

RELATIONSHIP BETWEEN STATISTICAL PROCESS CONTROL CRITICAL
SUCCESS FACTORS AND ORGANIZATIONAL PERFORMANCE

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Mechanical Engineering)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

JANUARY 2015

Dedicated to my loving family and friends,
who make all things seem possible

ACKNOWLEDGEMENT

In the name of Allah the Most Gracious, the Most Merciful. First and foremost I am truly grateful for the blessings of Allah that gives me the strength to complete this thesis.

I would like to convey my highest gratitude to all my supervisors; Prof. Dr. Sha'ri Mohd Yusof and Assoc. Prof. Dr. Ismail Mohamad for their excellent supervision, encouragement, understanding and patience throughout my study. May Allah bless and reward all of them. Without them, my Ph.D experience would be a very difficult one. Also, special thanks to Ministry of Higher Education Malaysia (MOHE) and Universiti Teknologi Malaysia for their sponsorship on this research (Vot No. 71817).

Finally, I am most thankful to my parents for their support and encouragement. My special thanks to my beloved wife, Hashazah Mohd Hashim and my daughter, Nurin Izzati Jafri and my son Muhammad Irfan Jafri for their love, great patience and understanding throughout this study.

ABSTRACT

Statistical Process Control (SPC) is a statistical based techniques and methods used within the improvement based philosophy such as Total Quality Management (TQM) and Six Sigma. SPC research can be divided into two major categories: technical and methodological aspects and the organizational and the implementation aspects. Between the two, the organizational and the implementation aspects of SPC is almost being neglected and lack of attention being given by the researcher. Based on the literature, the SPC implementation research focuses on identifying factors for successful implementation. What is missing from this SPC implementation literature is the relationship of how these so called SPC critical factors affects quality and firm performance statistically and empirically. Therefore, the objective of this research is to establish the relationships between statistical process control (SPC) critical success factors (CSF) and quality and firm performance. Empirical data were collected from 326 responses from Malaysian automotive related companies using industrial survey research methodology. In study 1, Exploratory Factor Analysis (EFA) was performed using Promax rotation with Principle Axis Factoring to determine the underlying dimension of SPC success factors and organizational performance. Preliminary findings from EFA (n = 122) provided evidence for six (6) success factor constructs and three (3) organizational performance constructs. The six (6) success factor constructs are training, role of quality department, deployment, top management commitment, process focus and teamwork. In study 2, results from confirmatory factor analysis (CFA) (n = 204) provided additional support for results obtained from study 1. The structural equation modeling (SEM) techniques was employed to examine the relationship between these six (6) SPC critical success factors (CSF) and performance. The results show that there is a positive and significant relationship between these CSF and organizational performance. This research has a practical value in which quality and operation manager would be able to identify and relate the success of his or her SPC implementation projects through managing of these associated factors.

ABSTRAK

Kawalan proses statistik atau “Statistical Process Control (SPC)” adalah satu kaedah untuk meningkatkan kualiti proses dan merupakan kaedah utama dalam falsafah pengurusan kualiti menyeluruh dan enam sigma. Penyelidikan dalam kawalan proses statistik terbahagi kepada dua kategori, aspek teknikal dan metodologi dan aspek pelaksanaan dan organisasi. Di antara dua kategori ini, aspek pelaksanaan dan organisasi yang kurang mendapat perhatian oleh para penyelidik akan tetapi kajian banyak ditumpukan untuk mengenalpasti faktor kejayaan pelaksanaan SPC program. Walau bagaimanapun, tiada kajian setakat ini yang dapat menghubungkan faktor kejayaan SPC dengan kualiti dan prestasi organisasi. Objektif kajian ini dilakukan ialah untuk mengkaji hubungkait faktor kejayaan kritikal SPC dengan prestasi organisasi dan kualiti. Data empirikal telah diambil dari 326 responden daripada syarikat berkaitan automotif di Malaysia menggunakan kaedah kajian soal-selidik industri. Dalam kajian pertama, “Exploratory Factor Analysis (EFA)” dengan putaran Promax dan “Principle Axis Factoring” digunakan untuk menentukan faktor kejayaan SPC dan prestasi organisasi. Penemuan awal daripada EFA ($n = 122$) mengenalpasti enam (6) faktor kejayaan SPC dan tiga (3) faktor prestasi organisasi. Enam (6) faktor kejayaan SPC tersebut ialah latihan, peranan jabatan kualiti, pelaksanaan, sokongan pihak atasan, fokus kepada proses dan kerja berpasukan. Dalam kajian kedua, keputusan daripada “Confirmatory Factor Analysis (CFA)” ($n = 204$) telah menyokong keputusan dapatan kajian pertama. Teknik “Structural Equation Modelling (SEM)” telah digunapakai untuk menghubungkan enam (6) faktor kejayaan SPC dengan prestasi organisasi. Keputusan menunjukkan terdapat hubungkait positif diantara faktor kejayaan SPC dan prestasi organisasi. Kajian ini mempunyai nilai praktikal yang tinggi kepada pengurus operasi dan kualiti organisasi dalam mengenalpasti faktor kejayaan SPC dan dapat menjangkakan faktor-faktor yang dapat menyumbangkan kejayaan dalam pelaksanaan program SPC dalam organisasi.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Six Sigma, Lean Sigma and Total Quality Management are the current improvement philosophies many manufacturing companies and organizations are adopting in order to improve productivity and quality for corporate survival. Six Sigma quality improvement initiative focus on reducing variability in the processes which leads to reducing defects. Six Sigma is a method for improving business processes that goes beyond quality control and quality assurance. One of the very important aspect of the Six Sigma methodology is its strong statistical components starting from define, measure, analyze, improve and control (DMAIC) cycle (Naslund, 2008).

Total Quality Management (TQM) is a quality management approach that focuses on customer satisfactions and process improvements. TQM is developed over five main components: customer focus, employee involvement, continuous improvement, leadership and fact-based decision making (Gutierrez *et al.*, 2009). Lean Sigma is a new organization change and improvement method, particularly as a combination of waste reduction mechanism and variability reduction philosophy. Both Six Sigma and TQM have emphasized the importance to observe and analyze the data and use statistical methods to draw conclusion (Gutierrez *et al.*, 2009; Naslund, 2008). One of the techniques that are being applied for improvement in both Six Sigma and TQM is Statistical Process Control (SPC). SPC refers to a

collection of statistical tools and techniques used to collect and analyze the data to reduce variability in manufacturing products and processes. These tools and techniques are applicable to any type of industries, including in small and medium size (SMI) industries and large organizations. The basic SPC tools are Pareto charts, cause-and-effect diagram, check sheets, histogram, scatter diagram, graphs and control charts. Some of these tools are not really statistical, but can be classified as graphical tools. All of these tools are very powerful and become accepted to determine if a process being analyzed is within the established parameters. With the rise of Six Sigma awareness and fierce international competition, the use of these SPC tools will certainly increase for the management to make decision based on facts.

Numerous benefits can be associated with a successful implementation of SPC such as reduced scrap and rework, improved knowledge of processes, improved customer satisfaction, improved corporate competitive advantage and provided business excellence model (Rungasamy *et al.*, 2002; Lepojivic and Kalac, 2012). Although many companies reported success in their SPC implementation, there are also examples of companies which are less successful or failures in implementation (Antony and Taner, 2003). As reported by Dale *et al.* (1990), more than seventy five percent of suppliers of Ford had encountered difficulties in introducing SPC program. Rungasamy *et al.* (2002) identified the following reasons for unsuccessful implementation of SPC: a) No need for SPC as the business is already quite successful b) Lack of awareness of the benefits of SPC c) Lack of resource and budget d) Not culturally ready for SPC e) Time constraint f) Management decision g) Not priority for the business. Shamsudin and Masjuki (2003) stated the following reasons: a) Lack of resources and upper management support b) Lack of statistical knowledge c) Require training and education to understand the importance and approach of deployment of SPC d) Lack of modern measuring methods and equipment and data processing devices. Talapatra (2007) suggested that the principal barriers to effective implementation of SPC in Indian manufacturing companies are the following: a) Lack of commitment and involvement from top management b) Lack of training and education of SPC tools c) Failure to interpret control charts and take appropriate action d) Lack of knowledge about product and process parameters e) Invalid capable measurement systems f) lack of understanding of customer

requirement. Lim and Antony (2014) reviewed 41 journal articles on SPC implementation and summarized the following factors: resistance to change, lack of sufficient knowledge of SPC, lack of management commitment, lack of continuous training and lack of statistical thinking culture.

Deleryd *et al.* (1999a) has divided four categories of reasons on why it is sometimes hard to conduct process capability studies. The researcher has adopted similar categories used by Deleryd *et al.* (1999b) for SPC implementation study. The four categories of the difficulty of SPC implementation is briefly discussed below:

i. Management issues

Organization without complete understanding of real challenges of SPC implementation issues are likely to fail. SPC is not “flavor of the month” or “join the band wagon” attitude. The management must set the direction, commit the budget and resources, provide continuous feedback and progress update, then, the smooth of progress of SPC implementation could be realized. If all these supports and commitments do not exist, the organization should probably do not adopt SPC.

ii. Conservative personal attitude

Although many organizations could commit to implement SPC, the management must deal with cultural issues and barriers. It should be recognized that organizational culture of putting quality into the forefront and planning of the process should be established. The understanding that continuous quality improvement is demanded at every level of employees should be emphasized.

iii. Practical problems

SPC is often considered as additional job to the quality control (QC) operator. The operator needs to collect the data, plot the data and sometimes the data collection sheet is too complicated. This activity of collecting and plotting data has caused additional paperwork to QC operator and additional job to his or her existing auditing or inspecting the process.

iv. Methodological aspects

The operator and engineer lack of process knowledge to relate between SPC charts and control action problem. There is a insignificant process improvement because of the wrong process parameter being selected for the process monitoring purposes. Because of the wrong process parameter being selected, no Plan Do Check Act can be implemented. Consequently, the results of implementing SPC are not realized.

Although SPC looks like a straight forward technique, its implementation issues in a organization is far more complex. Rungtusanatham *et al.* (1999) stated three main reasons why SPC implementation issues is being neglected by SPC academic researchers. The first reason is SPC's historical intellectual roots are in statistics. Much of earlier studies on SPC research is mainly conducted and focus on mathematical and statistical aspects of SPC. The second reason is lack of scientific aspect of conceptualizing what does it mean when the organization wants implement SPC. The third reason is the inability to measure the phenomenon itself, that is, lack of scientific study and empirical research of numerous claims that SPC practices will increase the quality performance of the organization.

1.2 Statement of the Problem

This research used an industrial survey research methodology to empirically identify critical success factors and to develop the relationship of how these critical success factors affect organizational performance in SPC implementation. This was achieved by measuring what are constitutes critical success factors and organizational performance constructs and empirically investigating how these critical factors related to organizational performance within the industrial sample studied. The fact that some organizations seems to succeed when implementing SPC, while, other similar organizations did not or having difficulty, led to the question, which factors are decisive in order to achieve a successful implementation. Most studies in SPC are based on case studies and anecdotal in nature to assess the impact of its implementation. Also, most of these studies and its investigations lack scientific rigorousness in its methodology in empirically identifying which factors significantly affect the organizational performance. Another shortcoming is that there is no generally accepted and unified theory or structural model regarding the associated success factors that will give an impact to organizational performance, thus, a rigorous statistics and empirical analysis is now required. A study is required to have better understanding on how SPC critical success factors affect organization performance in Malaysian manufacturing firms. Therefore, this study will attempt to build the structural model by finding relationship between the SPC success factors and organizational performance.

1.3 Research Questions

Based on this research background, an empirical study was designed to examine the relationship between success factors and organizational performance in SPC implementation. The following research questions were formulated to address the study:

Research Question 1: What are the proper SPC factors (or constructs) that will constitute SPC success factors which are statistically valid and reliable?

Research Question 2: What are the proper SPC factors (or constructs) that will constitute organizational performance which are statistically valid and reliable?

Research Question 3: How is the nature of relationship between SPC success factors and organizational performance?

1.4 Objectives of the Study

Having identified the gap in the literature and in an attempt to answer the above research questions, the following objectives of the study have been formulated.

1. To identify and validate the success factors obtained from the theoretical literature for SPC implementation.
2. To identify and validate organizational performance multidimensional constructs.
3. To develop and verify the interrelationships among the success factors and organizational performance or outcomes.

1.5 Scope of the Study

The scopes of this study are:

1. Focused on certified TS16949 automotive related manufacturing company in Malaysia.
2. Focused on cross sectional study based on the survey carried out between the periods of February - April 2008.
3. Focused on manufacturing organizations of some type and therefore, the study results will not be generalizable to organizations with markedly different characteristics to the organizations included in this study (eg. service sector, healthcare sector, etc.)

1.6 Importance and Expected Contribution of the Research

This research is expected to establish a more definitive and structural model to relate the SPC significant success factors and organizational performance. This research will extend the knowledge in SPC implementation field by:

1. Identifying and verifying statistically and valid SPC success factors or constructs.
2. Identifying and verifying statistically and valid organizational performance constructs.
3. Developing and verifying statistically and valid structural model of the relationship between SPC success factors and organizational performance.

Most empirical studies on SPC implementation aspects so far are focused mainly on identifying and exploring factors for effective implementation, which are called “success factors” (Antony *et al.*, 2000; Rungtusanatham *et al.*, 1999; Harris *et al.*, 1994; Donell and Singhal, 1996, Rungtusanatham *et al.*, 1997; Deleryd *et al.*, 1999a, Deleryd *et al.*, 1999b). By performing Exploring Factor Analysis (EFA), the number of SPC success factors and organizational performance can be identified. EFA is essential in helping the researcher to determine the number of latent constructs underlying a set of items (variables). Research results from EFA usually serve as stepping stones to verify the propose SPC success factors and organizational performance construct by using Confirmatory Factor Analysis (CFA). By setting up Structural Equation Modeling (SEM), the nature of the relationship between SPC success factors and organizational performance can be empirically and statistically tested.

1.7 Thesis Structure

This thesis will be organized in the following chapter. Chapter 1 discusses about the background of the research where the problem statement, main objectives and scope of the study are explained. Chapter 2 will discuss about literature review which is where the main source of this study was taken from. Chapter 3 will discuss the research methodology. Chapter 4 will discuss the result of the study and finally the last part, Chapter 5 will provide the conclusions and some recommendation for future study.

1.8 Definition of Terms

- i. Six Sigma – quality management improvement methodology that focuses on variability reduction on processes

- ii. Total Quality Management (TQM) – quality improvement methodology that focuses on satisfying customer needs
- iii. Exploratory Factor Analysis (EFA) – a factor analysis used to explore the underlying structure of collection of observed variables
- iv. Confirmatory Factor Analysis (CFA) – a factor analysis performed for the purpose of confirming a underlying hypothesized factor structure
- v. Structural Equation Modelling (SEM) – a comprehensive statistical approach to testing hypothesis about relations among observed and latent variables (often referred to as construct which cannot be measured directly)
- vi. Items/Indicators/Measures – a series of question in the survey instrument filled up by respondent
- vii. Rotation of factors – a transformation of the principal factors or components in order to approximate simple structure (eg. varimax, promax, etc.)
- viii. Scree plot – a graphical method of determining the number of factors extracted. The Eigen values are plotted versus sequence of principal factors. The number of factors is chosen where the plot levels off in a linear fashion of decreasing pattern
- ix. First-Order factor – represents the structural coefficients linking the latent variable to their respective a priori hypothesized measurement indicator
- x. Second-Order factors – represents the structural coefficients linking the first-order latent variable to overall higher order factor or explaining all variance and co-variance related to the first order factor. Such variation and covariation of first-order factor is presumed to be accounted for by the higher-order factors
- xi. Constrained Model – the correlation between two constructs set to 1.0
- xii. Unconstrained Model – the correlation between between two constructs are freely estimated

1.9 Summary

This chapter has discussed the research background, main objectives, and scopes of the study. Although SPC implementation works so far rely on case studies and anecdotal evidence, the present study attempts to propose a structural model of finding the relationship between SPC success factors and organizational performance through rigorous empirical and statistical analysis. Hence not only academic researchers will find this statistically valid model useful for future research but industrial practitioners can also use this statistically and empirically tested model to predict how their SPC success factors will affect organizational performance or outcome.

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