spend around 10 and 20 per cent of their time on projects, in most cases they only do it between 2 and 5 per cent. In this sense, project delays occur when belts and their teams do
not have sufficient time to work on their projects, since most of the GB’s time is spent performing their normal work duties.

- **Limited Black Belt support:**
  Black Belt support is considered a success factor as previously mentioned. When BB support is limited, GBs may have issues getting stuck during project implementation and make inappropriate decisions (when they are inexperienced for example) during project implementation. However, Proudlove et al. (2008) evidenced in their research that limited BB support in some occasions is not considered as a significant barrier for projects.

- **Team Too large:**
  Snee (2001) suggests that the team that works with the BB (or GB team leader) should be small, with no more than four to six members. As the size of the team increases, it also becomes increasingly difficult to find mutually agreeable meeting times and to reach consensus (Snee, 2001).

- **Difficulties Collecting Data:**
  Six Sigma is a data-driven approach and it is mandatory to support any conclusion from the project by correct data gathering and its analysis (Gijo and Rao, 2005). As mentioned by the authors, in some cases the relevant data are hard and/or expensive to collect. According to Feng and Manuel’s findings (2008), non-availability of data seems to be the major factor in the delay of a project, especially for the ones that require data acquisition from multiple departments. The fear and frustration of people to collect data may also hamper the progress of a SS project (Gijo and Rao, 2005).

- **Resistance to Change / Non Supportive Culture:**
  As in many other management processes, it is not surprising that a SS initiative encounters more or less resistance from organisational members and executives (Feng and Manuel, 2008). Hence, organisations without a change management plan may perceive a high risk of failing. For this reason, senior management’s strong commitment, support, and leadership are essential in dealing with any cultural issues or differences related to SS
implementation (Kwak and Anbari, 2004). As identified by Proudlove et al. (2008), a major weakness of SS is a lack of emphasis on the soft/people/cultural factors.

- **Deviations From the Structured DMAIC Process/ Over-emphasis on Quick Fix:**
  Some organisations may tend to feel impatient to get results, thereby deviating from the DMAIC methodology and looking for closure of projects by short-cut methods (Gijo and Rao, 2005). The use of the DMAIC process has been found to be beneficial but difficult, creating a source of frustration for many GBs (Proudlove et al., 2008). As the authors note, this can also occur due to the tendency of looking for ‘quick wins’, when this has been commonly done in previous improvement projects. Nonetheless, MBBs play an important role pulling teams back to address each part of the process rigorously (Proudlove et al., 2008).

- **Insufficient Resources to Work on the Project (i.e. computers):**
  At times, SS projects require a lot of data gathering and analysis, generating the need of proper software and computational facilities available (Gijo and Rao, 2005). Additionally, Gijo and Rao state that some organisations are unable to spare their people in the mandatory training of SS methodology and the equipment for trials, such as pilot runs, due to the usual production pressures.

- **Difficulty to Sustain Project Improvements:**
  Nonthaleerak and Hendry (2008) mention that the Control phase of the DMAIC process aims to institutionalise the improvement results from the SS project through documentation and standardisation of the new procedures. However, in their study they found that project leaders express concerns regarding this phase. For example, this can be particularly problematic when the project is cross-functional and when project ownership is not properly transferred to a process owner. Thus, they conclude that evidence suggests that process control tools alone are insufficient to sustain the improvement results, and that the role of management along with a good
quality control system can also be important. Same is identified by Snee (2001), reinforcing once again the importance of an active involvement and support from management as key to successful SS improvement.

- **Difficulties with Integration of Different Areas / Coordination Between Functions:**
  As SS projects are cross-functional, lack of proper coordination may lead to improper selection of CTQs, incorrect data, analysis and solutions (Gijo and Rao, 2005). Many projects have failed due to the lack of this support caused by personnel shortages (Snee, 2001). Furthermore, as described in the previous outlined barrier, this may lead to resistance to implement solutions.

The barriers described above negatively impact on different stages of SS project implementation process. Moreover, some of them may be qualified as more crucial than others, according to how much they inhibit the harmonious flow of the project. Therefore, studying the impact of these barriers provide practitioners with critical useful knowledge that may assist them with the identification of preventive measures required to avoid or control these issues.

### 2.8. Literature Gap and Justification of this Research

Nonthaleerak and Hendry (2008) argue that it is important for the academic community to continue to study the SS phenomenon given its acceptance in industry. More scholarly research is needed to “develop additional in-depth, scientific understanding of SS and separate fact from fiction” (Schroeder et al., 2008, p.537). Nonthaleerak and Hendry (2008) also mention the need of more conclusive empirical evidence that allows drawing conclusions on issues such as strengths and weaknesses of the SS approach.

Aboelmaged (2011), who as aforementioned identified the most influential barriers to SS implementation by conducting a survey, suggests that future research is required to enhance that survey data by using other methods such
as case study or longitudinal data, in order to provide more in-depth comparative insights into barriers to SS implementation in different contexts or time periods, expanding by doing so the existing literature on success factors and barriers. A process-based approach that focuses on barriers associated with each phase of the process through which a SS project is implemented is also suggested by Aboelmaged (2011). Having described the DMAIC methodology stages and the success factors and barriers to SS project implementation, it is possible to look for relationships between these factors and barriers, and specific DMAIC phases. Only few authors have directly associated success factors and barriers with each phase of the DMAIC process. Moreover, there has been less research that study success factors and barriers at the same time, providing an evaluation of the relationship of these and, for example, how can a project succeed regardless the existence of some barriers due to the high impact of specific success factors and, conversely, how can some projects that perceived specific success factors can fail due to the existence of highly obstructive barriers which can impact in such way that there is no room for success in the project.

In this sense, by identifying the requirements of more in-depth research on enablers and barriers to SS project implementation and the need of an extended verification of the existing theoretical knowledge and propositions in the field, it is possible to contribute to the literature by examining more SS projects, analysing their results and identifying, by case study research, critical success factors and barriers to implementations and the association of these with each phase of the DMAIC process. Hence, this research intends to explore these issues and, moreover, considering that the majority of the studies conducted in this field (India: Antony and Desai, 2009; Brazil: Martins et al., 2006; Italy: Brun, 2011; UK: Antony and Banuelas, 2002; UK: Antony et al., 2005; Thailand: Nonthaleerak and Hendry, 2008; Netherlands, UK and USA:: Van Iwaarden et al., 2008; among others) have not taken place in the context of a small, developing South American country, this research provides an overview of the implementation of SS projects and their success factors under this context, since it was conducted in an Ecuadorian company.
3. RESEARCH METHODOLOGY

3.1. Introduction

In this chapter the methodology designed to conduct this research is described. First, the research questions are presented, which originated from the identification of the literature gaps and research suggestions from the mentioned authors in Chapter Two. Second, the research design is detailed, which was elaborated according to the type of research questions. In this section, the qualitative research strategy is defined and the case study approach utilised for this study is presented, detailing the data collection and data analysis techniques that allowed organising and interpreting the findings obtained from the evaluation of SS GB projects developed at one Ecuadorian company.

3.2. Research Questions

Sound empirical research begins with strong grounding in related literature, identifies a research gap, and proposes research questions that address the gap (Eisenhardt and Graebner, 2007). This research aims to provide, in a small extent, an extended explanation of the previous work provided by authors such as Coronado and Antony (2002), Iwaaeden et al. (2008), Nonthaleerak and Hendry (2008) and Aboelmaged (2011), regarding the enablers and barriers to SS project implementation and their impact on each phase of the DMAIC process, by performing a research to obtain empirical evidence from an Ecuadorian food manufacturer.

Consequently, the following two research questions were defined:

- **RQ 1.** How are the identified success factors for Six Sigma project implementation related to each phase of the DMAIC process?
• **RQ 2.** How are the identified barriers to Six Sigma project implementation related to each phase of the DMAIC process?

The research designed to answer these questions is detailed in the following section.

### 3.3. Research Design

Research design should be effective in producing the required information within the constraints put on the researcher, such as time, budget and skills (Ghauri and Grønhaug, 2005). In this scenario, the defined research questions aim to identify success factors and barriers to SS project implementation, and, furthermore, provide an in-depth explanation of how these factors relate to the DMAIC phases. Hence, considering the type of questions and the constraints (mainly time), a qualitative research strategy was selected, by conducting a single case study as described below.

#### 3.3.1. Research Strategy: Qualitative Research

The word qualitative implies an emphasis on the qualities of entities and on processes and meanings that are not experimentally examined or measured in terms of quantity, amount, intensity, or frequency (Denzin and Lincoln, 2005). As defined by Denzin and Lincoln (2005), qualitative research is a situated activity that locates the researcher in the world and that consists of a set of interpretive, material practices that make the world visible, by studying things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. The aims of qualitative research are generally directed at providing an in-depth and interpreted understanding of the social world, by learning about people’s social and material circumstances, their experiences, perspectives and histories (Ritchie and Lewis, 2003), in order to derive fruitful explanations (Miles and Huberman, 1994). Hence, this type of research was found suitable for answering the research questions since no experimentation or measurements in terms of quantity, amount, intensity or
frequency were required to do so. Since there is no single, accepted way of doing qualitative research (Ritchie and Lewis, 2003), the approach selected to conduct this study was a case study method as described in the following section.

3.3.2. Case Study Method

This research was conducted by performing a single case study in an Ecuadorian food manufacturer part of a Swiss multinational, by studying SS GB projects developed across different areas of the company. Case study method is one of the several ways of doing social science research (Yin, 2009). A case study is a history of a past or current phenomenon, drawn from multiple sources of evidence, where context is important (Leonard-Barton, 1990). This methodology is characterised by design flexibility and reliance on the researcher’s ability to discern cause-and-effect relationships in complex organisational contexts (McCutcheon and Meredith, 1993).

Additionally, case study method was also selected to conduct this research since it contained three conditions that made it suitable (Yin, 2009):

1. The form of the research questions were explanatory (“how” questions).
2. There was no required control of the behavioural events.
3. There was a degree of focus on contemporary as opposed to historical events, since it was possible to deal with a full variety of evidence such as documents and interviews.

A single embedded design was determined (single company) in order to obtain in-depth data and also due to the time frame to perform the study. The embedded units of analysis were the studied projects. As indicated by Yin (2009), important aspects were taken into consideration such as avoiding a focus only on the subunit levels (projects). In order to constitute a single embedded case, investigation was done also at the original case (the entire SS GB programme at the company). The projects had common features such as general managerial aspects and they all applied the same SS methodology.
adapted to the company. Moreover, all the GBs received the same training by external BBs.

3.3.3. Collection of Data

Case studies can utilise a rich variety of data sources, such as interviews (generally the prime source), archival data, survey data, ethnographies, and observations (Voss et al., 2002; Eisenhardt and Graebner, 2007). Therefore, for this research the following data collection approaches took place:

1) Questionnaire: To initiate the case study, a questionnaire was developed to collect data related to success factors and barriers to SS project implementation identified by the only eight certified GBs from the studied company. Each GB answered the questionnaire two times (each one regarding one of their two developed projects required for their GB certification). These questionnaires were sent by email and aimed to allow collecting information from the eight GB project leaders while the researcher was in the United Kingdom. Additionally, this permitted reducing the duration of the interviews that were further developed (as explained in the following points) since the GBs where required to answer questions regarding their projects and this implicated them remembering their past experiences from leading the implementation process. The questionnaire included mostly closed questions to obtain information such as success factors and barriers that influenced on their projects’ implementation processes. Open questions were also added where the possible responses were unknown (Saunders et al., 2007) and detail was required from the GBs’ experiences. The questionnaire was elaborated after conducting an extensive literature review on the topic. Furthermore, it was tested with experienced people in the field before sending it to the respondents. The format of the questionnaire is shown in Appendix A.

2) Document collection: In order to obtain as much information available regarding the GB projects implemented, the following types of written materials were provided by the company: (a) training material; (b)
documents from the studied projects such as Project Storyboards; and, (c) reports on financial savings from the projects and Key Performance Indicators (KPIs). This information was also considered when selecting the projects on which the GBs would be interviewed.

3) Interviews: The data collection method that was employed to obtain in-depth information from the projects was semi-structured interviews using an open-ended interview protocol (Yin, 2009). Interviewing is considered a highly efficient way to gather rich, empirical data, especially when the phenomenon of interest is highly episodic and/or infrequent (Eisenhardt and Graebner, 2007).

Three types of interviews were designed:

a. An interview designed to obtain general information regarding the SS programme implementation in the organisation, such as its brief history and important facts. This was done to the Industrial Performance Manager from the company. The questions formulated for the interview are presented in Appendix B;

b. An interview designed to obtain information from one of the two external BBs from the company, regarding their roles, training process, coaching and other important facts. The format of this interview is shown in Appendix C;

c. An interview designed to obtain information from the GB professionals (see Appendix D) related to one of their delivered projects analysed in-depth, with detailed topics regarding the selection, development, follow up, difficulties and other experiences from the project implementation. As previously described, after collecting the two questionnaires answered from each GB regarding their two leaded projects, one of these two projects was selected in order to conduct the individual interview. Based upon the questionnaires, projects with different levels of success were selected in order to obtain variety of data. The level of success of each project was defined for this research in a similar way as the one described in the previous chapter utilised by Nonthaleerak.
and Hendry (2008), considering also the time management factor (as indicated by Morris and Pinto, 2004) and project sustainability, as follows:

![Levels of SS project success defined for this study](image)

**Figure 3.1: Levels of SS project success defined for this study**

All the interviews were recorded and subsequently, transcribed and translated, since they were done in Spanish language. Table 3.1 summarises the details of the interviews.

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Location</th>
<th>Interview Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Black Belt</td>
<td>Guayaquil</td>
<td>Structured Face to face, recorded 43 minutes duration Date: 1/July/2013</td>
</tr>
<tr>
<td>Industrial Performance Manager (IPM)</td>
<td>Fabric No.1 (Guayaquil South)</td>
<td>Semi-structured Face to face, recorded 50 minutes duration Date: 25/June/2013</td>
</tr>
<tr>
<td>GB Project Leader No.1</td>
<td>Distribution Centre Daule-Guayaquil</td>
<td>Semi-structured Face to face, recorded 35 minutes duration Date: 27/June/2013</td>
</tr>
</tbody>
</table>

Table 3.1: Information of the interviews (continued)
Table 3.1: Information of the interviews

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Location</th>
<th>Interview Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB Project Leader No.2</td>
<td>Fabric No.1 (Guayaquil South)</td>
<td>Semi-structured Face to face, recorded 54 minutes duration Date: 25/June/2013</td>
</tr>
<tr>
<td>GB Project Leader No.3</td>
<td>Fabric No.1 (Guayaquil South)</td>
<td>Semi-structured Face to face, recorded 37 minutes duration Date: 25/June/2013</td>
</tr>
<tr>
<td>GB Project Leader No.4</td>
<td>Fabric No.1 (Guayaquil South)</td>
<td>Semi-structured Face to face, recorded 35 minutes duration Date: 26/June/2013</td>
</tr>
<tr>
<td>GB Project Leader No.5</td>
<td>Fabric No.2 (Guayaquil North)</td>
<td>Semi-structured Face to face, recorded 25 minutes duration Date: 27/June/2013</td>
</tr>
<tr>
<td>GB Project Leader No.6</td>
<td>Fabric No.2 (Guayaquil North)</td>
<td>Semi-structured Face to face, recorded 24 minutes duration Date: 27/June/2013</td>
</tr>
<tr>
<td>GB Project Leader No.7</td>
<td>Fabric No.3 (Quito)</td>
<td>Semi-structured Phone interview, recorded 30 minutes duration Date: 28/June/2013</td>
</tr>
<tr>
<td>GB Project Leader No.8</td>
<td>Distribution Centre Cayambe - Quito</td>
<td>Semi-structured Phone interview, recorded 28 minutes duration Date: 28/June/2013</td>
</tr>
</tbody>
</table>

For ensuring the construct validity and reliability of the case study (Yin, 2009), multiple sources as previously described were utilised and a case study protocol was established. The protocol served both as a prompt for the interview and a checklist to make sure that all topics had been covered (Voss et
al., 2002). Data triangulation was addressed, since data was not just collected by interviews within the case study (McCutcheon and Meredith, 1993), but also by the other two described methods. This is further explained in the analysis of data section.

3.3.4. **Analysis of Data**

Since the majority of the data collected was qualitative (based on meanings expressed), a strategy for the qualitative analysis was designed. No single agreed-upon approach to qualitative data analysis exists (Ghauri and Grønhaug, 2005). However, for this research, specific guidelines were followed, as proposed by Miles and Huberman (1994):

a. Data reduction: Involves selecting, focusing, simplifying, abstracting and transforming the data that appear in written-up field notes or transcriptions, by using graphics or tables to categorise information and identify themes and patterns;
b. Data display: Consists in organising and compressing the data in order to permit drawing conclusions, by tables and figures.
c. Conclusion drawing/verifying: Includes noting regularities, patterns, explanations, possible configurations, casual flows and propositions.

Figure 3.2 illustrates this iterative explained process, where the researcher steadily moved among the nodes during data collection and then reduction, display and conclusion drawing/verification.

![Figure 3.2: Components of Data Analysis – Iterative Model](From Miles and Huberman, 1994)
Since each embedded unit from the case was a different project, each one of them was analysed independently where there was uniqueness of data. However, where common features were found, an analysis in the case level was executed.

No statistical analysis was undertaken with the data obtained from the initial questionnaires given that the quantity of data was insufficient to do so and the study was made in a single company. As previously mentioned, the information from the questionnaires was utilised as a basis to select one project developed by each GB from which they would be interviewed, and also to reduce the interview duration.

Considering the multiple sources of evidence, data triangulation was required in order to evaluate the information obtained and corroborate specific facts or phenomenon (Yin, 2009), as figure 3.3 illustrates. The use of logic models to achieve this and addressing rival explanations enhances the validity of the research (Ghauri and Grønhaug, 2005; Yin, 2009).

![Figure 3.3: Convergence of Evidence for Data Analysis](Adapted from Yin, 2009)
3.4. Conclusion

This chapter outlines the study method that was utilised to conduct this research. A single case study was developed, with an Ecuadorian food manufacturing company as the unit of analysis. Figure 3.4 summarises the data collection approaches and data analysis model applied.
4. FINDINGS

4.1. Introduction

This chapter contains the findings obtained from the Ecuadorian company where the case study was conducted. It initiates with a brief description of the company’s background. Secondly, the information obtained regarding its SS programme implementation is presented, including themes such as a brief history, BBs’ roles and responsibilities, GB selection process and training, and project selection and implementation aspects. Furthermore, a summary of the findings related to the GB projects developed at the company and the success factors and barriers to their implementation identified by the interviewed GBs (project owners) is presented. Four of these projects are described in more detail in order to provide an in-depth view of the data collected, which will be further discussed in Chapter Five.

4.2. Company Background

The studied company (hereafter referred to as The Company), with more than 2,000 employees, is a group of four companies located in two cities in Ecuador and it is part of a large multinational food manufacturer with its headquarters located in Switzerland. This multinational reported sales of 92,186.00 millions of Swiss Francs (CHF) on its financial statement of 2012 and 12,000.00 millions of CHF of total sales on the Latin America and Caribbean Zone (The Company in Ecuador included), as shown in Table 4.1.

In 2008, The Company formally introduced a Continuous Improvement Programme (CIP) across all plants in the world, as an approach to operational efficiency and with the objectives of eliminating waste, increasing efficiency and effectiveness, and improving quality in all operations. The CIP aims to consolidate the principles of Lean Manufacturing, Total Productive
Management, Six Sigma, 5S and other methods of the Toyota Production System, and other quality and productivity disciplines.

<table>
<thead>
<tr>
<th>Consolidated Income Statement for the year ended 31 December 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(In millions of CHF)</strong></td>
</tr>
<tr>
<td>Sales</td>
</tr>
<tr>
<td>Trading operating profit</td>
</tr>
<tr>
<td>as % of sales</td>
</tr>
<tr>
<td>Profit for the year attributable to shareholders of the parent (Net profit)</td>
</tr>
<tr>
<td>as % of sales</td>
</tr>
<tr>
<td>Capital expenditure</td>
</tr>
<tr>
<td>as % of sales</td>
</tr>
<tr>
<td>Equity attributable to shareholders of the parent (before proposed appropriation of profit of The Company)</td>
</tr>
<tr>
<td>Market capitalisation, end December</td>
</tr>
<tr>
<td>Operating cash flow ( a )</td>
</tr>
<tr>
<td>Free cash flow ( b )</td>
</tr>
<tr>
<td>Net financial debt</td>
</tr>
<tr>
<td>Ratio of net financial debt to equity (gearing)</td>
</tr>
<tr>
<td><strong>Total Sales Zone Latin America and Caribbean (in millions of CHF)</strong></td>
</tr>
</tbody>
</table>

( a ) 2011 comparatives have been restated following the changes in the cash flow statement described in the Consolidated Financial Statements: Note 1 - Accounting policies.
( b ) Operating cash flow less capital expenditure, expenditure on intangible assets, sales of property, plant and equipment, investments (net of disinvestments) in associates and other investing cash flows. As from 2012, movements with non-controlling interests are no longer deducted. 2011 comparative has been restated accordingly.

Table 4.1: Financial Statement of The Company of year 2012

4.3. Six Sigma Implementation at The Company.

The CIP includes the SS DMAIC process as a problem solving tool. In 2009, when the requirement of implementing this new approach was received at The Company it was not so clear what the corporate executives expected, so the company hired two external BBs who started training according to accepted DMAIC guidelines. In 2011, the training process for the GBs started to follow The Company’s international specific guidelines on DMAIC. According to the
interviewed BB, this DMAIC approach “has characteristics that differentiate it from the rest of the DMAIC approaches and that make it effective for The Company”. Figures 4.1, 4.2, 4.3, 4.4 and 4.5 illustrate the roadmap for each DMAIC phase, adapted by The Company for the GBs to follow. These roadmaps are clear in objectives that GBs require to achieve, and also identify the tools taught in the training sessions that can be applied at each stage of the DMAIC phases.

**DEFINE Roadmap**

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>OBJECTIVE</th>
<th>TOOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define Problem/Opportunity</td>
<td>• Define problem opportunity/statement</td>
<td>• 5W1H</td>
</tr>
<tr>
<td></td>
<td>• Determine business case, overall targets and benefits</td>
<td>• Is/is not</td>
</tr>
<tr>
<td></td>
<td>• Map the high level process</td>
<td>• Financial Sheet/Evaluation</td>
</tr>
<tr>
<td>Define Process</td>
<td>• Define the project scope</td>
<td></td>
</tr>
<tr>
<td>Understand the Customer</td>
<td>• Identify and prioritise customer segments</td>
<td>• SIPOC</td>
</tr>
<tr>
<td></td>
<td>• Gather customer needs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Define and prioritise customer requirements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Select performance measures</td>
<td></td>
</tr>
<tr>
<td>Understand the current situation</td>
<td>• Identify current situation</td>
<td>• Voice of the Customer</td>
</tr>
<tr>
<td></td>
<td>• Gather customer needs</td>
<td>• Critical-to-Quality Tree</td>
</tr>
<tr>
<td></td>
<td>• Define and prioritise customer requirements</td>
<td>• Kano Model</td>
</tr>
<tr>
<td></td>
<td>• Select performance measures</td>
<td></td>
</tr>
<tr>
<td>Plan Project</td>
<td>• Develop project plan</td>
<td>• Time series plot</td>
</tr>
<tr>
<td></td>
<td>• Identify team and stakeholders</td>
<td>• Trends/Seasonality Study</td>
</tr>
<tr>
<td></td>
<td>• Create project charter</td>
<td></td>
</tr>
<tr>
<td>Define team skills</td>
<td>• Map the team’s initial skills</td>
<td>• Project Charter</td>
</tr>
<tr>
<td>Gain Approval</td>
<td>• Obtain approval to proceed</td>
<td>• Project time Plan</td>
</tr>
<tr>
<td>Measure</td>
<td></td>
<td>• Communication Plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Skill Matrix</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• GB Toll gate reviews</td>
</tr>
</tbody>
</table>

*Figure 4.1: ‘Define’ Roadmap of the DMAIC process*
Figure 4.2: ‘Measure’ Roadmap of the DMAIC process
**ANALYSE Roadmap**

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>OBJECTIVE</th>
<th>TOOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restore basic conditions</td>
<td>• Identify and eliminate possible problems</td>
<td>• Just do it</td>
</tr>
<tr>
<td>List possible causes for each focused problem</td>
<td>• With team participation, list all potential causes of the focused problems (identified in Measure)</td>
<td>• Brainstorming</td>
</tr>
<tr>
<td>Group potential causes</td>
<td>• Group similar potential causes in a clear, visual way</td>
<td>• Cause-Effect diagram (fishbone) • Affinity Diagram</td>
</tr>
<tr>
<td>Identify and prioritise potential causes for verification</td>
<td>• Identify and prioritise potential causes • Plot input data to analyse patterns, trends and Variation • Assess risk</td>
<td>• 5 Whys • Interrelationship Pareto/bar Chart diagram • Prioritisation Matrix • Frequency plots • Multivariate Charts • FMEA</td>
</tr>
<tr>
<td>Verify the root causes</td>
<td>• Verify statistical significance of root causes with facts and data</td>
<td>• Control charts • Hypothesis Testing • Regression • Design of Experiments</td>
</tr>
<tr>
<td>Gain Approval</td>
<td>• Obtain approval to proceed</td>
<td>• GB toll gate review</td>
</tr>
</tbody>
</table>

Figure 4.3: ‘Analyse’ Roadmap of the DMAIC process

**IMPROVE Roadmap**

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>OBJECTIVE</th>
<th>TOOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate solutions</td>
<td>• Propose actions to eliminate/minimize verified root causes</td>
<td>• Brainstorming</td>
</tr>
<tr>
<td>Select solutions</td>
<td>• Select best solution based on agreed-upon criteria • Assess implementation risks</td>
<td>• Impact x Effort Matrix • Solution Selection Matrix • FMEA</td>
</tr>
<tr>
<td>Test solution</td>
<td>• Pilot, in a small scale, the effectiveness of the solution</td>
<td>• Hypothesis Testing</td>
</tr>
<tr>
<td>Implement solutions</td>
<td>• Define actions, deadlines and responsibilities for the execution of the solutions • Map the new process • Conduct full scale implementation</td>
<td>• Action Plan (5W2H) • Communication Plan • Stakeholder Analysis • Responsibility Matrix • Detailed Process Map</td>
</tr>
</tbody>
</table>

Was the target achieved?  
Yes  
No  
Control  
Redo measure or analyse phase

Before/After  
• Times Series Plot • Pareto Chart • Control Charts • Process Capability • Process Performance • Sigma calculation • GB toll gate review

Figure 4.4: ‘Improve’ Roadmap of the DMAIC process
### 4.3.1. The Company’s Black Belts: Roles and Responsibilities

There are two external BBs part of the SS programme at The Company. Their roles and responsibilities within The Company’s SS implementation are described as follows:

a. Provide support in the selection of projects: The projects are defined by The Company, and the BBs are only able to confirm whether a project constitutes a SS project or not. They approve, disapprove or provide recommendations when there is a high risk of a project not being suitable for DMAIC. A BB does not seek out new projects.

b. BBs train and coach the GBs. According to the interviewed BB, they seek to ensure that the GBs can conduct a project by themselves. They have identified that while the new GB trainees are conducting their first projects,
they usually require more advising and help to resolve problems. There are two coaching sessions at each phase of the DMAIC process (except on the Measurement and Analysis phases which have three coaching sessions). More coaching is provided when required, but this does not commonly happen.

c. The third responsibility of a BB is to provide visualisation and feedback (by reports) to sponsors, champions and process owners regarding the status of the projects and performance of the GBs.

4.3.2. Selection of Green Belt prospects

According to The Company’s Industrial Performance Manager (IPM), the GB selection process involves looking for candidates that meet a specific profile, competencies, knowledge and performance in their jobs, such as being focused on results, analytic, people-oriented and with communication skills. On the knowledge side, GB prospects are required to have undergraduate education or at least being students at the moment, due to the requirements of some statistical background. The IMP indicated: “… we have an internal selection process… From every area it is evaluated who is going to the GB course and this goes through a committee. Managers and The Company board see this. We deliver the approved list of candidates who go to the GB course with their assigned project… ”. However, the interviewed BB confirmed that the first waves of GBs trainees were not selected under these guidelines. As he noted: “… There have been issues due to the trainees’ background… From the beginning, there has not been a formal selection process that permits to know that the selected trainee will have the capacity to perform a DMAIC. A potential GB does not necessarily need to be someone who knows a lot of statistics, but at least is required to like numbers, be analytic and critic. These are important characteristics that make someone a good DMAIC candidate… And sometimes this is not evaluated… However, from 2012, most of the following GB candidates have had an appropriate selection process and better results have been perceived… ”.
According to both The Company’s IPM and the interviewed BB, The Company now also intends to assign the projects to a specific GB according to their capabilities, position and knowledge in the related area of the project. The corporate level suggests that GBs conduct at least one project per year. However, The Company also seeks that the GBs provide training and coaching to White Belts (WBs) within the enterprise.

4.3.3. Green Belt Training

GBs receive 120 hours of training. In some cases they receive an extra 20 hours of Lean Manufacturing courses. Each phase of the DMAIC process constitutes one module of the course. For the Analysis phase trainees are taught an additional module of introduction to statistics before they receive the module of inferential statistics, since not all of them have a statistical background. In order to become a GB, candidates must have completed at least two projects at a Green Belt level.

According to the interviewed BB, trainees from the manufacturing and supply chain areas have better performance than people from beyond operations (BO) during the trainings (at The Company, beyond operations are considered the areas that are not either supply chain nor manufacturing, such as legal, finance, marketing, sales, human resources departments and so on). As he noted: “…people from BO are normally a bit reluctant and put less attention to the course because they do not notice much, at first instance, the relationship of the course with what they do in their jobs. They come with a set mind that Six Sigma was made for improving manufacturing processes… ”.

Regarding to difficulties during the training sessions, the interviewed BB stated that these are related to the background of the trainees and a lack of formal selection process of them, as described before. He also added: “… Some people are selected for the GB programme because of their leadership skills, which are not sufficient. They do not perform well when they don’t have the other mentioned skills…”. 
4.3.4. Green Belt Project Selection

According to the IPM, projects emerge from an Operational Master Plan. In conjunction with the business units, the company’s priorities for the following three years are defined and every year adjustments are made. Accordingly to these priorities and visions, SS projects are selected. He indicated that “…based on the necessities of The Company a project portfolio is created, and the projects are classified according to their complexity level; if they will be GB or WB. All of the projects are oriented to the different fabrics’ strategies and necessities”. However, some of the projects analysed in this case study have been proposed by the project leaders. This occurred mainly on the first two waves of GBs trained. Also, the interviewed BB confirmed this fact: “The project selection process has varied between projects… now the aim is that the GBs come to the courses already with an assigned project…”.

4.3.5. Green Belt Project Implementation: Views from The Company’s Black Belt perspective

Analysing the supportiveness and commitment of the personnel from the company to the SS quality movement, the interviewed BB commented that “…The required priority and support at the managerial level has not been given to the GB programme. There has been a major focus on factors considered as ‘urgent’ by the company. A new governability model is being implemented to tackle this problem. Hence, since most of the managerial level has not seen the programme as important as it is and have not demonstrated a required level of involvement, the lower levels have not done it either”. The interviewed BB also stated that there has not been a well-established communication strategy among champions, sponsors, BBs and GBs. Regardless that the coaches (BBs) send reports, there is no major feedback from managers or sponsors and the communication mainly takes place between project leaders and coaches.

Another aspect of the project implementation is that the training and project implementation is aimed to take place simultaneously. However, the GBs project leaders are required to invest around 20 per cent of their labour hours
working on their project, which does not always occur. Consequently, delays take place and the training ends generally while team leaders are working in the Analysis phase of the DMAIC process.

According to the interviewed BB, normally GBs do not ask for additional support or assistance from the BBs. During the coaching sessions they revise the project progress. Additionally, the interviewee identified the most common issues that the GBs perceive during project implementation for which they require assistance. These are presented in Figure 4.6.

<table>
<thead>
<tr>
<th>DMAIC Phase</th>
<th>Black Belt’s Views</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>&quot;Normally there are no major issues at this phase.&quot;</td>
</tr>
<tr>
<td><strong>Measurement</strong></td>
<td>&quot;Analysing and identifying the stratification factors in order to have a focused problem is one of the arising issues at this phase. Additionally, some GBs have trouble identifying which tools to apply.&quot;</td>
</tr>
<tr>
<td><strong>Analysis</strong></td>
<td>&quot;The qualitative part of the analysis is performed with no major difficulties. The identification of the root causes of the problems are done by Ishikawas, Cause and Effect Matrix, Failure Mode and Effects Analysis (FMEA), and so. However, GBs present issues regarding to hypothesis testing. They struggle in some occasions in selecting the appropriate tool to be applied.&quot;</td>
</tr>
<tr>
<td><strong>Improvement</strong></td>
<td>&quot;When no Design of Experiments is required, GBs perform this phase without major support from us... Nonetheless, depending on their statistical background, when Design of Experiments is conducted they do require for assistance.&quot;</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>&quot;At this stage, as coaches we seek to make sure that project leaders implement sustainable solutions. GBs generally develop or apply tools such as checklists and 5 S, for example. However, we promote the use of other robust tools such as Poka Yoke and Visual Control.&quot;</td>
</tr>
</tbody>
</table>

Figure 4.6: Issues experienced by Green Belts (from Black Belt’s perspective)
4.4. The Company’s Six Sigma Projects - Green Belt Level

In the following section, it is outlined the main characteristics and information of the selected studied GB projects. Across The Company, only eight of all the GB trainees have obtained the qualification of GBs since The Company began implementing SS. They have conducted two projects each, from which the selection process varied. However, they were approved by the company at a managerial level as GB projects and obtained (some even surpassed) the financial benefit required from this category of belts (yield cost savings/avoidance in the range of $25,000.00 to $100,000.00). As mentioned in Chapter Three, the eight project leaders were interviewed regarding one of their projects. Basic information obtained of these eight projects is summarised on Table 4.2, where the main success factors and barriers identified by the project owners is presented. As shown in Table 4.2, most of the success factors listed on the questionnaire answered by the GB project leaders (see Appendix A), were qualified as critical or highly influential. In the interviews it was possible to identify that GBs made more emphasis on specific success factors for project implementation according to their experience conducting the SS projects. Link of SS to human resources was the only success factor considered as moderately influential. Similarly, specific barriers were identified by the GBs as influential in their leaded projects, while other barriers did not take place at all during the DMAIC process.
<table>
<thead>
<tr>
<th>No.</th>
<th>Project Title/Objective</th>
<th>Project suggested by</th>
<th>Area</th>
<th>Location</th>
<th>Total Annual Benefit (US Dollars)</th>
<th>Project Duration (Target: 6 months)</th>
<th>Number of Team Members</th>
<th>Improvements Sustained Over Time?</th>
<th>Level of Success</th>
<th>Main Success Factors Identified by the GB project leader</th>
<th>Main Barriers Identified by the GB Project Leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20% reduction of the percentage of rejected sold goods in the area of Guayas (Distributors and Wholesalers Channels), from June 2012</td>
<td>GB with sponsor</td>
<td>Supply Chain</td>
<td>Distribution Centre Daule-Guayaquil</td>
<td>$160,426.95</td>
<td>6 months</td>
<td>8</td>
<td>Yes</td>
<td>High</td>
<td>- Strategic selection of the project - Strong leadership and managerial commitment/involvement/support - Effective training - Black Belt/Technical support - Appropriate understanding, selection and use of quality tools and techniques - Supportive organisational culture - Supportive team / Effective team work - Link of the project to the business strategy - Project management and control skills</td>
<td>- Insufficient time to work on project - Difficulties collecting data</td>
</tr>
<tr>
<td>2</td>
<td>50% reduction of metal dust in cocoa powder, in the semi-elaborated line to Q1 2010</td>
<td>GB</td>
<td>Manufacturing</td>
<td>Fabric No.1 (Guayaquil South)</td>
<td>$ 26,436.00</td>
<td>1 year</td>
<td>18</td>
<td>Yes, but only because project owner is continuously controlling, regardless that this is not his responsibility</td>
<td>Moderate</td>
<td>All the success factors from the questionnaire’s list qualified as highly influential, with higher emphasis on: - Strong leadership and managerial commitment/involvement - Link of the project to the business strategy - Link of the project to customer (customer focus)</td>
<td>- Insufficient time to work on project - Team too large - Difficulty in identifying process parameters - Difficulties collecting data - Resistance to change - Tendency to deviate from the structured DMAIC process - Insufficient financial resources - Poor measurement of customer satisfaction - Unclear cost of poor quality - Difficulty to sustain project improvements due to high personnel rotation</td>
</tr>
<tr>
<td>3</td>
<td>Reduction of ingredients overdose on ‘R Cookies’, production line, from 5.33% to 1.9%. Stages: Dough – Lamination.</td>
<td>GB</td>
<td>Manufacturing</td>
<td>Fabric No.1 (Guayaquil South)</td>
<td>More than $100,000.00</td>
<td>6 months</td>
<td>7</td>
<td>Yes</td>
<td>High</td>
<td>All the success factors from the questionnaire’s list qualified as highly influential, with higher emphasis on: - Strategic selection of the project - Strong leadership and managerial commitment/involvement/support - Black Belt support - Effective Communication - Supportive team / Effective team work - High interest of the process owner</td>
<td>- Insufficient time to work on project - Insufficient availability of resources (i.e. computers) - Difficulties with integration of different areas / coordination between functions</td>
</tr>
<tr>
<td>4</td>
<td>Technical shutdowns reduction from 1.9% to 1% in Production Line No. 2</td>
<td>GB</td>
<td>Manufacturing</td>
<td>Fabric No.1 (Guayaquil South)</td>
<td>Around $30,000.00</td>
<td>1 year</td>
<td>11</td>
<td>No</td>
<td>Low</td>
<td>All the success factors from the questionnaire’s list qualified as highly influential, with higher emphasis on: - Black Belt support - Appropriate understanding, selection and use of quality tools and techniques</td>
<td>- Insufficient time to work on project - Resistance to change - Insufficient financial resources - Difficulty to sustain project improvements due to changes on the basic process conditions (affected sustainability)</td>
</tr>
</tbody>
</table>

Table 4.2: Summary of the 8 Green Belt projects selected for this case study (continued)
<table>
<thead>
<tr>
<th>No.</th>
<th>Project Title/Objective</th>
<th>Project suggested by</th>
<th>Area</th>
<th>Location</th>
<th>Total Annual Benefit (USD)</th>
<th>Project Duration (Target: 6 months)</th>
<th>Number of Team Members</th>
<th>Improvements Sustained Over Time?</th>
<th>Level of Success</th>
<th>Main Success Factors Identified by the GB project leader</th>
<th>Main Barriers Identified by the GB Project Leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1% reduction of rework in ‘tacos’ format of ‘G chocolates’ production line No.1</td>
<td>Fabric Manager</td>
<td>Manufacturing</td>
<td>Fabric No.2 (Guayaquil North)</td>
<td>Around $30,000.00</td>
<td>9 months</td>
<td>8</td>
<td>No</td>
<td>Low</td>
<td>Most of the success factors from the list qualified as highly influential factors, with higher emphasis on: - Strategic selection of the project - Link of the project to the business strategy - Link of Six Sigma to human resources</td>
<td>Lack of managerial support - Insufficient time to work on project - Resistance to change - Impossible to sustain project improvements due to changes to the basic process conditions of the process. Basically, the project improvements were lost.</td>
</tr>
<tr>
<td>6</td>
<td>4% increase of ‘E Production line’ performance in order to reduce 50% of the technical stoppages in ‘Product M - 90g’</td>
<td>Fabrication Manager of the production line</td>
<td>Manufacturing</td>
<td>Fabric No.2 (Guayaquil North)</td>
<td>$30,000.00</td>
<td>8 months</td>
<td>8</td>
<td>Yes</td>
<td>Moderate</td>
<td>Most of the success factors from the questionnaire’s list qualified as highly influential factors, with higher emphasis on: - Strategic selection of the project - Effective Training - Black Belt and technical support</td>
<td>Insufficient time to work on project - Difficult to coordinate meetings with team members - Difficulty to sustain project improvements (many complex controls established)</td>
</tr>
<tr>
<td>7</td>
<td>25% reduction of ‘Product P’ processing costs related to material handling, versus historical accumulated costs January-August 2011 period</td>
<td>Production line Manager and GB</td>
<td>Manufacturing</td>
<td>Fabric No.3 (Quito)</td>
<td>$40,000.00</td>
<td>4 months</td>
<td>10</td>
<td>Yes</td>
<td>High</td>
<td>All the success factors from the questionnaire’s list qualified as critical or highly influential, with higher emphasis on: - Strategic selection of the project - Strong leadership and managerial commitment/involvement/support - Appropriate understanding, selection and use of quality tools and techniques - Supportive team / Effective team work</td>
<td>Insufficient time to work on project</td>
</tr>
<tr>
<td>8</td>
<td>16% reduction of underutilised time in the Distribution Centre, versus historical accumulated time January-December of 2010 period</td>
<td>Manager</td>
<td>Supply Chain</td>
<td>Distribution Centre - Cayambe - Quito</td>
<td>$140,000.00</td>
<td>4 months</td>
<td>10</td>
<td>No</td>
<td>Moderate</td>
<td>Most of the success factors from the questionnaire’s list qualified as critical or highly influential, with higher emphasis on: - Strategic selection of the project - Strong leadership and managerial commitment/involvement/support - Appropriate understanding, selection and use of quality tools and techniques - Supportive team / Effective team work</td>
<td>Insufficient time to work on project - Improvements not sustained (New Line manager/Process owner not committed, controls not taking place)</td>
</tr>
</tbody>
</table>

Table 4.2: Summary of the 8 Green Belt projects selected for this case study
From these eight projects, four were selected to be described in more detail in the following section, since they contain rich data that was considered by the researcher as representative of the information and opinions from the project owners of the eight studied projects, who provided similar facts, thoughts and perceptions.

4.4.1. Green Belt Project No. 1

**Title/Objective:** 20 per cent reduction of the percentage of rejected sold goods in the area of Guayas (Distributors and Wholesalers Channels), from June 2012.

Basic characteristics of the project:
- Project selected by GB with sponsor.
- Area: Supply Chain
- Location: Distribution Centre Daule - Guayaquil
- Total Annual Benefit: $160,426.95
- Project Duration: 6 months
- Number of Team Members: 8
- Level of Success: High
- Improvements sustained

Tables 4.3 and 4.4 present in detail the success factors and barriers (respectively) to SS project implementation identified by the GB during the DMAIC process. A brief description of these is provided to support their findings.
<table>
<thead>
<tr>
<th>Success factors identified by the Green Belt</th>
<th>Description provided by Green Belt</th>
<th>Strongest relation to the following DMAIC phases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic selection of the project</td>
<td>Project strongly aligned with the company objectives. High potential of obtaining strong financial benefits.</td>
<td>D</td>
</tr>
<tr>
<td>Strong leadership and managerial commitment / involvement / support</td>
<td>High interest, involvement and support from the sponsor and managers, facilitating activities such as traveling and integrating other areas of the company. Weekly meetings to revise progress of the project. The line manager (and sponsor) works directly with the process owner, which favours project sustainability.</td>
<td>M - I - C</td>
</tr>
<tr>
<td>Effective training</td>
<td>Training was very effective. Highly knowledgeable and experienced BB's.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Black Belt / Technical support</td>
<td>Coaching for selecting which tools to apply. Availability of the coach to agree with the caching sessions according to the available time of the team leader.</td>
<td>M - A</td>
</tr>
<tr>
<td>Appropriate understanding, selection and use of quality tools and techniques</td>
<td>Highly related to effective training.</td>
<td>M - A - I</td>
</tr>
<tr>
<td>Supportive organisational culture</td>
<td>People from the area are improvement focused. Changes have been taking place during the past years, so employees have developed a continuous improvement mentality.</td>
<td>M - A - I - C</td>
</tr>
<tr>
<td>Supportive team / Effective team work</td>
<td>Organised and timely responses</td>
<td>M - A - I - C</td>
</tr>
<tr>
<td>Link of the project to the business strategy</td>
<td>KPI's are presented weekly and are of high interest of the company. The project was strongly linked to the Operational Master Plan.</td>
<td>D - C</td>
</tr>
<tr>
<td>Project management and control skills</td>
<td>Previous participation in other projects. DMAIC allowed the GB to be a team leader. Skills developed in other projects and trainings provided by the company.</td>
<td>D - M - A - I - C</td>
</tr>
</tbody>
</table>

Table 4.3: Success Factors identified by the GB owner of Project No. 1

<table>
<thead>
<tr>
<th>Barriers identified by the Green Belt</th>
<th>Description provided by Green Belt</th>
<th>Strongest relation to the following DMAIC phases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient time to work on project</td>
<td>Limited team leader and members’ availability to work in the project and limited time to coordinate meetings.</td>
<td>D-M-A-I-C</td>
</tr>
<tr>
<td>Difficulties collecting data</td>
<td>Extensive analysis was required in order to identify erroneous registered data that could not be utilised.</td>
<td>M</td>
</tr>
</tbody>
</table>

Table 4.4: Barriers identified by the GB owner of Project No. 1
According to the GB owner of Project No.1, his project was considered as highly successful. This can be verified with the savings obtained from it and the sustainability of the project, mainly due to the commitment of the process owners, the established controls and the strategic link of the project with the company's objectives and the Operational Master Plan. The interviewee indicated from his experience, that the combination of the success factors described allowed conducting the project successfully and finishing it on time. As he commented: “… there was a high interest from my sponsor... Because of this I received his support. If the sponsor is highly related to the project, they provide facilities to develop the project...”. Additionally, it is important to identify that the project was defined by the GB with his sponsor.

Another fact mentioned by the GB was that the team was strategically selected, as he quoted: “The first person that I selected to be part of the team was the person who was going to provide me the data I required and also who was going to be most positively affected by the improvements of the project...”. In this way, collaboration was gained from the team. The way in which the other success factors identified by the GB influenced in the project development is explained in Table 4.3.

On the barriers side, insufficient time to work in the project and difficulties collecting data were the only obstacles identified by the GB. However, as he stated, these factors did not affect the success of the project since they could be overcome with effort and commitment.

### 4.4.2. Green Belt Project No. 2

**Title/Objective:** 50 per cent reduction of metal dust in cocoa powder, in the semi-elaborated line to Q1 – 2010

Basic characteristics of the project:
- Project selected by the GB. The GB was part of the “first wave” of GB trainees. For this group of trainees, there was no previous selection of
projects done at the managerial level, and each GB had to propose a project.
- Area: Manufacturing
- Location: Fabric No.1 (Guayaquil South)
- Total Annual Benefit: $26,436.00
- Project Duration: 1 year
- Number of Team Members: 15
- Level of Success: Moderate
- Improvements sustained, but mainly due to the controls from the GB project owner, regardless that this is no longer his responsibility.

Tables 4.5 and 4.6 present in detail the success factors and barriers (respectively) to SS project implementation identified by the GB during the DMAIC process.

<table>
<thead>
<tr>
<th>Success factors identified by the Green Belt</th>
<th>Description provided by Green Belt</th>
<th>Strongest relation to the following DMAIC phases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic selection of the project</td>
<td>The project was considered of high impact due to &quot;Compliance&quot; issues, customer service, quality problems and equipment damages due to friction.</td>
<td>D</td>
</tr>
<tr>
<td>Strong leadership and managerial commitment / involvement / support</td>
<td>Managers provided valuable feedback during the meetings.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Effective Training</td>
<td>The training methodology was considered very good. Regardless that the statistics and use of Minitab was something that required a lot of effort to learn in short time, the trainers were excellent teachers and clarified doubts when trainees needed.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Black Belt / Technical support</td>
<td>As indicated by the GB: &quot;It was the best&quot;. At all the stages their feedback and opinion was highly constructive.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Appropriate understanding, selection and use of quality tools and techniques</td>
<td>Key on the definition of the variables and main root causes of the problem. This ensured the effectiveness of the improvements.</td>
<td>M - A</td>
</tr>
<tr>
<td>Effective Communication</td>
<td>The team leader considered that there was good communication between him and the team members. This allowed the GB to gain the collaboration of the operators of the machines, since he explained effectively the benefits of the project to the ones that were reluctant at the beginning.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Link of the project to the business strategy</td>
<td>Focused on the Quality Policies and Objectives of the Organisation. Linked to Food Safety controls.</td>
<td>D</td>
</tr>
<tr>
<td>Link of the project to customer (customer focus)</td>
<td>Since the project affected directly the quality of the product, which is food, this has a high impact on the customer satisfaction and health issues.</td>
<td>D</td>
</tr>
</tbody>
</table>

Table 4.5: Success Factors identified by the GB owner of Project No. 2
As shown in Table 4.5, the GB owner of Project No. 2 experienced many both success factors and barriers during the implementation. The GB made a strong emphasis on the nature of his project, which he considered to be linked to the business goals but at the same time, difficult to measure it from a customer’s perception. Moreover, the project did not ensure major financial benefits. The GB expressed that he was part of the first wave of GBs, which practically had to define a project by themselves in a short period of time. However, his project was approved at a managerial level and concluded.

Table 4.6: Barriers identified by the GB owner of Project No. 2

<table>
<thead>
<tr>
<th>Barriers identified by the Green Belt</th>
<th>Description</th>
<th>Strongest relation to the following DMAIC phases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient time to work on project</td>
<td>Highly influential barrier. Insufficient time of the team leader since his job required travelling. Also it was difficult to coordinate work with the operators of the machines, since there are 3 shifts and the ones that were part of the team rotated every week.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Team too large</td>
<td>The team was large but only few people really collaborated with the project. There was information required from different people that were not always available. Difficult to agree on meeting times.</td>
<td>M - A</td>
</tr>
<tr>
<td>Difficulty in identifying process parameters</td>
<td>Some parameters were not well controlled before, and the operators managed this only based on experience.</td>
<td>M</td>
</tr>
<tr>
<td>Difficulties collecting data</td>
<td>Some data was not available. Additionally, when data was required from other areas, it was not always possible to get it on time.</td>
<td>M</td>
</tr>
<tr>
<td>Resistance to change / Non supportive culture</td>
<td>There was some resistance to change from operators, who were reluctant to collaborate at the beginning since they felt that in the past, when they suggested improvements, they were not listened and for this reason, they had &quot;lost faith&quot; on improvement attempts.</td>
<td>M - A - I - C</td>
</tr>
<tr>
<td>Deviations from the structured DMAIC process/over-emphasis on quick fix</td>
<td>In some occasions there was the &quot;temptation&quot; to accelerate the process by looking for quick fix, but this only had a low influence since the coach prevented this from happening.</td>
<td>A</td>
</tr>
<tr>
<td>Insufficient financial resources</td>
<td>Many changes in the equipment of the production line were required. The project did not have a high impact on savings, which made difficult to justify these investments.</td>
<td>I</td>
</tr>
<tr>
<td>Poor measurement of customer satisfaction</td>
<td>Customer cannot identify this quality characteristic. However, it is crucial for the organisations that regulate food safety issues.</td>
<td>D</td>
</tr>
<tr>
<td>Unclear cost of poor quality</td>
<td>It was difficult to quantify these costs, since customers did not measure or are aware of this. Hence, it does not affect on the buying decision.</td>
<td>D</td>
</tr>
<tr>
<td>Difficulty to sustain project improvements</td>
<td>High influence of this factor, due to high rotation of personnel from the area. As the GB stated: &quot;the problem is not always the tools, but the people who manage these tools&quot;.</td>
<td>C and Sustainability</td>
</tr>
</tbody>
</table>
The project owner highly appreciated the training and the BB support at the coaching sessions. He also made an emphasis on the benefits of having ‘soft skills’, especially to convince people regarding the importance of the project and tackle issues such as resistance to change. Regarding the barriers presented, Table 4.6 explains their effects at the DMAIC phases.

4.4.3. Green Belt Project No. 3

**Title/Objective**: Reduction of ingredients overdoses on ‘R Cookies’ production line, from 5.33% to 1.9%. Stages: Dough – Lamination.

Basic characteristics of the project:
- Project proposed by the GB and approved by the area Manager.
- Area: Manufacturing
- Location: Fabric No.1 (Guayaquil South)
- Total Annual Benefit: More than $100,000.00
- Project Duration: 6 months
- Number of Team Members: 8
- Level of Success: High
- Improvements Sustained

Tables 4.7 and 4.8 present in detail the success factors and barriers (respectively) to SS project implementation identified by the GB during the DMAIC process.
<table>
<thead>
<tr>
<th>Success factors identified by the Green Belt</th>
<th>Description provided by Green Belt</th>
<th>Strongest relation to the following DMAIC phases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic selection of the project</td>
<td>Project with high impact on cost reduction (losses exceeded $100,000.00 per year).</td>
<td>D</td>
</tr>
<tr>
<td>Strong leadership and managerial commitment / involvement / support</td>
<td>High interest and support from sponsor, line manager, process owner.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Effective training</td>
<td>Considered highly important. The trainer had very good teaching skills.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Black Belt / Technical support</td>
<td>The coaching sessions were very productive.</td>
<td>A</td>
</tr>
<tr>
<td>Appropriate understanding, selection and use of quality tools and techniques</td>
<td>Considered critical.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Effective communication</td>
<td>Effective communication with the team members from the plant.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Supportive team / Effective team work</td>
<td>Good relationship with all the team. Collaborative members.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Project management and control skills</td>
<td>Important at all stages. Strategic assignment of tasks to team members.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Maintenance of the basic conditions of the process</td>
<td>Collaboration of the operators and maintenance team, to monitor after maintenance activities that the basic conditions are kept in order to ensure that the project was sustainable.</td>
<td>C and Sustainability</td>
</tr>
<tr>
<td>High support and commitment of process owner</td>
<td>An advantage of this project is that if the improvements are not sustained, the fabric will highly be affected, since the savings are considerable. Hence, it is easy to identify if the controls are not maintained. The KPI's are always monitored by the process owner.</td>
<td>I - C and Sustainability</td>
</tr>
</tbody>
</table>

Table 4.7: Success Factors identified by the GB owner of Project No. 3

<table>
<thead>
<tr>
<th>Barriers identified by the Green Belt</th>
<th>Description provided by Green Belt</th>
<th>Strongest relation to the following DMAIC phases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient time to work on project</td>
<td>Limited team leader and members availability to work in the project and time to coordinate meetings.</td>
<td>D - M - A - I - C</td>
</tr>
<tr>
<td>Insufficient resources to work in the project (i.e. computers)</td>
<td>The project required extensive data gathering and analysis, and it was very inconvenient to work without a laptop. Some team members did not have computers available all the times.</td>
<td>M - A</td>
</tr>
<tr>
<td>Difficulties with integration of different areas / coordination between functions</td>
<td>When help was required from people from other area, it was difficult in some occasions. Managerial support helped removing this barrier.</td>
<td>A - I - C</td>
</tr>
</tbody>
</table>

Table 4.8: Barriers identified by the GB owner of Project No. 3
Similarly to the analysed Project No. 1, Project No. 3 can be considered as successful due to its reported savings, duration and sustainability. As noted in Table 4.3, the GB interviewee identified several success factors that permitted achieving the project objectives. For example, he made emphasis on the strategic selection of the project done with the process Line Manager: “...we identified the largest amount of waste originated in the process in order to define a very specific project. The project was approved by the Line Manager and the Plant Manager. Additionally, the BB coach qualified it as a viable project...”. Another success factor that was explained in detail is the maintenance of the basic conditions of the process. In order to sustain the project improvements, part of the controls established required a validation of specific process conditions after maintenance activities.

Again, the insufficient time to work on the project was a barrier that affected negatively on the project since it was a project from the manufacturing area, where high daily pressures and considerable work load is common. Another barrier identified was the difficulty integrating different areas from which support was required. However, strong managerial support played an important role helping removing these barriers. Hence, it is possible to verify that these elements did not exert a major negative impact that could impede the project to succeed.

4.4.4. Green Belt Project No. 4:

Title/Objective: Technical shutdowns reduction from 1.9% to 1% in Production Line No. 2.

Basic characteristics of the project:
- Project selected by the GB.
- Area: Manufacturing
- Location: Fabric No.1 (Guayaquil South)
- Total Annual Benefit: Around $30,000.00
- Project Duration: 1 year
- Number of Team Members: 11
- Level of Success: Low
- Improvements no longer sustained
Tables 4.9 and 4.10 present in detail the success factors and barriers (respectively) to SS project implementation identified by the GB during the DMAIC process.

<table>
<thead>
<tr>
<th>Success factors identified by the Green Belt</th>
<th>Description provided by Green Belt</th>
<th>Strongest relation to the following DMAIC phases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Belt / Technical support</td>
<td>Coaching when selecting which tools to apply. Availability of the coach to agree with the caching sessions according to the available time of the team leader.</td>
<td>M - A</td>
</tr>
<tr>
<td>Appropriate understanding, selection and use of quality tools and techniques</td>
<td>Highly related to effective training.</td>
<td>M - A</td>
</tr>
</tbody>
</table>

**Table 4.9: Success Factors identified by the GB owner of Project No. 4**

<table>
<thead>
<tr>
<th>Barriers identified by the Green Belt</th>
<th>Description provided by Green Belt</th>
<th>Strongest relation to the following DMAIC phases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient time to work on project</td>
<td>The workload of the team leader was very high, leaving little time to work on the project. Difficult to coordinate the meetings with other team members due to their other responsibilities.</td>
<td>D - MA - I - C</td>
</tr>
<tr>
<td>Resistance to change / Non supportive culture</td>
<td>The GB noted: &quot;When the controls require new tasks to be performed by employees (such as production programmes), and there are not in their roles description, they do not take high responsibility for them&quot;</td>
<td>C and Sustainability</td>
</tr>
<tr>
<td>Insufficient financial resources</td>
<td>There was no assigned budget for the improvements of the project. The available financial resources were limited since they required to be in the annual budget elaborated at the beginning of the year.</td>
<td>I</td>
</tr>
<tr>
<td>Difficulty to sustain project improvements</td>
<td>The layout of the machines and other conditions of the process changed, making the improvements difficult to maintain since they would require to be changed as well. Also personnel rotation has affected the sustainability.</td>
<td>C and Sustainability</td>
</tr>
</tbody>
</table>

**Table 4.10: Barriers identified by the GB owner of Project No. 4**

This project contains some similarities to Project No. 2. The project duration, which was targeted to be six months, extended to one year mainly due to the insufficient time to work on the project. Additionally, there were delays caused by a budget management for improvements. The project is considered as low in
success since as stated by the GB, “… during the years 2011, 2012 and 2013 so far, the shutdowns have been higher than the target established in the project objectives. Many basic conditions of the process have changed and some improvements were not concluded by the maintenance area. Moreover, the inspection plans generated for controlling the four types of mechanical and electrical problems identified only took place at the beginning when the project was delivered but after a while they stopped controlling them. There has been personnel rotation (mechanics and electricians) in that production area which also has caused the increase of technical shutdowns in the line… ”. As shown in Table 4.10, these factors and resistance to change exerted a highly negative impact on the project, making the improvements unsustainable.

4.5. Conclusion

In this chapter, it has been presented an overview of the SS programme implemented at The Company. Some important facts such as the implications of having external BBs, the selection process of GBs as well as SS projects have been described. Furthermore, the variety of projects studied, with different levels of success, allowed obtaining in-depth information regarding the success factors and barriers to SS project implementation and their relationship to the DMAIC phases. It is possible to note that some of them are strongly related to specific phases while others appear to have an influence on the entire process. This information obtained from different sources at The Company is further discussed in the next chapter, which addresses the defined research questions.
5. DISCUSSION

5.1. Introduction

In this chapter, the defined research questions are addressed through the discussion of the findings from the Chapter Four, which are contrasted with the literature review from Chapter Two of this dissertation. The relationships between the SS project implementation success factors and the phases of the DMAIC process are explained. In the same way, the impact of the barriers to SS project implementation experienced by the GBs through the DMAIC phases and how the critical ones were overcome is detailed. Further, some relationships between success factors and barriers are identified. Finally, this chapter concludes with the key aspects that resulted from the findings discussed.

5.2. Answer to the Research Questions

5.2.1. Research Question No.1: How are the identified success factors for Six Sigma project implementation related to each phase of the DMAIC process?

From Chapter Four, it is possible to identify that the success factors most mentioned in the previous literature also appear to be the most influential or critical in the success of SS project implementation at The Company. Table 5.1 presents the success factors related to each one of the DMAIC stages according to the opinions and experiences of the GBs from the studied company. The only success factor that is not showed in Table 5.1 is Link of SS to human resources, since it was identified by GBs as moderately influential and they did not related to the projects’ execution.
The identified success factors and their relationship with the DMAIC phases are described as follows:

- **Strategic Selection of the Project:** The findings indicate that this factor was considered critical to the successful studied projects. As reviewed in the previous literature, SS implementation is top down, starting with upper management (Coronado and Antony, 2002; Raisinghani et al., 2005; Pyzdek and Keller, 2010) and the decision rights to initiate a project are allocated to
senior management (Schroeder et al., 2008). All of the studied projects were approved by top management. However, they were not entirely selected at a managerial level. For instance, Projects No. 2, 3 and 4, where defined by their GB project owner. From these three projects, only one of them was highly successful, while the other two achieved a low and medium level of success. The most successful projects had managerial involvement in their identification and Definition process. Moreover, projects such as Project No. 3, where the selection process was rigorous, made by the GB and the Line Manager, and approved by the BB, were highly successful.

As it was also possible to identify, this success factor highly relates to the Definition phase of the project, where the problem is stated, the financial evaluation is elaborated and the performance measures are selected.

- **Strong Leadership and Managerial Commitment/Involvement/Support:**
  As revised in the previous literature, strong leadership and managerial commitment is probably the most cited among the other success factors (see Table 2.3). Accordingly to this, most of the GB project leaders attribute part of the success of the project implementation to this factor. The successful projects had high interest, involvement, commitment and support from managers, sponsors and process owners, from the beginning of the Definition stage until the end of the Control phase and, furthermore, in the sustainability. Additionally, managers in some cases played an important role removing barriers such as insufficient time to work in the project, obtaining fast approval for financial investments in the Implementation phase and ensuring the collaboration of the process owners during the Control phase.

- **Effective Training:** Six Sigma training at The Company covers a large range of tools and techniques to be applied at each DMAIC phase. Moreover, the training is specifically designed for Belts at a Green level, which is congruent to what authors recommend: an intensive differentiated training (Zu et al., 2008). Regardless that not all the trainees had a statistical background, the effective training with experienced and highly knowledgeable BBs allowed them to perform all the planned tasks mainly by themselves, since the BBs'
role was to coach rather than advice during the project execution. As illustrated in Chapter Four, the training hours where sufficient and even an additional module of statistics was provided. Training included detailed objectives and sub processes or roadmaps for each DMAIC phase, with clear tools and techniques to apply at each sub task. Hence, GBs felt that this factor was crucial at all the stages of the DMAIC process and that it was critical to obtain project success.

- **Black Belt / Technical support**: The external BBs provided coaching sessions and were always willing to support the project leaders when additional doubts emerged from the GBs during the project implementation. According to Nonthaleerak and Hendry (2008), companies claim that less experienced belts require more support from a BB to guide them in developing the projects and selecting appropriate tools. Nevertheless, it is important to note that it is also possible to obtain successful projects with two to three coaching sessions at each DMAIC phase, as it was expressed by the project owners at The Company. This is similar to the findings of Proudlove *et al.* (2008), who, as mentioned in Chapter Two, evidenced that extensive BB support is not always considered a success factor for projects.

As noted in the findings of this study, less BB support also may allow GBs develop the ability and criteria to perform future projects by themselves, without requiring additional coaching sessions or frequent technical support. However, it can be argued that BB support may be less required only when effective training is received and GBs are selected appropriately, regardless that they have non-statistical background. Nonetheless, when GBs were conducting projects for the first or second time at The Company, this success factor played an important role during the Measurement and Analysis phases, where there is a wide range of available statistical tools that can be applied and which inexperienced GBs found perhaps overwhelming. Surprisingly, the barrier of difficulties on selecting and applying complex SS tools was not reported by the GBs in the interviews, since the BB mainly played the role of approving their selected tools and, as aforementioned, GBs had to apply them mainly by themselves.
• **Appropriate Understanding, Selection and use of Quality Tools and Techniques:** This success factor is strongly related as well to the effective training factor previously described. As aforementioned, at The Company BBs have the responsibilities of coaching more than assisting in selecting tools. In this sense, the GBs were required to understand and be critical when doing this at all the stages of the DMAIC process, as it is essential to apply the right tool in the right situation in order to achieve successful results (Tjahjono *et al.*, 2010). Previous literature identifies the importance of this factor mainly in the Measurement and Analysis phases, where tools are considered complex. However, in this study the BBs mentioned that they exerted an important influence promoting the use of robust tools in the Control phase, where the sustainability of the improvements is ensured.

• **Supportive Organisational Culture:** In many occasions, as described in the previous literature, the acceptance of SS requires everyone in a company, at all levels, to understand and appreciate the power of the system (Chowdhury, 2003). As stated by the GB leader of Project No. 1, he experienced a highly supportive culture from the team members involved in the project, due to a continuous improvement mentality from the employees. This improvement focus mind has been developed thanks to a high number of changes and improvements that had already been taking place over the past years across The Company. At all the DMAIC phases, but mainly from the Measurement until the Control phase, this factor could be perceived as a positive influence that permitted conduct the project successfully and delivering it on time.

• **Effective Communication:** The findings indicate that highly successful projects involved good communication among the team members during the five DMAIC stages. However, the team leaders who considered this factor as highly important attributed the effective communication mainly to their soft skills, which permitted them gain the collaboration and support from the personnel involved. This is somehow congruent with the interviewed BB’s view, who also stated that there has not been a well-established and formal communication strategy among champions, sponsors, BBs and GBs. As
Pyzdek and Keller (2010) identify, cross-functional collaboration is required, and either formal or informal, good communication is crucial. Hence, in some cases, team leaders achieved a good communication plan in a formal way (with sponsors and managers in the meetings when reports were provided), and in an informal way when it was needed. However, not all the project leaders perceived good communication, which will be further discussed in the next sections.

- **Link of the Project to the Business Strategy:** According to the findings of this research, project leaders recognised the relationship between success and the link of the project to the business strategic goals. The project improvements that had a direct impact on both financial and operational goals (Coronado and Antony, 2002) had the acceptance from managers. The team leaders from highly successful projects, such as Project No. 1, noted the strong link of his project to the Operational Master Plan. Moreover, the KPI’s and metrics defined in the project are still presented in weekly meetings, as suggested by Pyzdek and Keller (2010). Hence, it is possible to identify a higher impact of this factor mainly in the Define and Control stages of the DMAIC process. Additionally, it has contributed to the sustainability of the improvements after delivering the project.

- **Link of the Project to Customer (Customer Focus):** This factor was identified by the eight GBs as highly important for project success. However, the GB owner from project No. 2 was the only one to make an emphasis on this factor, since his project had a particular difference with the others. As it will be further explained, it was not possible to measure the customer satisfaction from this and the financial savings were not high. Nevertheless, this factor played a critical role in this project because of the nature of the health issues in the food company, and for this reason it was approved by managers. The Definition phase was strongly related to this factor, since it was at that stage of the DMAIC process that the link of the project to the customer was presented. This demonstrates that this factor can be
considered a powerful condition for project approval, regardless the fact that financial savings may only reach the minimum required from a GB project.

- **Project Management and Control Skills:** As Coronado and Antony (2002) suggest, project leaders require having several basic management skills to prevent projects from failing, such as setting agendas, rules, responsibilities and meetings. As confirmed by the project owners of the highly successful projects (such as Project No. 1 and No. 3), this factor was critical at all the DMAIC phases. Previous participation in projects and/or developed skills allowed team leaders to conduct the project in a disciplined and strategic manner. As it was also possible to note that ensuring that GBs are capable of leading a SS project is also one of the selecting criteria of GB prospects.

- **Maintenance of the Basic Conditions of the Process:** Organisations are continuously changing and improving processes. In this study, it was possible to note that in manufacturing projects, the maintenance of the process’ conditions plays and important role. As mentioned by the GB owner of Project No. 3, this factor exerted a positive influence in the Control phase and, furthermore, on the sustainability of the improvements. The required controls included activities that involved the maintenance department participation. In a different way, the GB owner of Project No. 5, who perceived a medium success and none sustainability of the improvements obtained by the project, identified this factor also as critical mainly due to the lack of it in the project. A relationship between this factor and the link of the project to the business strategy success factor can be noted. The decision of sudden changes in the production line that are not contemplated in an Operational Master Plan or in an initial business plan, for example, inhibit the sustainability of the projects and causes discontent to the project leaders who perceive that their projects where practically “in vane”.

- **High Support and Commitment of Process Owner:** This factor can be related to the leadership and managerial commitment factor previously described. However, due to the results from this study it is considered as
highly important and analysed separately because of the impact that it caused on the Improvement and Control phases of the DMAIC process, when implementing the changes and when establishing the controls that had to be performed by personnel from the area. GBs qualified this factor as critical also to ensure improvements’ sustainability.

5.2.2. Research Question No.2: How are the identified barriers to Six Sigma project implementation related to each phase of the DMAIC process?

Some of the barriers identified in this study where commonly evidenced by more than one GB project, while others affected specific ones. Table 5.2 presents the barriers related to each one of the DMAIC stages, according to the experiences of the GBs when leading the projects.

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Table 5.2: Barriers related to the DMAIC phases
In some cases, some barriers negatively influenced each project, in a specific way, while in other occasions, common barriers exerted similar effect among different projects.

- **Insufficient Time to Work on Project:** Regardless the fact that The Company expects GBs to invest 20 per cent of their labour hours working on the project, as it is also suggested by Snee (2001), insufficient time to dedicate to the project was a common barrier identified by the eight GB project leaders. The limited time of the GBs due to the high workload part of their normal duties affected some projects more than others. For instance, some projects had a one year duration, when the target was to deliver them in six months. The availability of time of the GB was not the only barrier, but also the time from the team members and other personnel from which support was required. Coordinating meetings was normally a complicated task. Additionally, when help was required from factory workers who had rotating shifts, for example, the manufacturing projects suffered delays in some occasions. According to the GBs, this barrier was present from the beginning of the DMAIC process until the end when the project was delivered. However, not in all cases it caused delays in the projects, and some GBs managed the situation by distributing workload or asking for additional resources.

- **Team Too Large:** From this study, only one GB (from Project No. 2) claimed having perceived this barrier during project implementation, which affected mainly during the Measurement and Analysis phases. Since the project required the involvement of approximately eighteen people (much more than what is suggested in the literature) who were all included initially as part of the project team, it was difficult not only to agree on meetings, as Snee (2001) explained, but also to gain their collaboration and obtain the information required from them. At the end, the GB identified that approximately only eight people were engaged on the project as real team members.
• **Difficulty in Identifying Process Parameters**: Once again, this barrier was experienced by a single GB (from Project No. 2). During the Measurement phase, it appeared difficult to identify clearly process parameters in the production line, due to the non-existence of registered information. Many operators managed these variables mainly based on their experience working on the line, so the team leader had to work with the data available and make sure that it was reliable.

• **Resistance to Change**: This barrier was perceived by the GBs owners of the less successful projects (Projects No. 2 and 5). The project leaders related it to the Measurement, Analysis, Improvement and Control phases. There was resistance from operators from the manufacturing line, who had lost faith on attempts of making process improvements. However, the team leader performed a crucial role gaining their commitment and required support during the Measurement and Analysis phases. In the Improvement and Control phases, when new tasks where included in the daily activities of people involved in the process (for example production programmers), making them responsible was a hard task, especially if there was no major support from the process owner.

• **Insufficient Financial Resources**: According to the findings, this barrier was linked by the GBs to the Improvement phase. However, regardless that the highly profitable company may have had the financial resources to make the investments, this barrier mainly affected causing delays when approvals were required from different managers, since there was no assigned budget for SS project improvements in the annual manufacturing general budget. Moreover, it was considered difficult to get approvals for investments when the projects did not contribute with high financial benefits (Project No. 2)

• **Insufficient Resources to Work on the Project**: This barrier mentioned by Gijo and Rao (2005) affected the project implementation while gathering and analysing data. Project leader No. 3 struggled with the non-availability of facilities (mainly computers) for use of all of the team members, especially
during the Measurement and Analysis phases. However, the situation was managed and the project succeeded without delays, but having more available computers could have caused fewer struggles to the team leader which is something that should concern the company. Perhaps other team leaders with less motivation would simply have not been able to manage the issue and as a consequence delay the project. Hence, it is important that companies provide the sufficient working resources to GBs, especially due to the fact that they are required to manage busy and strict schedules while working on their daily duties and on their SS projects.

- **Difficulties Collecting Data:** At the Measurement phase, this barrier seemed to be somehow an obstacle that took effort and time from the project leader. Extensive analysis was required in order to identify erroneous registered data. If this had not been done carefully and if there had not been a selective criteria from the GB to identify the information that can be utilised in the Measurement phase, the project may have failed to obtain the improvement objectives. However, in this case the project leader that perceived this barrier could overcome the situation. Thus, the barrier did not impede achieving high project success neither caused delays in the project, as it commonly happens (Feng and Manuel, 2008).

- **Deviations from the Structured DMAIC process / Over-emphasis on Quick Fix:** At a lower magnitude than the previous described barriers, this factor affected negatively one of the studied projects during the Analysis phase. Looking for quick answers and solutions to the problems was a temptation during the process. However, as it has been reported in previous studies (Proudlove et al., 2008), the BB reacted timely, preventing potential deviations from the DMAIC process and providing effective recommendations during the coaching sessions.

- **Poor Measurement of Customer Satisfaction:** As mentioned before in the discussion of the success factor “Link of the project to customer (customer focus)”, GB leader of Project No. 2 evidenced this issue during the Definition
phase. This was mainly due to the nature of the project and the impossibility of the customer to perceive the product attribute measured in the project. However, it was a factor considered important for the company, which gave the project the managerial attention required.

- **Unclear Cost of Poor Quality**: As described in the previous barrier (poor measurement of customer satisfaction), this barrier affected the same project for similar reasons as the ones that explain the previous barrier.

- **Difficulty to Sustain Project Improvements**: This barrier was encountered during the Control phase of the project and, moreover, it affected the sustainability of project after it was delivered to the process owner. According to the findings, difficulties to sustain project improvements emerged due to the following reasons:

  - High personnel rotation in the area who required new training for performing the established controls to sustain the improvements (affected Project No. 2);
  - Changes that altered the basic conditions of the process which have made impossible to sustain project improvements of Projects No. 4 and 5;
  - Large number of complex controls defined during the Control phase of Project No. 6. However, the GB that identified this factor, noted that regardless the number and complexity of the controls defined, they have been performed until date and the project is still sustained; and,
  - Lack of commitment of the process owner was the main cause of failure of the sustainability of Project No. 8, as stated by the project owner. Regardless that the project had a successful financial impact, the improvements are no longer maintained due to the lack of support from a new line manager (process owner). This demonstrates once again how critical is managerial commitment / involvement as a project success factor. Additionally, there may have been a cultural factor influencing the lack of commitment of the new manager and, moreover, the fact that he was not involved in the project from the beginning may have influenced in
his low interest in the project. Thus, companies should also ensure that new personnel are aware of the quality improvement programmes that are being implemented, and manage also the cultural issues.

It is also important to note that, as Nonthaleerak and Hendy (2008) mention, this barrier can be problematic when the project ownership is not properly transferred to a process owner. Something similar occurred in Project No. 2, where the project owner expressed to feel somehow attached to the project and regardless that it is no longer his responsibility to monitor the process, he still does it.

- **Difficulties with Integration of Different Areas from which Support was Required:** Cross functional collaboration is required in SS projects (Pyzdek and Keller, 2010), due to the impact that they cause in different departments of an enterprise and the participation that is needed from personnel of these areas in the project deployment. As explained by the GB owner of Project No. 3, it was difficult at several occasions to gain the support from the people from different areas, in the Analysis, Improvement and Control phases. However, once again, managerial support influenced positively in a different way, by helping remove this barrier. Hence, the project success was achieved regardless the existence of this issues.

- **Lack of Managerial Support:** This last barrier was not identified by any of the four projects explained in detail in Chapter Four. However, it is possible to note from Table 4.2 that Project No. 5, which is categorised as a low successful project, evidenced this problem at all phases.
5.2.3. Conclusion

To summarise the discussed findings, it is possible to draw some conclusions regarding to the relationships identified between the success factors of SS project implementation, the barriers to it and the DMAIC phases of the process.

Some success factors were found to be related to specific phases of the DMAIC process, such as BB/Technical support and Link of the project to the business strategy. However, the success factors identified as the most critical, such as strong leadership and managerial commitment, and effective training, appear to be crucial at all times during project implementation. Similarly, some barriers affected at specific DMAIC phases. It is important also to note from the findings that, in some cases, success factors relate to each other and also inhibit the threats of some barrier by performing a counteracting effect. Figure 5.1 illustrates these relationships evidenced. The findings discussed in this chapter, analysed together, provide some valuable information such as which success factors are critical to project success and can inhibit specific barriers. Additionally, it is important to know on which DMAIC phases highly obstructive barriers exert a negative influence, in order to be prepared to overcome them or prevent their appearance at all.
Figure 5.1: Relationships between SS Success Factors and Barriers to Project Implementation
6. CONCLUSION

6.1. Introduction

The purpose of this chapter is to provide the concluding remarks of this research. First, a review of the research aim, objectives and questions achieved by conducting this study is presented. Further, the contributions to the literature from this study are detailed and the practical implications are described. Finally, the limitations of the study are outlined and the recommendations for future research are suggested.

6.2. Review of the Research Aim, Objectives and Questions

This research was based on the study of success factors and barriers to SS project implementation in a developing country context. The research was conducted by case study method, being its unit of analysis and Ecuadorian food manufacturer (referred to as The Company). Data was collected by questionnaires, documents and interviews, and further analysed by following Miles and Huberman (1994) guidelines: data reduction, data display and conclusion drawing/verifying. The single case study at The Company permitted obtaining in-depth information required to achieve the objectives outlined for this research:

- The success factors and barriers to SS project implementation experienced by GB project leaders at The Company were identified, both by the questionnaires and interviews developed.
- Existing relationships between each SS success factor identified in this study and specific phases of the DMAIC process were noted. Some success factors were found to be related to specific phases while others appeared to be critical during the entire project deployment process.
- Similarly to the case of the success factors, some of the barriers experienced by the GB project leaders at The Company appeared to be related to specific phases of the DMAIC process, while others negatively affected the success
of the entire project and hampered the progress of the implementation process.

- While discussing each success factor and barrier to project implementation experienced by the GBs from The Company it was possible to note relationships among these success factors and barriers. Moreover, projects were compared according to their levels of success determined by evidence such as financial savings, duration of the project and sustainability. This allowed relating the project success level achieved to the presence of specific success factors. For example, projects with high level of success proved to experience the most critical success factors, while projects with low level of success evidenced a lack of some of them and were affected by highly obstructive barriers.

The research objectives were achieved while answering the research questions, by contrasting the findings from the case study and the previous existing literature regarding the studied topic:

**RQ 1: How are the identified success factors for Six Sigma project implementation related to each phase of the DMAIC process?**

In conclusion, several of the identified success factors have been linked to specific stages of the DMAIC process. The findings demonstrate that coincidentally, most of the success factors considered as the most critical to SS project implementation in the previous literature where related to all of the DMAIC phases of the implementation process. Strong leadership and managerial commitment/involvement/support, communication, effective training, supportive culture, project management and control skills and appropriate understanding, selection and use of the quality tools and techniques did not appear to be more important in some phases than others. However, aspects such as strategic selection of the project and link of the project to the customer were strongly related to the Definition phase, and managerial involvement in this task was proven to be essential. Link of the project to the business strategy was related to the Definition and Control phase due to the importance of it when presenting the project objectives defined and when the project was ended.
expecting to sustain its improvements. BB support was majorly linked to the Measurement and Analysis phase due to the perception of the complexity of the tools when GBs are conducting projects for the first or second time. Nevertheless, extensive and constant BB support was not considered as critical as the previous mentioned factors, but it is important to note that this much depends on the effectiveness of the trainings and the appropriate selection of capable GBs.

The commitment and support of the process owner was a success factor specifically added by the GBs during the interviews, and a strong positive relationship was identified between this factor and the Improvement and Control phases of the project, which is based on the fact that the sustainability of the improvements is not ensured solely with the best controls but with the people who are required to perform them. The maintenance of the conditions of the process was another new enlisted success factor described in some way by more than one project leader from the manufacturing area, and linked to the Control phase and the sustainability of the project.

**RQ 2: How are the identified barriers to Six Sigma project implementation related to each phase of the DMAIC process?**

To summarise, some of the identified barriers affected the implementation process at specific stages, and the negative influence from some of them was higher than from others. For instance, congruent to the findings regarding the managerial support and commitment success factor, lack of managerial support was a powerful inhibitor to success of project implementation. Insufficient time to work on project was a common barrier among all the project leaders and affected in some projects more than in others. Poor measurement of customer satisfaction and unclear cost of poor quality were barriers directly related to the Definition phase of the project. However, it was shown that due to the nature of some projects, regardless these barriers the projects are approved by managers and conducted in a moderate successful way. During the Measurement and/or Analysis phases, issues such as team too large, difficulties collecting data, difficulties identifying process parameters and
insufficient resources to work in the project seemed be obstacles, but ones that team leaders eventually tackled. In the Improvement stage, GBs confronted obstacles such as insufficient financial resources which were mainly caused by required approvals for expensive investments. Finally, difficulty to sustain project improvements appeared from the Control stage and manifested beyond that, after delivering the project, due to personnel rotation, changes in the basic conditions of the process, large number of complex controls defined and lack of commitment of the process owner.

Many of these barriers were overcome by the counteracting effect of specific success factors, as it was also found in this study. Hence, it is possible to state that higher attention should be put to the most critical and influential success factors. Additionally, knowing when (at what phase or phases of the DMAIC process) specific barriers may emerge as a negative influence, the level of impact that these may cause to the project execution and, the possible factors that are able to inhibit them, may allow acting strategically on managing these aspects and ensure SS project success.

6.3. Contributions

From an academic perspective, this study contributes to the literature on success factors and barriers to SS project implementation in various ways. A large amount of the literature regarding SS success factors and barriers has resulted from conducting studies in various countries (mostly developed ones). However, this research was performed in a small developing South American country, therefore, it expands the variety of contexts under which these factors have been analysed, finding similarities and adding new insights. Additionally, since this is an in-depth study, it provides more detailed facts regarding the studied factors, the effects they induce on the project implementation process and the magnitude of these effects.

This research also identifies a relationship between success factors and barriers to SS project implementation and the DMAIC process through which
SS projects are implemented, which is something few previous studies identify in a specific or direct way. Moreover, there was no paper found which studies the success factors and barriers and, at the same time, relates these factors to the DMAIC phases.

As another contribution, two factors were added to the previous group of success factors enlisted in the literature review. The first one is the high support and commitment from process owner, which was differentiated from the managerial support and commitment factor due to the critical impact that performs. The second one described is the maintenance of the basic conditions of the process, which was specifically identified by GBs that developed projects in manufacturing processes.

Finally, the barrier named in the previous studies as difficulty to sustain project improvements was further explained, enlisting the reasons why this may appear as an obstacle: high personnel rotation in the area, changes that affect the basic conditions of the process (in manufacturing environments), large number of complex controls and lack of commitment of the process owner with the defined controls to sustain the improvements.

6.4. Practical Implications

These findings provide to organisations some insights that may be useful when implementing SS projects. For example, understanding the success factors and obstacles that impact on project implementation allows them to focus on the positive factors and be prepared to overcome the barriers that may appear along the DMAIC process. Moreover, identifying the most critical success factors that help inhibiting barriers is valuable since promotes a stronger emphasis on them.

The results from this study also suggest that organisations can be more prepared to overcome the most powerful barriers and invest fewer resources in the ones that may not be so critical and that can be inhibited by specific critical
success factors. For example, it is noted that extensive BB support may not be necessarily required. For a company where there is an external BB, paying for additional coaching sessions may be expensive. Hence, instead on doing so, perhaps resources should be invested ensuring effective trainings and selecting appropriately GB candidates, which are factors that have proved to be critical.

Organisations may also use this research as a guide to obtain information regarding the common issues that arise when implementing SS projects across their different departments. This could be done, for example, by surveying project leaders and asking them similar questions to the ones from the questionnaire utilised to collect data for this study, where they could identify from the enlisted barriers the ones experienced by them under the context of their projects.

6.5. Limitations of the Research

One of the limitations of this research is that the previously drawn conclusions are based upon the results from a single case study. Therefore, it is not possible to make generalisations from the findings since results may vary under different contexts. For example, in another company, GBs may find different relationships between the success factors and barriers to SS project implementation and specific DMAIC phases of the process.

Due to the fact that some projects where developed one or two years before this study was conducted, some of the interviewees may have forgotten important information or experiences regarding the success factors and barriers presented while working on their projects and also how they perceived the impact of these at the moment they occurred.

Finally, since the study was performed in Ecuador and the researcher could only collect data in-site during a period of two weeks, it was also difficult to perform a follow up after the researcher returned to the UK and to continue collecting additional information regarding the projects. Moreover, due to the
limited time to conduct this research, interviews could not be performed to other team members of the projects or to sponsors for example, which would have been valuable to triangulate more data.

6.6. Recommendations for Future Research

As the first recommendation for future research, replicating this study could be suggested in order to extend the number of diverse studied projects (including projects from the service sector) under different contexts. This could allow comparing if the relationships between success factors and barriers and the DMAIC stages are similar to the ones found in this study or, if some relationships are very specific to some projects. Additionally, not all the barriers identified in the previous literature where experienced by the GBs that participated in this research. Replicating the study will permit finding the impact and relationship of these other barriers to the DMAIC phases of the projects’ implementation process.

A longitudinal study can also be performed to answer similar questions to the ones from this research, where information could be collected while GBs are conducting projects. This would allow obtaining fresh information regarding the success factors and barriers that appear along the process and evaluate the impact of these while they occur.

Finally, in this research it was also possible to note that some of the identified success factors and barriers affect strongly on project sustainability. Hence, studying success factors and barriers to SS project sustainability is suggested, identifying when these factors exert a positive or negative (respectively) influence. For example, a specific success factor may ensure project sustainability by performing a positive influence at a specific phase of the DMAIC process and also after the project has been delivered.
REFERENCES


APPENDIX A: Green Belt Questionnaire Format (Sent by e-mail)

Questionnaire for the Six Sigma Green Belts – Project Owners

Title of the project:
Total Annual Benefit:
Date:

1. Do you consider that the project achieved the expected results? Was it successful? Y/N. Please briefly explain the main reasons that support your answer.

2. On a scale from 1 to 5, how would you categorise the following factors according to their positive effect and influence on the success of the project?

   1: No influence; 2: Minimal influence; 3: Medium influence; 4: High influence; 5: Critical factor

<table>
<thead>
<tr>
<th>SUCCESS FACTOR</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>Strategic selection of the project</td>
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<td>Strong leadership and managerial commitment / involvement / support</td>
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<td>Effective training</td>
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<td>BB / Technical support</td>
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<td>Appropriate understanding, selection and use of quality tools and techniques</td>
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<tr>
<td>Supportive team / Effective team work</td>
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<td>Supportive organisational culture</td>
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<td>Effective communication and reporting structure</td>
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<tr>
<td>Link of the project to the business strategy</td>
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<td>Link of the project to customer (customer focus)</td>
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<td>Link of Six Sigma to human resources (i.e. rewards and compensations)</td>
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<tr>
<td>Project management and control skills</td>
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<tr>
<td>Other:</td>
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</table>

3. Please select from the previous question the two or three success factors that you consider that had a higher impact on the project deployment and explain briefly the reasons that support your answer.
4. On a scale from 1 to 5, how would you categorise the following factors according to their negative influence on the implementation of your project?

<table>
<thead>
<tr>
<th>BARRIER</th>
<th>1</th>
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<tbody>
<tr>
<td>Deficient project selection (i.e. there is no structured and disciplined approach to selecting projects)</td>
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<td>Project scope too large</td>
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<td>Insufficient / deficient training</td>
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<td>Project objectives not important to the organisation / not linked to the organisation’s strategic goals</td>
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<td>Lack of managerial support</td>
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<td>Insufficient time to work on project</td>
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<td>Limited Black Belt support</td>
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<td>No clear measure of success (deficient performance metrics defined)</td>
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<td>Team too large</td>
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<td>Difficulty on identification of customers and processes</td>
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<td>Difficulties selecting and applying complex SS tools and techniques</td>
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<td>Difficulty in identifying process parameters</td>
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<td>Difficulties collecting data</td>
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<td>Deviations from the structured DMAIC process/over-emphasis on quick fix</td>
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<td>Resistance to change / Non supportive culture</td>
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<td>Focus on short-term savings</td>
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<td>Insufficient financial resources</td>
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<tr>
<td>Insufficient resources to work in the project (i.e. computers)</td>
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<td>Poor measurement of customer satisfaction</td>
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<td>Low emphasis on the voice of customers</td>
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<td>Unclear cost of poor quality</td>
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<td>Difficulty to sustain project improvements</td>
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<td>Intangibility of the project results</td>
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<tr>
<td>Uncertainty of the project results</td>
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<tr>
<td>Difficulties with integration of different areas / coordination between functions</td>
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5. Please select from the previous question the two or three barriers that you consider that had a higher impact on the project deployment and explain briefly the reasons that support your answer.
APPENDIX B: Green Belt Interview Questions

Interviewee Name:
Title of the Project:
Date:

Structured section of the interview:

1. How was the project selected?
2. What were the objectives of the project?
3. What was the number of team members from the project and how was the selection process of the team?
4. How was your relationship with your sponsor?
5. What was the amount of time invested to work in the project? Did you consider it sufficient?
6. Are the improvements obtained from your project sustained up to date?

Unstructured section of the interview:

7. Open discussion on each success factor of project implementation (from the questionnaire obtained).
   • The GBs are asked to identify relationships between each step of the DMAIC process and the success factors.
8. Open discussion on barriers to project implementation (from the questionnaire obtained).
   • The GBs are asked to identify relationships between each step of the DMAIC process and the identified barriers.
APPENDIX C: Black Belt Interview Questions

Date:

1. What are your defined roles and responsibilities as Black Belt in The Company?
2. Do you consider the personnel from The Company to be supportive to the Six Sigma quality approach? Are the people (from different levels) committed to it and believe in its advantages?
3. How are the Green Belt prospects selected?

Training process general information:

4. How long does the training process last?
5. How was the performance and participation of the certified Green Belts during the training sessions?
6. What difficulties emerged during the training sessions? (i.e. issues understanding the quality tools)

Projects information:

7. How are the Green Belt projects selected?
8. What is your level of involvement in the selection process of the projects?
9. Is the training and the first project implementation of the Green Belts done simultaneously?
10. How frequent was your involvement in the project implementation?
11. How frequent did the Green Belts reached to you for additional support or assistance?
12. What were the most common issues that the Green Belts perceived during the project implementation for which they required your assistance?
13. Do you consider that there is a high, moderate, or low managerial involvement in the projects?
14. Is there a communication strategy among Green Belts and managers/champions/sponsors to report status of the projects?
APPENDIX D: Industrial Performance Manager Interview Questions

Interviewee Name:
Date:

1. Please provide some details about the implementation of Six Sigma in the company (Brief history)
2. Does the company have a quality management system part of its general strategy? And, is Six Sigma part of it?
3. Before implementing Six Sigma, was any evaluation made in order to identify if it was a suitable option for the company?
4. Was there an assessment and evaluation on the organisational culture before/during/after implementing Six Sigma?
5. Do you consider the personnel from The Company to be supportive to the Six Sigma quality approach? Are the people (from different levels) committed to it and believe in its advantages?
6. How is the Six Sigma project selection process?
7. How are the Green Belt prospects selected?
8. What are the roles and responsibilities of the Black Belts and Green Belts?
9. Do you consider that there is a high, moderate, or low managerial involvement in the projects?
10. Is there a communication strategy among Green Belts and managers/champions/sponsors to report status of the projects?
11. What advantages has the company obtained since Six Sigma projects were implemented?
12. Do you consider all the projects implemented so far have provided the company the benefits expected or have had a high impact on quality improvement? Please explain your answer.
13. What general problems have you been able to identify that have emerged during the Six Sigma programme implementation?