An Exploratory Study on Statistical Process Control in the UK Food Industry

Sarina Binti Abdul Halim Lim

Submitted for the degree of Doctor of Philosophy

Heriot-Watt University

School of Management and Languages

January 2016

ABSTRACT

Statistical Process Control (SPC) is an effective technique improving process performance in manufacturing companies; however, the literature shows its implementation in the food industry is still less evident. This research aims to assess the SPC implementation in the UK food industry and subsequently develops an SPC implementation roadmap (SPCIR) and SPC Readiness Self-assessment Tool for food companies to assess their readiness level to adopt SPC. Survey and multiple-case studies were conducted to identify the widespread of SPC, challenges of implementing SPC, Critical Success Factors and the reasons for not implementing SPC in this industry. A five-phase SPCIR was refined through the action research, while five SPC readiness factors were identified through the Delphi study. This study adds value to the current knowledge by extending organisational readiness theories through the identification of SPC readiness factors and expands the organisational learning theory by uncovering type of learning created within SPC implementation. This study is relevant, practical, and useful to both practitioners and academics by providing a holistic implementation roadmap to guide the managers to implement SPC not only at the organisational level but also at the project level. This study offers an itinerary of organisational readiness that enables the managers to confirm the organisational preparedness for the adoption of SPC. The small sample size may limit the generalisability of the findings. But this exploratory study provides critical information to the managers in this sector to develop a strategic plan for a successful SPC implementation.

ACKNOWLEDGEMENTS

Firstly and above all, I praise God, the Almighty for granting me the capability to proceed successfully. I would like to offer my sincere thanks to the people who facilitate me to develop the thesis appears in its current form.

My greatest appreciation is given to my esteemed supervisor, Prof. Jiju Antony for accepting me as his student, continuously support my Ph.D. study, offering valuable experience, trust, knowledge, great opportunities and especially for his patience and guidance along the journey. I could not imagine arriving at this stage without his guidance. I thank Dr. Norin Arshed as my second supervisor for providing me great assistance for my research methodology and offering review during the preparation of this thesis. I am greatly indebted to Michael Mitchell and Prof. Nazamid Saari for critically assisted in my data collection and lending their valuable time for great discussion sessions.

I would like to thank my parents, Abdul Halim Lim and Khatifah Ahmad for their spiritual support, continuous prayers and warm thoughts as they are my greatest inspiration and motivation to walk through this journey. This Ph.D. journey is greatly facilitated by husband Qadyr, as my Ph.D. companion and life partner where we both survived the difficult path of being a doctoral candidate away from our home and loved ones. I would like to thank my parents-in-law, Wan Mohtar and Che Husna for their moral support and constantly praying for my success in life. I am also grateful to my sisters, Aida and Norhaslina and sibling in-laws for always providing me nothing but excellent moral support.

Thanks to my dear friend Saja Albliwi who is also one of my research team members for her great companion and offering excellent discussions through my PhD journey. My warm thanks for my friends Faridah, Zila and Mang, Aishah, Aisyah and Lan, Tiger Peipei, Anjar, Muhammad and Yana and the late Arthur R.I.P for supporting and helping me along the process.

A final word of gratitude is reserved for the Malaysian Ministry of Higher Education and Universiti Putra Malaysia, for allowing and providing financial support over the duration of my Ph.D. study. I am grateful to the help of the staff in School of Management and Languages, Heriot-Watt University, Edinburgh and Department of Design, Manufacture and Engineering Department, University of Strathclyde, Glasgow for providing the support that I needed to produce and complete my thesis.

TABLE OF CONTENTS

LISTS OF TABLES

LISTS OF FIGURES

List of Publications

- Abdul Halim Lim, S., Antony, J., Arshed, N. (2016). A Critical Assessment on SPC Implementation in the UK Food Industry. *Journal of Systemics, Cybernetics and Informatics 14 (1)* (ahaead-of-print).

- Abdul Halim Lim, S., Antony, J., Arshed, N., & Albliwi, S. (2015). A systematic review of statistical process control implementation in the food manufacturing industry. *Total Quality Management & Business Excellence*, (ahead-of-print), 1-14.

- Lim, S. A. H., Antony, J., Garza-Reyes, J. A., &Arshed, N. (2015). Towards a conceptual roadmap for Statistical Process Control implementation in the food industry. *Trends in Food Science & Technology 44 (1)*, pp. 117-129.

- Lim, S. A. H., Antony, J., &He, Z. (2015). Critical Observations on the Statistical Process Control implementation in the UK Food Industry: A Survey. *International Journal of Quality & Reliability Management* (Accepted in September 2015)

- Antony, J., Abdul Halim Lim, S., Arshed, N. (2015). A critical assessment on SPC implementation in the UK food industry. Proceedings Volume II of The 19th Wold Multi-Conference on Systemics, Cybernetics and Informatics (WMSCI). July 12-15, Orlando, Florida, USA, pg. 51-56

- Lim, S. A. H., Antony, J., & Albliwi, S. (2014). Statistical Process Control (SPC) in the food industry–A systematic review and future research agenda. *Trends in Food Science & Technology*, *37(2)*, 137-151.

- Lim S.A.H and Antony, J., (2014) The Implementation of Statistical Process Control in the Food Industry: A Systematic Review in Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management (IEOM), Bali, Indonesia, January 7 – 9, 2014, pp:1683-1691

- Lim. S.A.H. and Antony, J. (2013), 'Statistical A Conceptual Readiness Framework for Statistical Process Control (SPC) Deployment', in the Proceedings of the IEEE International Conference on Industrial Engineering and Engineering Management (IEEM 2013) Bangkok, 10th-13th December 2013.

- Lim. S.A.H. and Antony, J. (2013), 'Statistical Process Control Implementation: SPC Team Development', in British Academy of Management: proceedings of the BAM 2013 conference: Managing to Make a Difference, Aintree Racecourse

Liverpool, 10th-12th September 2013. University of Liverpool Management School.

- Lim. S.A.H. and Antony, J. (2013), 'Statistical Process Control Implementation in the Food Industry: a Systematic Review and Implications for Future Research', in Advances in Manufacturing Technology XXVII: proceedings of the 11th International Conference on Manufacturing Research. Cranfield University, Cranfield, 19th-20th September 2013. Shehab, E., Ball, P., Tjahjono, B.: Cranfield University Press, pp. 593-598.

- Lim. S.A.H. and Antony, J. (2013). A Conceptual Framework for Statistical Process Control Implementation in Food Industry. International Conference on Quality, Reliability and Operations Research (ICONQROR 2013) Mumbai, January 7th -9th 2013.

- Lim. S.A.H. and Antony, J. (2012). A Critical Assessment of Statistical Process Control (SPC) Implementation Frameworks and Agenda for Future Research. 12th Annual Conference of the European Network for Business and Industrial Statistics (ENBIS), Ljubljana, Slovenia, September 9th -13th 2012.

- Lim, S. A. H., Antony, J., & He, Z. A Practical Tool to Assess Organisation Readiness for the Implementation of SPC. *Trends in Food Science & Technology –submission-*

- Lim, S. A. H., Antony, J., & He, Z. An exploratory study of Statistical Process Control implementation in the UK Food Industry: A multiple case study. *Production, Planning and Control.-submission-*

CHAPTER 1 – INTRODUCTION

Rapidly changing economic and market environments make it ever more important for businesses to meet their customers' needs. This means reducing costs, innovating every aspect of their company's operations and continuously improving their products, services and process performance, are relatively crucial.

It is impossible to inspect or test the quality of all the goods, so the products must be manufactured right first time. All those involved (including operators, engineers, quality control/assurance personnel and managers) must be able to monitor the state of process performance and reduce variability in key parameters to ensure processes remain statistically stable. Furthermore, the quality system must address both the technical and soft aspects of quality improvement, facilitating CI in every aspect of business operations, if the company is to remain competitive. On-line statistical process control (SPC) is widely used for this purpose across the manufacturing sector, though not so far in the food industry. The foundation of this technique is coming from a solid statistical theoretical background of the control chart, which has proven until now; it has not changed since it was introduced. This chapter introduces the background to the study and outlines the key research gaps to be investigated.

1.1 Statistical process control implementation framework

Dr Walter Shewhart first developed SPC in the 1920s when he joined the Western Electric to help the engineering team improve the quality of its telephone hardware. The technique gained popularity after World War II, and in1980, the US military began using sampling techniques to inspect their equipment. SPC was also adopted by the US automotive and semiconductor industries, which were struggling in the face of high-quality competition from Japan.

Research into SPC has greatly increased since 1980 as the demand has grown for CI and ever-higher process quality. Provided theoretical statistical studies significantly outnumbering studies from the operational management perspective research in this have taken one of two aforementioned perspectives (Kotz et al., 2002). Unfortunately, some of the most useful mathematical results from the theoretical studies are not accessible to quality practitioners (Woodall and Montgomery, 2014, Woodall, 2000, Stoumbos et al., 2000), leaving them unable to realise the full benefit from the technical advances that have been made in SPC over the decades.

There are gaps between the theory and actual practice of SPC in modern manufacturing where the most useful mathematical results are not accessible to quality practitioners (Woodall and Montgomery, 2014, Woodall, 2000, Stoumbos et al., 2000).The existence of this gap is showing the inability of the practitioners to achieve the full potential benefit from the technical advances in SPC for the past decades in realpractice.

To implement an effective SPC application, the process of applying the technique must be correctly managed. Renowned 'quality guru', William Edward Deming claimed that:

"*A system must be managed. It will not manage itself. Left to themselves in the Western world, components become selfish, competitive, independent profit centres, and thus destroy the system. . . . The secret is cooperation between components toward the aim of the organisation. We cannot afford the destructive effect of competition"'*(Deming, 1986)

It is a challenge to make the food companies understand that SPC does not just involve the construction of control charts – it requires companies to carry out a series of projects (starting with a pilot project), to monitor, control and improve their process performances (Hubbard, 2003). Developing practical guidelines are therefore crucial, as are studies that investigate the key factors for successful implementation, as such are useful for providing relevant managerial advice. However, such practical guidance is rare; most researchers have adopted the case study approach and offered only vague reflections on their findings (Gauri, 2003, Srikaeo and Hourigan, 2002). Only a few studies offer companies SPC frameworks for both project and organisational level without specifying any industry (Does and Trip, 1997, Noskievičová, 2010, Kumar and Motwani, 1996). Given the general lack of research on the practical aspects of SPC implementation, it is not surprising that the usage of SPC reportedly lacks in the food industry with 15% among European food companies, studies by Dora et al. (2013a).

1.2 Research context

The food industry is a major contributor to the UK economy. As one of the largest manufacturing sectors in the UK, it accounts for 60% of all manufacturing companies. In 2014, the food industry as a whole contributed £103 billion (6.9%) to the national Gross Value Added (GVA) and provided 3.8 million jobs nationally. Around 402 000 of these are in the manufacturing sub-sector – this represents approximately 13% of the UK's manufacturing workforce. Although the UK's food manufacturing sector still lags behind its international competitors (Wijnands et al., 2007), it is increasingly able to take on other countries and their home-grown industries; in 2015, UK food firms collectively exported £18.8 billion worth of food and drink products. In related to the food waste, UK is reportedly by The Guardians, as the worst offenders toward the EU food waste, with 3.9mt (Sedghi, 2015)

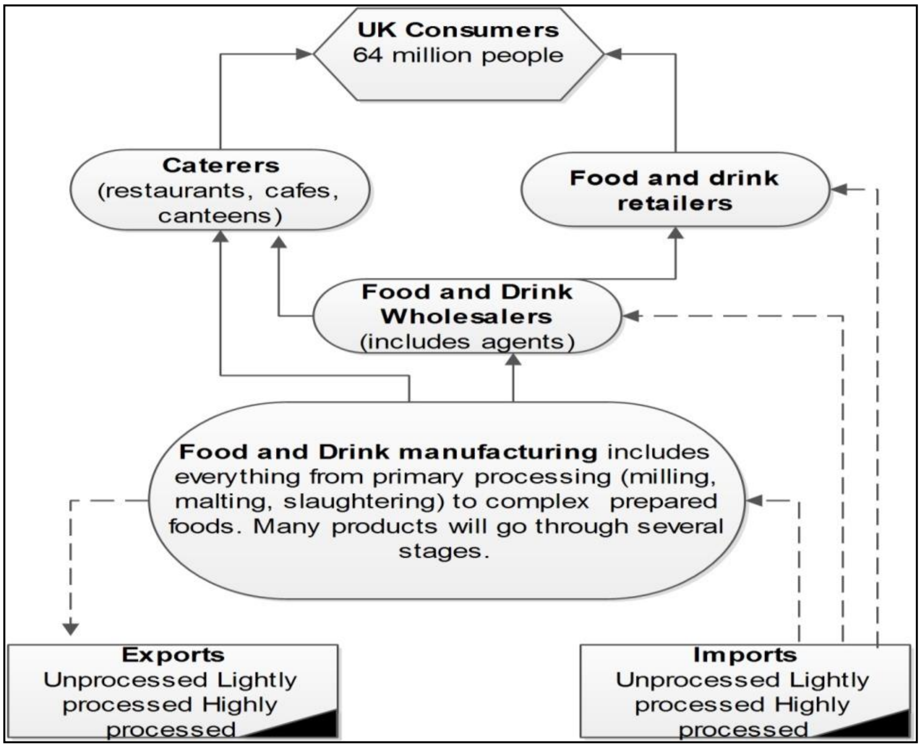


Figure 1.1 UK food industry chain (Department of Environment Food and Rural Affairs, 2015)

For the past eight decades, the food industry has witnessed food researchers, scientists and technologists facing issues of variation in food materials, products and processes, which has caught the attention not only of food researchers, but also of academics and the government (Surak, 1999b).

As Figure 1.1 makes clear, the output of the manufacturing process is the input to other components in the food chain. It is, therefore, crucial that the products delivered be safe to consume and of high quality. The food industry has less scope for growth due to there is a limit to consumer intake capacity, and therefore, this sector critically depends on the quality improvement (Department of Environment Food and Rural Affairs, 2015). The fact that it is also the sub-sector where products are most likely to be modified and optimised has led many food industry practitioners to recommend the widespread use of SPC.

Food businesses are under increasing pressure to transform their manufacturing practices to survive and thrive in the global marketplace (Oakland and Tanner, 2006, Mann et al., 1999, Mann and Adebanjo, 1998). They need to develop mechanisms that allow them to learn continuously and develop world-class practices. However, they start from an unpromising position; the food industry has a long-standing trade deficit (the result of a poorly developed management system) and a poor record for implementing improvements, compared to other sectors (Mann et al., 1999). Nevertheless, many large organisations have made a start by adopting formalised quality initiatives such as Six Sigma, Lean and Total Quality Management, all of which can impact on organisational culture as much as profits, and all of which employ SPC as a key quality improvement technique. SPC is primarily associated with the automotive and electrical industries (Grigg, 1998), and the standard manuals used for these industries are not suited to the food sector (Hubbard, 2003, Lim et al., 2014), making it difficult to apply the guidelines in this industry.

1.2.1 Organisational learning theory

Recent studies have focused on organisational learning (OL) in current manufacturing practices through the application of CI initiatives (Lagrosen et al., 2011, Malik and Blumenfeld, 2012, Malik et al., 2012, Lee and Lee, 2014, Savolainen and Haikonen, 2007). It has been claimed that quality control and quality improvement underpins the adaptive/incremental learning in OL theories, but it was argued that some of the activities within SPC may lead to generative learning (Senge, 1990). Learning in the organisation is continuous, which is congruent with SPC practices under a philosophy of CI.

Argote and Miron-Spektor (2011) describe OL as an on-going cycle in which task performance is converted into knowledge that is assimilated by the organisation – this then shapes future practices aimed at process improvement. The importance of OL theory in this study due to facilitate the effort to sustain the implementation of SPC in the food companies through continuous learning(Grigg and Walls, 2007b).

1.2.2 Organisational change readiness theories

SPC is widely perceived as being too advanced to incorporate into existing food quality management systems.Surak (1999a) comments that SPC is not implemented effectively within the food industry, particularly the food manufacturing companies while Grigg (1998) cites the lack of SPC knowledge and training as the major barriers to its widespread use in this sector. Recent research into CI initiatives provides evidence that organisational readiness is crucial to the successful adoption of CI initiatives such as SPC (McNabb and Sepic, 1995, Lameei, 2005, Hensley and Dobie, 2005, Abdolvand et al., 2008, Lagrosen et al., 2011, Lee et al., 2011).However, the literature fails to explain fully the specific criteria or critical factors by which an organisation should assess its readiness to adopt SPC.This is, therefore, one of the key areas of investigation in this research.

1.3 Research aim and research questions

The food industry iskey to the UK economy, and as such is desperately in need of powerful management technologies such as SPC that can improve the bottom-line and bring about cultural change. However, as many researchers have reported, there is a paucity of literature relating to the application of SPC in this sector (Grigg, 1998). Accordingly, the first research task was to review systematically and synthesise the previous research on SPC as one of the powerful techniques for process management. The review of the CI literature highlighted some themes around operational management perspective within the SPC implementation. The aim and objectives of the study, which were developed from these themes, are discussed below.

1.3.1 Status of SPC implementation in the food industry

It has been argued that the processes within the UK food production are being put at a disadvantage because of the lack of real-time SPC in its process management (Higgins, 2003). There is none in the existence of the statistics on some companies in the food industry employ SPC, as neither from the government nor the Food and Drink Agency. This was, therefore, the focus of the first research question.

Research Question (RQ) 1: *What is the status of SPC implementation in the UK food industry?*

In order to address the research question above, the researcher is required to achieve the respective research objectives below:

- To determine the widespread of SPC implementation in the food industry.
- To understand what type of SPC tools and charts are commonly applied in the food industry.
- To determine whether company size and commodity type influence SPC adoption.

1.3.2 Factors that inhibit and facilitate the implementation of SPC in the UK FMI

Where SPC is an appropriate choice, a range of factors will act to either facilitate or inhibit its uptake. The literature shows the principal structure to address this question is CSFs, barriers, reasons for not implementing SPC, and the type of learning involves which facilitate the sustainability of SPC (Grigg and Walls, 2007b). Therefore, the key themes associated with the implementation of SPC are stated as the research objectives.

RQ 2: *What are the organisational factors that critically inhibit and facilitate the SPC implementation in the context of the UK's FMI?*

In order to address the research question above, the researcher is required to achieve the respective research objectives below:

- To determine the factors that have facilitated (CSFs) the application of SPC within food organisations.
- To determine the barriers for SPC implementation in this sector
- To explore the reasons why SPC is not being adopted in food companies.
- To determine the type of organisational learning in the SPC implementation.

1.3.3 Structure of SPC implementation framework

This research aims to offer a practical guide for managers and key people in the food sector who are tasked with implementing SPC. The scholars argue that operation management and statistical theories are equally important for successful implementation. This question involves searching and connecting the key ingredients to facilitate the success of the implementation process. Guided by Argyris's (1990) theory-in-use, the researcher seeks to achieve this research objective by learning from the food company's experience of SPC adoption. Therefore, through the reflections of experience from the action research project, the researcher was able to collect soft data about communication in the company, its structures of authority, customs, decision-making style, functional collaborations and organisational politics.

RQ 3*: How to manage a successful SPC implementation in a food company?*

In order to address the research question above, the researcher is required to achieve the respective research objectives below:

- To identify the activities, those make up successful SPC projects in practice.
- To highlight the practical issues surrounding SPC implementation.

1.3.4 SPC readiness factors

This question addresses the most important aspect of the research: how companies can tell whether they are ready to embark on the SPC journey. Such readiness state was assessed across five factors, which were identified from the literature and empirical research.

RQ 4*: How can food companies assess their organisational readiness to adopt SPC?*

In order to address the research question above, the researcher is required to achieve the respective research objectives below:

- To explore the critical factors involved in developing an SPC readiness self-assessment tool.
- To develop a self-assessment tool for the use of food companies to evaluate their organisational readiness to implement SPC.

1.4 Research approach

The research approach is presented in Figure 1.2. There were three strands to the Research: A, B and C. Research strand A involved developing a body of knowledge on the status of SPC application in the food industry by means of a systematic literature review, survey and case studies. The review allowed the researcher to develop a conceptual understanding of the key themes associated with SPC implementation and implementation frameworks such as CSFs, the benefits and challenges of implementation, tools and techniques, and SPC team and process performance. Finally, it enabled the identification of the research gaps; this led to the formulation of RQ2, RQ3 and RQ4.

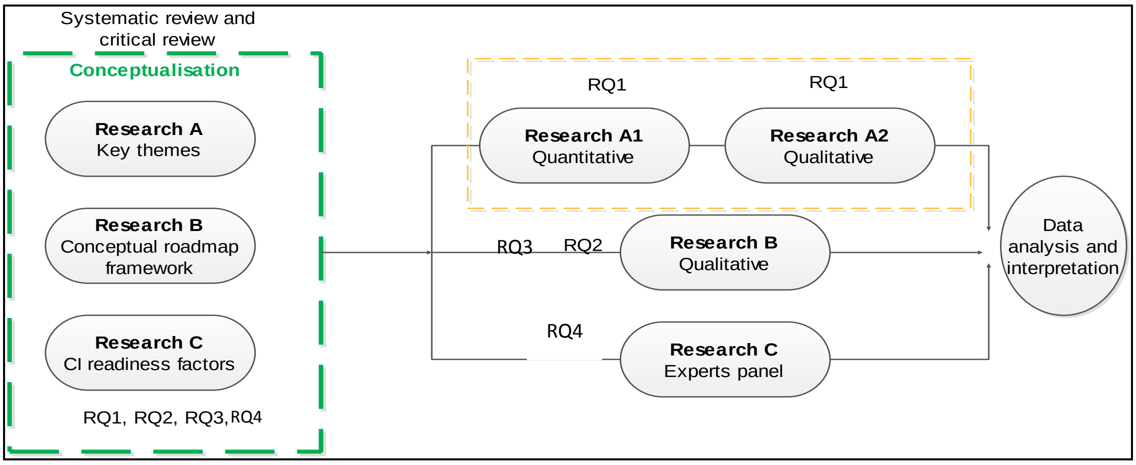


Figure 1.2 Model of research approach

Research strand A was pursued through two empirical studies, Research A1 (see Chapter 5) and Research A2 (see Chapter 6).In the former, a survey was conducted of 59 food companies to identify the status of SPC practices in the UK food industry, quality tools and techniques applied, CSFs, barriers factors, reasons for not applying SPC, SPC leader, common quality certifications, differences of process performance between SPC and non-SPC companies and finally assess the influence of company size, type of commodity and food quality certification on SPC adoption. In Research A2, multiple case studies were conducted to answer similar questions in the survey. The data gathered in Research A2 was used to explain and support the findings from Research A1 and to explore the type of learning currently found in the food industry.

Research strand B focused on RQ3. Drawing on theory-in-use, action research was employed to investigate the introduction and implementation of SPC in a food company (see Chapter 7). This study built on the findings from the critical review of existing implementation frameworks.

Finally, to address the exploratory nature of Research strand C, the expert panel approach was employed. The study in this research strand starts with the assessment of the organisational readiness theory from an extensive literature review of organisational readiness towards CI and later carried out an empirical study to explore the SPC readiness factors. The Delphi survey was conducted among academics and industry practitioners to identify which organisational factors determine a company's readiness to adopt SPC.

1.5 Structure of the thesis

Each chapter will contain, firstly, a brief explanation of what the chapter covers and how this relates to the research topic outlined in the Introduction. A summary will be provided at the end of each chapter to highlight to the reader the degree to which the objectives have been met throughout the respective chapter, including any critical remarks. The thesis is made up of ten chapters, the contents of which are outlined below.

Chapter 1: Introduction

In this chapter, the research context and topic are outlined and introduced. The motivation to conduct the research and the study's background are described, and the scope of the research and the development of the research aims were defined. In addition, the research objectives and questions are established.

Chapter 2: Statistical process control in the food industry

This chapter is aimed at exploring the current academic research on the SPC application within the food industry and related topics uncovered through a systematic literature review. In this chapter, the first research question (RQ1) is developed and partial attempts are made to address the question towards the end of the chapter by the conceptual result extracted from the systematic review.

Chapter 3: A conceptual Statistical Process Control implementation roadmap

This chapter comprises a review of the processes involved in SPC implementation and the activities relating to such processes in current publications in two research domains — the food manufacturing industry and SPC implementation framework. This is followed by an extensive review of the literature on organisational readiness for the adoption of CI.

Chapter 4: Research design and methodology

This chapter presents and justifies the rationale behind the choice of particular philosophies, approaches, strategies and data collection methods. The researcher will follow the research design outlined in this chapter in order to answer the research questions proposed in Chapter 1. At the end of the chapter, the researcher discusses the techniques and research quality criteria used to evaluate the quality of the present research.

Chapter 5: Quantitative data analysis: a survey

In this chapter, an analysis of the survey instrument using SPSS 15.0 is presented. The author focuses on descriptive statistics to analyse the findings on the status of SPC implementation (widespread of SPC implementation, managerial and operational aspects). Statistical testing of the assumptions extracted from the literature review was also carried out. This chapter partly addresses research questions RQ1 and RQ2 and sets the stage for performing multiple case studies in selected food companies in Chapter 6.

Chapter 6: Qualitative data analysis: multiple case studies

This chapter outlines the findings from the multiple case studies conducted through semi-structured interviews with representatives from eight UK food-manufacturing companies. The case studies explore richer information compared to the results derived from the survey. The findings highlight the type of OL in the companies, critical differences between the performances of SPC companies compared to non-SPC companies that answered the RQ2

Chapter 7: Introducing SPC to the food manufacturing company

In this chapter, action research projects in food manufacturing companies are illustrated, to carry out SPC pilot projects using the conceptual framework described in Chapter 3. The study identifies the various activities involved in introducing SPC and a pilot SPC project and captures pragmatic remarks derived from the project. The type of OL is identified through the activities involved in SPC implementation. By reflecting on the project, RQ3 is addressed and finally the SPC implementation roadmap was developed.

Chapter 8: SPC readiness self-assessment tool: A Delphi study

This chapter explores a definition for SPC readiness, as there is no previous publication on this topic. In this study the criteria to be used for assessing a measure of the readiness of a company are further determined; SPC experts (academics, consultants and practitioners) suggested doing this with the use of two rounds of a Delphi survey. Thematic analysis is used to determine readiness factors in CI determined from the literature, to reduce duplication and overlap. This chapter provides details of the pre-phase of an SPC implementation framework and the results presented answer RQ3.

Chapter 9: SPC implementation roadmap (SPCIR)

In this chapter, the author proposes an SPCIR (RQ3) and a customised framework for SPC adoption and implementation in SPC. The readiness factors and the implementation roadmap framework are designed by comparing findings from primary and secondary research.

Chapter 10: Conclusions and future research

In this chapter, theoretical and practical contributions from the research are explained, an assessment of the quality and limitations of the research given, and the future research agenda suggested. This chapter explains the conclusions for the research and provides a reflection on the researcher's research journey.

CHAPTER 2 — STATISTICAL PROCESS CONTROL IN THE FOOD INDUSTRY

2.1 Introduction

This chapter provides review of SPC implementation in the UK food industry. This review majorly focuses on benefits, motivations, challenges, and limitations, framework of implementing SPC in general and readiness of CI implementation. The trend of SPC applications (SPC tools used, and evolution of SPC in this sector) is reviewed. The review of literature on SPC application in the food-manufacturing environment leads to the research gaps, which develop the key research questions for this study.

2.2 The concept of Statistical Process Control

SPC is defined as a powerful collection of problem-solving tools useful in achieving process stability and improving capability through the reduction of variability (Montgomery, 2012). Attempts have been made to expand the concept of SPC beyond the process monitoring technique. SPC is categorised into several types of topics such as:

- technological innovation (Bushe, 1988, Roberts et al., 1989)
- process management technique (Bissell, 1994)
- control algorithm (O., 1997)
- a component of total quality management (TQM) (Barker, 1990)
- One of the quality management system in the food industry (Caswell et al., 1998).

Wallace et al. (2012) and Davis and Ryan (2005) viewed SPC as a participatory management system — teamwork efforts, employee involvement and enable real-time decisions were made (Deming, 1986, Elg et al., 2008).

The focus of SPC is understanding the variation in values of quality characteristic (Woodall, 2000). The process stability refers to the stability of the underlying probability distribution of a process over time and these very often can be described as the stability of the distribution parameters overtime (Mahalik and Nambiar, 2010). The process stability extremely crucial as it is one of the pre-requirement condition prior to the process capability indices determination (Brannstrom-Stenberg, 1999, Motorcu and Gullu, 2006, Sharma and Kharub, 2014). Mathematically, of course, we can calculate the capability indices, but for an unstable process, these indices measurement have no real significance, as assignable causes of variations in the process have not been identified. Therefore, a correct identification of the type of probability distribution is insufficient without the assurance that the process is statistically stable state overtime.

2.2.1 SPC tools

Based on the SPC definitions discussed in the previous section, it is assumed that the tools related to SPC are broad enough to include all statistically-based techniques range from taking a random sample to the very sophisticated design of experiments (Montgomery, 2012). There is no standard set of tools within SPC, however, Gaafar and Keats (1992) and Duffuaa and Ben-Daya (1995) argue that there is a general agreement on the seven tools which includes data gathering, Histogram, Pareto chart, cause and effect analysis (CEA)/fishbone diagram, scatter diagram, check sheets and control charts. However, it is generally agreed that control chart is a primary tool within SPC. Table 2.1 describe the SPC tools and its examples in the food manufacturing industry (FMI) application.

SPC is arguably involved more than its mathematical literacy issues. According to Rungtusanatham et al. (1997), the term SPC implementation requires a clear understanding of the procedures to be adopted and activities to be performed using a set of tools ─ indicating participatory management. Therefore, such argument is seconded with the implications from the dual concepts of SPC — "the operation of statistical control" and "the state of statistical control" suggested by Shewhart (1939).

According to Pena-Rodriguez (2013), Lim et al. (2014), Grigg (1998), there is a crucial need to develop customise guideline for the food industry to apply and integrating all these tools in a systematic manner at the correct problem.

Table 2.1SPC tools and its application in the food manufacturing

Tools	Description	Food Industry application	References
Pareto chart	Main purpose: Prioritisation by ranks the data, in descending order, from the highest frequency of occurrences to do laws frequency of occurrences. Principle 8020: Emphasise the need to focus first on the 20% of the causes that matter, without totally ignoring the remaining 80%. Question: which are the big problems?	Customer/consumer complaint analysis Sensory evaluation Vendor selection Ingredient/raw material risk assessment Marketing and sales Manufacturing deficits Process and quality control Equipment maintenance priorities	(Cravener et al., 1993, Varzakas and Arvanitoyannis, 2007, Dalgiç et al., 2011, Fotopoulos et al., 2011)
Scatter diagram	Main purpose: to illustrate the relationship or correlation between different variables. Principle: demonstrates the results of a series of experiments applied to document the relationship between the variables. Question: what are the relationships between factors?	Product and process improvement Process control Process and product design Downtime trend Trend of craft productivity	(Knowles et al., 2004, Grigg, 1998, Pluta, 2014)

CEA/ Ishikawa diagram	Main purpose: to identify possible causes for problem, uncover bottlenecks in the processes, identify where and why the process is working Principle: Identify all possible relationships among input and output variables, there is, five or six categories of the following skeleton (machines, methods, materials, manpower, measurements, environments) Question: What are the relationships between factors? Why does this happen?	Product and process design Product and process improvement Process optimisation Hazards and risk assessment Process control Audit (laboratory control and process, product and field performance.	(Varzakas and Arvanitoyannis, 2007, Saini et al., 2011, Hubbard, 2013, Desai et al., 2015)
Histogram	Main purpose: To illustrate and identify the distribution of the observations from a set of data. Principle: A graphical representation of the frequency of occurrence process that the points or a class that represents a set of data points. Question: what does the observation look like?	Stock and storage distribution analysis Estimation of the maintenance workload Process characterisation Customer/consumer complaint analysis Process performance distribution Analysis of shift in downtime distribution Raw material supplier reliability microbiology testing analysis	(Ooi and McFarlane, 1998, Srikaeo et al., 2005, Mertens et al., 2009, Mataragas et al., 2012, Dalgiç et al., 2011, Rábago-Remy et al., 2014)
Flowchart	Main purpose: to endeavour understanding of the process flow, a process for improvement, to communicate to others on how the process is done and to document the process. Principle: brainstorming activities (arranged activities in the process in proper sequence)	Process control and monitoring Process improvement Process characterisation	(Dalgiç et al., 2011, Mertens et al., 2009, Cinar and Schlesser, 2005, Srikaeo and Hourigan, 2002)

	Question: what are the steps and process involved?		
Check sheets	Main purpose: To provide a simple means for recording data and enable the analyst to determine the relative frequency of occurrence of the various categories of the data. Principle: brainstorming activities (arranged activities in the process in proper sequence) Question: how often is it done?	Data collection for process/quality performances Stock and storage check Work sampling Reviewing raw materials Incoming quality Raw materials Supplies	(Bidder, 1990, Hubbard, 2013)
Control chart	Main purpose: To study process changes over time, control on-going processes by finding and correcting problems as the current, to predict the expected range of outcomes from a process, to determine whether a process is table, to analyse evidence of process variation from special causes or common causes, whether the quality improvement project should be to prevent spastic problems or to make fundamental changes to the process. Principle: The graft of process characteristics plotted in sequence, it includes the calculated process mean of statistical control limits. Question: Which variations to control and how?	Vendor control and selection Process and product specification conformance Sensory (colour, flavour, odour) Sort, wash, clarify, heat, filter, mill Package integrity, code, feel, appearance Defects and wastage calculation Productivity Process performance Microbiology Product specification conformance Process, product, process performance Process, product, control planning	(Grigg, 1999, Grigg and Walls, 2007a, Ittzes, 2001, Hayes et al., 1997)

2.2.2 SPC and inspection

An inspection is an organised examination assessment of formal evaluation exercise. The results are usually compared to the specified requirements and standards for determining whether the target is achievable and this practice are usually destructive. In the error of inspection quality control of the product was limited only to the corrective inspection (e.g. it was away to check the uniformity of the final product by determining the defective products). In 1922, the inspection were linked formally with the quality management with the publication of the book "The Control of Quality in Manufacturing" (Paiva, 2013). The objective of inspection is to send only non-defective product to the customers which similarly the reasons why SPC is applied. Critical differences that opt out inspection as a quality control technique as depicted in Figure 2.1.

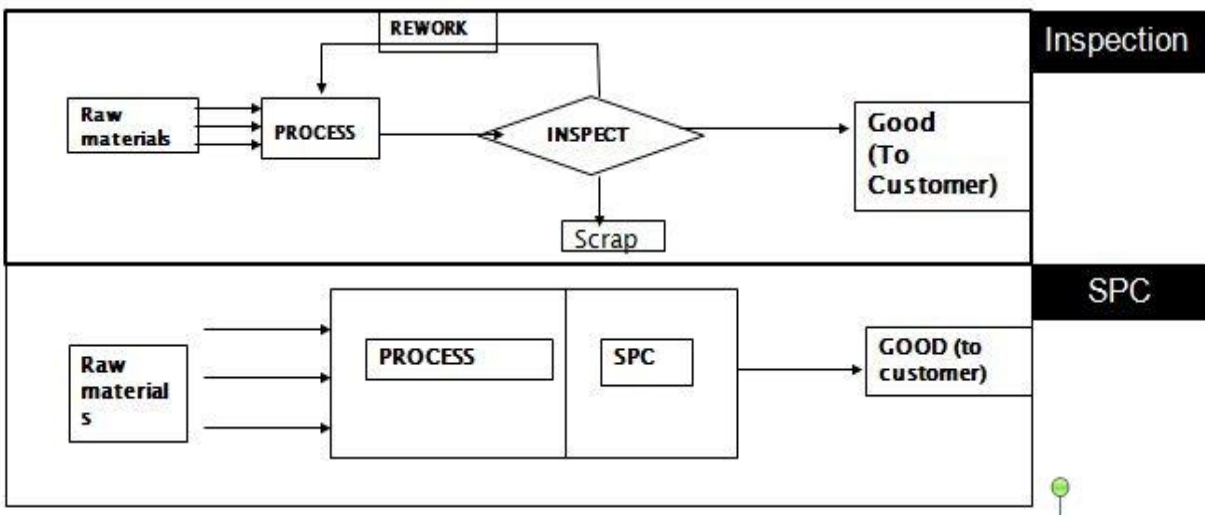


Figure 2.1 SPC versus inspection

Deming (1986) criticised the US manufacturing that applied mass inspection as quality control practice has significant drawbacks and bringing the industry down. Similarly, some of the critics of the inspection practice were listed below (Prosser, 2009, White, 2013, Fotopoulos and Psomas, 2009, Hurst and Harris, 2013):

- Inherently, it is timely, not economic call and ineffective to inspect each item very closely.
- Quality control inspectors have to be paid although they may not add value to the product.
- Inspection to improve quality is too late, ineffective, and costly.

- The inspection has a demoralising effect on employees, which reduce the likelihood of zero-defect production, which an architect of the Toyota production system Taichi Ohno, concluded after his study tour of Ford in Detroit (early 1950s)− that *“ there was too much ways and rework in the so-called most efficient car plant in goal”.* He argued, *"The mass production properties errors to keep the line running caused errors to multiply endlessly. Any worker could reasonably think that errors will be caught at the end of the line and he was likely to be disciplined for any action that caused the line to stop"*(White, 2013).
- There is no infallible inspection system. Inspectors also inevitably influenced inspection system by the human factor such as fatigues and inconsistency.

The differences of SPC and inspection depicted in Table 2.2.

Table 2.2 Differences between SPC and inspection

SPC	Inspection
Prevention	Detection
Proactive	Reactive
Control start at the production process	Control start at the production end light
Exist a feedback to production process for improvement	No feedback to production process
Output information gained: process behaviour, process trend, process performance	Output information gained: yes /no, go/no-go, defect/non-defect, conformance/non-conformance, accept/reject

In fact, Deming (1986) accentuated that even if there is inspection of every end-products, it does not necessary assure quality. Both Deming (1986) and Crosby (1984) agreed on the basic policy of eliminating product defects by prevention instead of reaction. It is also mean that quality control should start at the production process instead of production end-line which, leads to the implementation of SPC.

2.3 Systematic Literature Review

Systematic literature review (SLR) is viewed as a methodical and defined approach of identifying, assessing, and analysing published empirical or primary studies to address the research questions (Staples and Niazi, 2007). SLR is used to discover the patterns of existing research, provides reliable answers and identify the gaps that can be addressedby future studies(Thomas and Harden, 2008). SLR greater validity and reliability to be attributed to the synthesised findings. The process of SLR and its related procedures thatwere discussed in the next sectionhas played a significant role in evidence-based practices (Tranfield et al., 2003, Vasconcellos, 2003).

The research questions stated in Chapter 1 leads to the usage of SLR from the academicians perspectives, the reviewing process in SLR increases the methodological rigour and reduces biasness, and for the practitioners, this type of review facilitated the development a set of 'field tested and grounded technological rules' (Mensah and Julien, 2011).

2.3.1 Process of SLR: Selection and analysis

Based on specific techniques in the literature review, sources on SPC implementation were searched, collected, assessed and reported. This review was investigating the emerging issues in SPC implementation within the food industry, published between 1980 and 2015. Although SPC was initially pioneered by W.E. Deming in 1950, who elaborated on the principles developed by W. Shewart in 1920, it was not until 1980 that the manufacturing industry rapidly adopted the technique for their applications (Srikaeo et al., 2005, Montgomery, 2012)

This SLR is conducted by following four phases: planning, sampling, analysis and reporting. Such phases are based on SLR stages (planning the review; conducting the review, and reporting and dissemination) outlined by Tranfield et al. (2003) for evidence-based research in management studies. The overall process of the review is summarized in Figure 2.2.

2.3.1.1 Planning phase

The planning phase is crucial in portraying the structure of the SLR, and in helping decide the direction of the review to achieve the research objectives. Formulating a research question is the first and the far most important task in the review, as a good SLR is based on well-formulated and answerable questions (Counsell, 1998, Tranfield et al., 2003, Adams et al., 2015).

Planning

As in any type of research, a literature review should be planned and managed as a project, where elements of time, quality and money need to be considered. In this phase, the research aim, objectives and scope are identified.

Sampling

The purpose of the sampling phase is to increase the literature source credibility by providing a transparent article search and selection process using criteria developed in the plan phase.

Analysis

This is a phase where evidences are extracted from the selected sources, and is then categorized to produce new explanations or theories accounting for the range of findings.

Reporting

Writing a systematic review should not only report the review's results, analysis and gaps, but also the methods and considerations taken for the review.

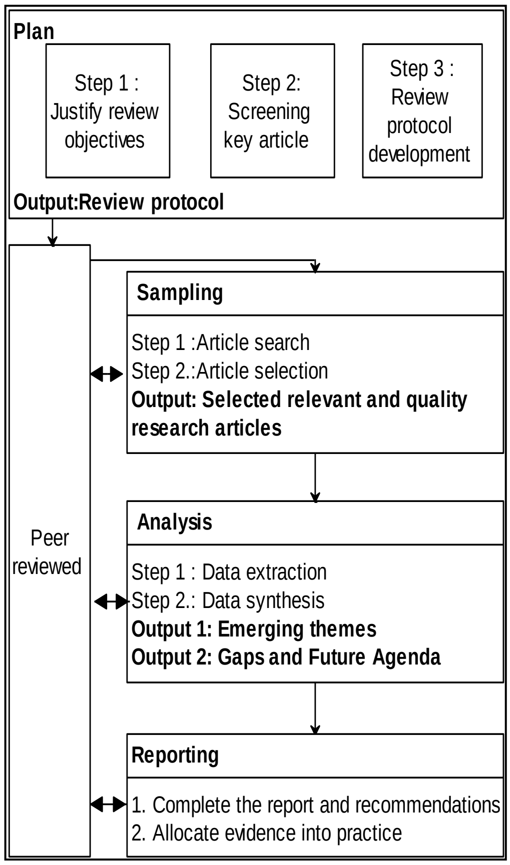


Figure 2.2 Systematic review process

Therefore, the researcher applied CIMO framework (context-intervention-mechanism-outcome) (Denyer and Tranfield, 2009, Briner and Denyer, 2010, Rousseau, 2012), which it is the management version of the PICO framework in health care (population-intervention-comparisons-outcome) to formulate the review questions (Figure 2.3). This framework determines the relevance of the collected articles, the criteria for evaluation, the research contributions, the research rigor and the communication of the research findings and subsequently facilitated the development of a review protocol.

A review protocol entails research aims, questions and objectives; research background; inclusion and exclusion criteria; the language of the article; a search and selection strategy; a study design; and tools for data synthesis and analysis (Tranfield et al., 2003). The protocol is essential to guide the literature review process towards answering the research questions and promotes the transparency, transferability and repeatability of the review and its findings(Boiral, 2012, Booth et al., 2012).

Context	Which institutional setting is being studied? • Food industry, processing, manufacturing	The effects of the events, action or activities, which are being studied? • SPC, Six Sigma, TQM, CI	Intervention
Output	What are the effects of the interventions? • Benefits, barriers, limitation, motivations, CSFs	What are the mechanisms that explain the relationship between interventions and outcomes? • SPC implementation process	Mechanism

Figure 2.3 C-I-M-O framework

2.3.1.2 Sampling phase

The sampling phase was rendered by the application of four databases using the following search strings: [(statistical process control) or (six sigma) or (total quality management) or (quality control) and (food industry) or food or agricultur* not service] (total quality management) and (food industry or food or agricultur*) or (statistical process control) (food industry or food or agricultur*) or (six sigma) and (food industry OR food OR agricultur*).As suggested in the previous section, the C-I-M-O framework guided the search process by determining the inclusion criteria for this review. The databases used were Emerald Insight, IEEEXplore, ScienceDirect and ABI/Inform.

2.3.1.3 Inclusion/exclusion criteria

The advantage of conducting an SLR is that the reviewer bias is reduced by the comprehensiveness of the search strategy and the transparency of the review's relevant article selection (Figure 2.5) (Sargeant et al., 2005, Tranfield et al., 2003, Booth et al., 2012). Selection of the articles was carried out based on the inclusion and exclusion criteria, which were developed from the research questions, objectives and review scope.

The exclusion criteria for 'context' are food services and laboratory trials since this review is focused in the industrial settings. Quality Function Deployment (QFD), Just-In-Time (JIT) and lean was excluded for there is no clear evidence that the usage of SPC underlies these techniques and philosophies.

Inclusion criteria related to 'mechanisms' are SPC introduction process and its implementation efforts; while the exclusion criterion is mathematic theoretical development articles. Finally, database search results usually include all types of sources—conference proceedings, book chapters, leaflets, brochures and website contents and peer-reviewed journals, where standardising the sample guarantees the quality of the information. In this particular case, the sample only included peer-reviewed journal articles. Upon that, the final sample of articles was selected according to the inclusion/exclusion criteria discussed in this section. The reviewed articles sampling process flow is presented in Figure 2.4.

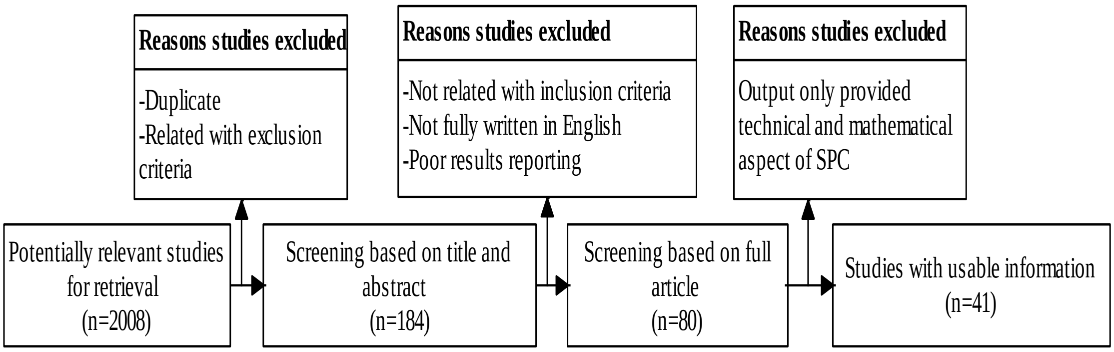


Figure 2.4 Articles selection process

Quality appraisal was conducted to ascertain whether the result of the study is reliable (Booth et al., 2012). The form for quality appraisal outlined byTranfield et al. (2003) was used and tested for quality appraisal (which represents an internal validity), as well as the external validity utilizing the impact factor of journals. As quality appraisal is closely connected to the selection process (Booth et al., 2012), both were conducted at the same time.

2.3.1.4 Analysis phase

Data extraction was carried out using inclusive and selective criteria of the qualitative findings. This approach is more comprehensive and resource-intensive, which means only particular types of data were extracted, i.e. data meeting pre-specified quality standards, data supported by interviews or observations, and data related to specific issues or research questions (Noyes and Lewin, 2011, Bates and Coren, 2006). Considering articles collected in this review are based on the SPC implementation aspect, which are mostly, used observations and interviews – this data extraction approach is the most appropriate. Thematic synthesis is chosen instead of meta-analysis due to the qualitative nature of this research; the extracted data that shaped the finding synthesis related to motivation, benefits, limitation, barriers, and the CSF of SPC implementation (Boiral, 2012, Medeiros et al., 2011, Thor et al., 2007, Thorpe et al., 2005).

2.3.1.5 Reporting phase

SLR has some reasons why this approach is considered the value to the literature in the context of research findings presented. In reporting, four important aspects (clarity-audibility-applicability–transparency) CART was considered. This paper uses the similar structure that uses the IMRAD (introduction-methods-results-and-discussion) format required when presenting any primary report (Booth et al., 2012).

2.4 Literature Trends

2.4.1 Growth of publications over commodities and time

Since its introduction in the manufacturing industry in the 1950s, the growth of SPC adoption has varied over time depending on the evolution and maturity of the knowledge available on this technique; then, it is comprehensible that the author proposed to consider the reported distribution of SPC application across commodities in the food industry over the considered timeline.The aforementioned consideration shows an inconsistent trend of growth of SPC publications in the food industry, and in 1998, demonstrated research on SPC implementation reached its summit Figure 2.5.

The selected journal article were mostly representative of the bakery industry — bread, pastry goods, cakes, rusks and biscuits and dairy industry — liquid milk, cream, butter, cheese and other milk-derived products (20.31%).

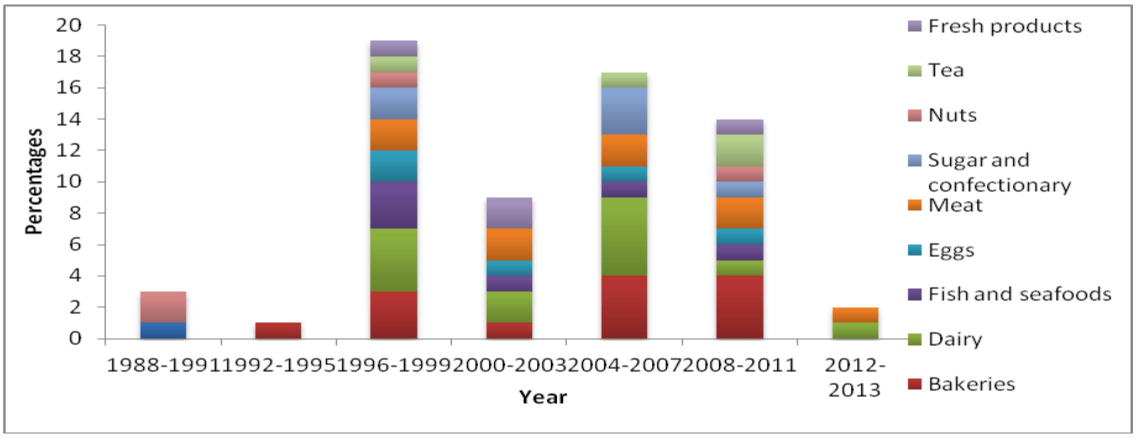


Figure 2.5 Growth of publication commodities

The smaller amount could explain this declaration and less complex processes in these industries compared to other commodities, enabling the observed wider application of SPC. In the dairy industry, the implementation of SPC is observed because of the obligation to comply with strict food safety laws. It was also found that most SPC applications in this industry are integrated with the use of HACCP (Jacxsens et al., 2011, Hayes et al., 1997, Hurst and Harris, 2013).

2.4.2 Growth of SPC publications over country and time

To organise the body of literature, details of articles growth discussing SPC implementation in the food industry are shown in Figure 2.6. The distribution of the reviewed articles per publication year showed an impressive number of articles in the period of 1996-1999. However, it is declining drastically in the year of 2000. By this period 1996-1999, there are many quality standards emerged and highly sought by the food manufacturing companies as depicted in Figure 2.8. Most of the quality initiatives in this period were implemented due to the requirements of food quality standards such as HACCP, (British Retail Consortium) BRC and ISO (Caswell et al., 1998).

Based on a total number of studies across the countries the research were carried out, most of the journal articles of SPC application in the food industry published from the United Kingdom and followed by the United States. The UK and USA manufacturing practices demonstrates many similarities and the quality management maturity is much more advanced than other countries (Swamidas and Winch, 2002).

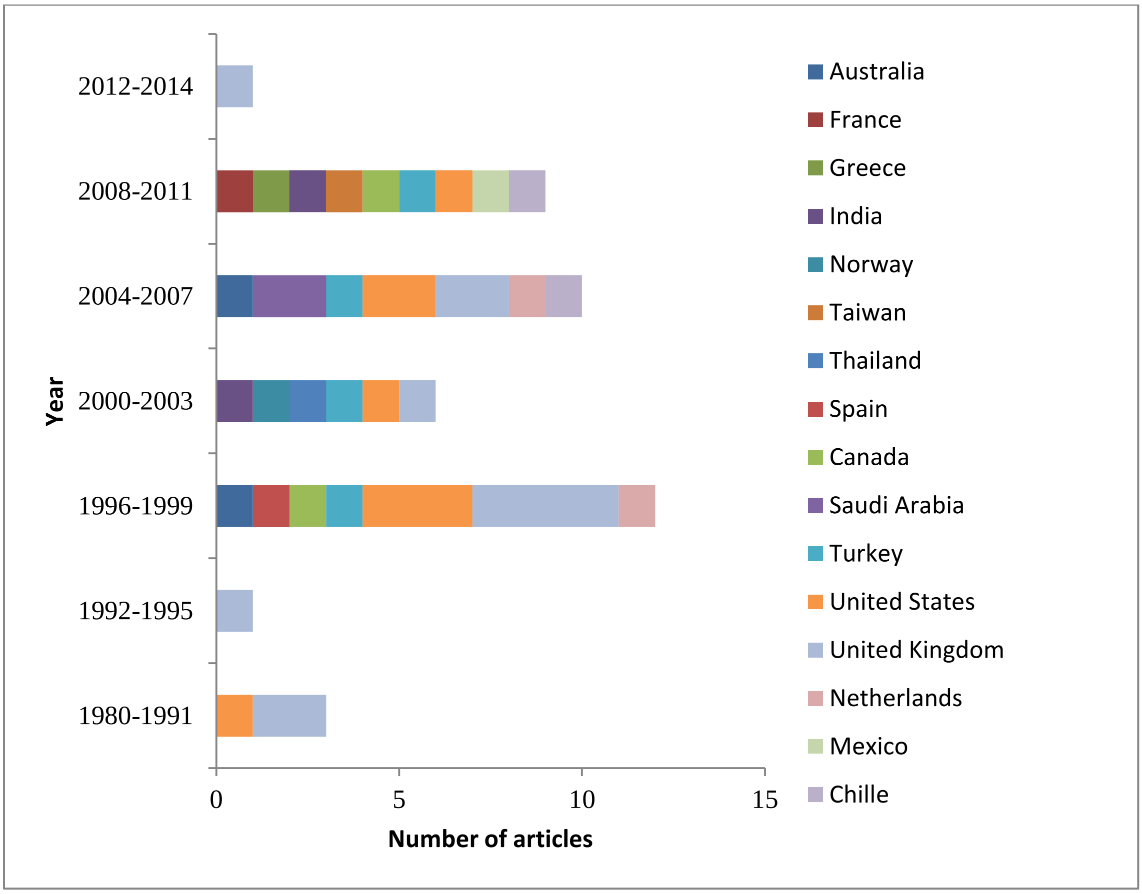


Figure 2.6 Year and country of publications

Since 1980s, the governments in the UK made macroeconomic transformation, which influencing the investment in manufacturing practice. This has narrowed the gap of the manufacturing practices between the two countries by the year 1990. (Swamidass and Winch, 2002, Lim et al., 2014). Therefore, Swamidass and Winch (2002) pointed that the countries with similar cultural and economic performance that promote globalisation may portrait similar manufacturing technology practices.

2.4.3 Research strategy in SPC implementation studies

This study breakdown the articles and type of paper according to the research methods applied in the Journal articles. Type of paper will be categorised into conceptual and empirical studies. The conceptual studies include literature review, perspectives and arguments, and secondary data articles and empirical studies refer to the application of case study, interview and survey and mixed method approach to answer their respective research questions. The distribution of this research method is depicted in Figure 2.7.

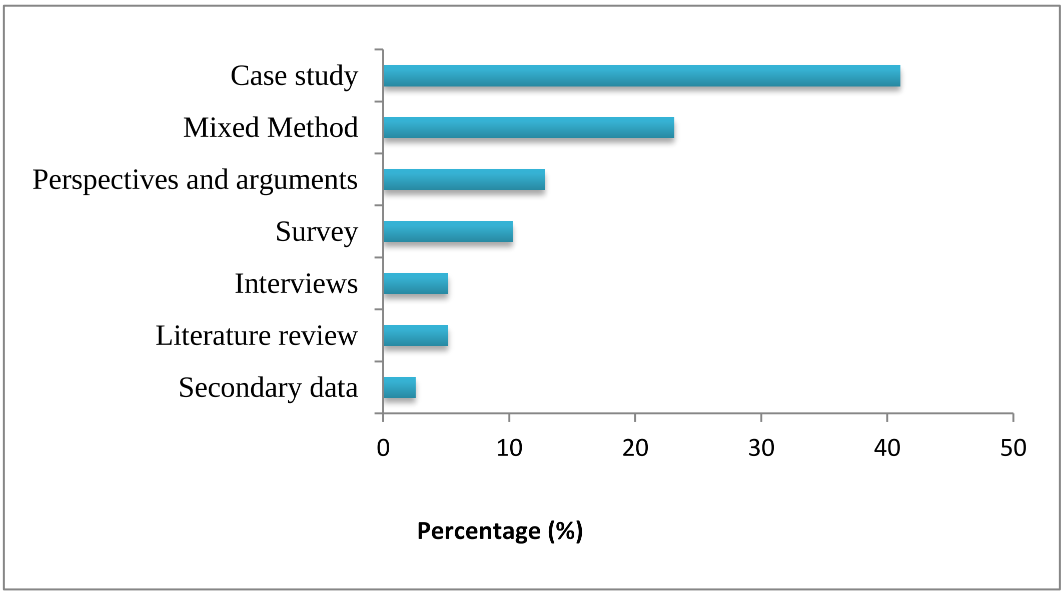


Figure 2.7 Type of research methods

Out of 41 journal articles in the review, empirical studies accounted the largest part of the literature body of SPC implementation within the FMI. Most of the reviewed articles discussed SPC issues and its opportunities using case studies with 41%. Case studies s used in most operation management studies due to its appropriateness to investigate the real situation within the context of interest (McCutcheon and Meredith, 1993). Many researchers used mixed methods as well, combining both quantitative and qualitative methods.

This literature review is carried out to determine the major themes discussed in the current literature review in regards to the topic SPC implementation within the FMI to scope the area of study of this research. According toTranfield et al. (2003), the area of study referred to features of the study; including sample characteristics, contexts, emergent themes, links to other concepts and main outcomes.

2.5 Evolution of the SPC implementation in the FMI

The essentials of food quality control can be traced back to around 2500 BC where Egyptian laws had provisions to prevent meat contamination (Edith and Ochubiojo, 2012). Although coined in engineering terminology, the term *quality control* was borrowed from the food industry (Herschdoerfer, 1967)and has been widely used in all types of settings.

The statistical approach to quality control has its origins in the invention of the control chart by W.A. Shewhart for the Bell Telephone Laboratory in the 1920s.

However, it was not until the late 1940s when W. Edwards Deming, having adopted Shewhart's work, found that the use of statistical techniques such as control charting could be beneficially employed in manufacturing industry. Pereira and Aspinwall (1991) report that it was not until the mid-1950s that the use of statistical quality control methods in the food industry became significant. One of the first successful applications was the control of container filling processes (Herschdoerfer, 1967, Pereira and Aspinwall, 1993). Until then, most of the applications of statistical quality control took place in the packaging process.

As stated by Pereira and Aspinwall (1991), the food industry began to apply SQC methods in combination with operational research techniques in the so-called Evolutionary Operations (EVOP), opening a window of opportunity to control operations of processes under continuous change and for process improvement.

The concept of quality assurance spread in the 1970s by food processors and public bodies, which it was believed as the best remedy for the quality issues faced by the food industry. One of the major foci, especially in the USA, was the establishment of the Food Products Safety and Consumer Protection Act. By achieving this, an integrated quality system was suggested, and Good Manufacturing Practice (GMP) was proposed (Hubbard, 2013, van der Spiegel et al., 2003). In 1986, the American Society for Quality Control (ASQC) published the Food Processing Industry Quality Systems Guidelines outlining the basic elements of structuring and evaluating the systems required for food production. Additionally, the utilisation of SPC has facilitated HACCP applications to control and monitor the process in real time (Grigg, 1998, Hayes et al., 1997).

Entering the millennium years, quality control studies, especially in the food industry, have diverted its direction to nurturing a statistical thinking mind-set in the whole business (Hersleth and Bjerke, 2001, Grigg and Walls, 2007a). The culture of CI and statistical thinking has set a new perspective in the food industry on quality related issues, where quality control and improvement activities are not only useful at the production line but also for the other business units across the organisation. Figure 2.8 maps the evolution of SPC in the food industry literature. In the face of the emerging trends above, the key questions to be answered are: What is the driving force for SPC implementation for the food manufacturing companies? What are the challenges and limitations of SPC implementation in the food industry? What is the future research direction of SPC implementation in the context of the food industry? Thus, the following subsections are structured to address these questions.

2.6 SPC case studies in the FMI

41% of the sampled articles carried out case studies; out of which three studies applied SPC through the implementation of Six Sigma methodology. Of the remaining sources, all SPC studies depicted an integration of other quality tools and technique such as Design of Experiment (DOE). Most of the integrated SPC and HACCP cases refer to food safety control and the main issue discussed in these articles concerns the validation of critical control points (CCP).

From the case studies presented in Table 2.3, a considerable number of critical parameters involved in the food processes were identified. These appertain sensory attributes (i.e. size, weight, texture, colour, height) and safety attributes (i.e. microbial counts). In the same way, for the food industry, SPC implementation prime characteristics of quality include food safety attributes, sensory attributes and packaging attributes of the products. It was reported in the seminar of quality control for processed food by the Asian Productivity Organization (APO) that a Japanese food quality pre-requisite programme named *Importance of the Quality Control*, where they highlighted the most important criteria in quality control of processed food to be safety and reliability, followed by "deliciousness" and "appropriate price" (Raju, 2005).

	1950s	1960s	1970s	1980s	1990s	2000	2010
Development of SPC application for food quality	Focus on canning and preserving industry Basic statistical techniques for monitoring food quality	The importance of managerial aspects Preventive quality control Statistical methods as a management tool	Major concern is Food products safety and consumer protection Quality assurance in food industry An improvement in national standards	SPC in food quality management Consumer focus in food business	Quality standards and certifications	Organisational learning in SPC SPC in business improvement programmes Statistical thinking	Quality improvement activities linked with business strategic planning
Quality tools, techniques and programmes	• Inspection • Sampling plan • Control chart	• Design of Experiment • SPC • Process Capability • Zero Defects • Evolutionary Operations	• Total Quality Control • Quality Costs	• Total Quality Management (TQM) • ISO 9000 • HACCP • Quality Circles		• ISO 9000:2000 • Lean • Six Sigma • Lean Six Sigma	

Figure 2.8 Evolution of SPC in the food industry

Table 2.3 SPC application in the food industry

Articles and Country	Commodities (Product)	Issues	Quality characteristics	Type of SPC tools	Other quality program	Output: Benefits and Duration
Knowles et al. (2004), -UK	Sugar confectionery (Medicated sweets)	The variation in the sweet size caused reworks, scraps, machine downtime.	Sweet thickness	• Xbar chart • R chart • Histogram • Scatter plot • Ishikawa diagram	Six Sigma Taguchi method	Saved £290 000 Improve C*pk* from 0.5 to 1.6 -12 months
Daniels (2005), -USA	Bakeries (Pie)	The major customer filed complaints on the crust strength and risk of losing the customer.	Crust strength	• X-bar chart • Box plot • Pareto chart	HACCP Six Sigma DOE	Reduce scrap rate 40% Saved £274, 983
Grigg et al. (1998) -UK	Fish	Product giveaway and unnecessary checkweigher rejection	Package weight	• X-bar chart • R chart	None	Reduce product giveaway and rejection rate.
Negiz et al. (1998) -USA	Dairy	In dairy pasteurisation, if the product temperature drops below 1610F (15s holding time), the product must be diverted	Temperature	• Hotelling T^2 chart	None	20% over processing were detected. Receive signals for non-compliance.

		immediately to comply.				
(Srikaeo and Hourigan, 2002) -Australia	Eggs	There is no evidence of the effectiveness of HACCP elements.	Temperature pH Chlorine level	• Individual chart	HACCP	The CCP value validated (All control measures are capable to design critical limits except chlorine level). - 6 months
Augustin and Minvielle (2008) - France	Meat processing and preserving	The low rate of unsatisfactory batches of *Enterobacteriaceae* and *Pseudomonas* count detection caused doubt on the efficiency of the traditional control scheme.	Microbial count	• Moving Average chart, • Box plot • Histogram	HACCP	Validates the assumption of microbiological contamination variances is in control (2% variances above the control limit).
Dalgiç et al. (2011) -Turkey	Meat processing and preserving	There is demand for more effective quality control technique to assist HACCP implementation.	Moisture content pH	• Process mapping • Pareto chart • Scatter plot • Ishikawa diagram • X-bar chart • R chart	TQM HACCP ISO 2200 ISO9000 FMEA	Stabilise the moisture content (reading approximately 40%). Able to prioritise 5 critical problems. Enable plant operators to take action quickly. -3 months
Rai (2008)	Tea	The critical problem faced in tea production is the	Weight	• CUSUM • Xbar chart	None	Reduction of out-of-control situation from 66% to 4%

-India		weight variation in the tea packet (underweight or overweight).				
(Srikaeo et al., 2005) -Australia	Biscuits	Best practice is required for process characterisation either for newprocess or for when a process has undergone significant engineering change.	Temperature Cooking time Press pressure (in moulder)	• Histogram • X-bar chart • R chart	None	Able to detect the worst line performance; Cpk 0.63< 1.33 (required values) An inadequate measurement system with operators' measurement variations for wheat protein and moisture content contributes 92.21% and 98.84% of total variation respectively. -10 months
Miller and Balch (1991) -USA	Nuts	Downtime for the blend/grinding process caused lost production and more equipment wear off.	Colour Salt content	• Pareto charts • X bar chart • R chart	None	Reduce 35% blending/grinding downtime and 61% total downtime occurrences. Uniform feed of salt into the grinder Reduce 55% colour variation. -15 months
Hung and Sung (2011a) -Taiwan	Bakery	During re-steaming bun process, customers complaints that the product has issues such as shrinkage, foreign material	Weight	• Pareto charts • Tree diagram • Process mapping • Ishikawa	Six Sigma GMP DOE	Decrease the 70% shrinkage rate (defects). -6 months

		and crack.		diagram • X-bar chart • R chart		
Hayes et al. (1997) -UK	Dairy	There is neither proper trend analysis nor warning to out-of-control CP in the Relative Light Units (RLU) - reading for ATP Bioluminescence Technique for food safety purposes.	RLU reading	• CUSUM • Individual chart	HACCP	Provide warning in FAIL case as early as Day 51 before the out-of-control on Day 74. Depict better prevention, control system with the integration of SPC and HACCP -3 months
Özdemir and Özilgen (1997) -Turkey	Nuts	Production of hazelnuts worth £312,480,500 faced a quality problem of damage during the cracking process.	Damaged nuts	• p-charts	DOE	The quality performance is clear and able to detect the need for equipment readjustment and the operational problem (crusher equipment).
Gauri (2003) -India	Bakery	Loss of profit due to manufacturing target is set above the declared packaging weight.	Thickness Weight	• Pareto chart • X-Moving Range chart • Scatter plot	None	Reductions of 4.6 g average pack weight Reduction of 5.65 S.D Reduction of 10% underweight packet, and 1.2% for overweight Increase 48.6% yield

Benefits of implementing SPC

The result of this review pointed that the highest cited benefit is defective products reduction, food safety and financial advantage (Table 2.4). Most of the articles reported that variation reduction of the product is achievable due to the effective application of control charts. However, the applications of other SPC tools have rarely been discussed. Such practice is argued to be against the definition of SPC —'SPC is a combination of statistical and problem-solving technique where control chart is one of the tools listed in SPC' (Montgomery, 2009). Variation reduction enables the SPC users to achieve other SPC benefits as depicted by the Deming's chain reaction model – a range of advantages which includes reduction of defects, wastage, scrap, the cost of quality, improving process efficiency, compliance to food law and regulatory and improvement in the business image (Barker, 1990).

Table 2.4 Benefits of SPC implementation

Factors	References
Reduced non-conforming products • Process variation reduction • Increased consistency in product	(Scott et al., 2009, Alsaleh, 2007, Grigg and Walls, 2007a, Grigg and Walls, 2007b, Kourti, 2005, Cinar and Schlesser, 2005, Knowles et al., 2004, Daniels, 2005, Gauri, 2003, Grigg, 1998, Özdemir, and Özilgen, 1997)
Guaranteed food safety • Establish trend of CCP data • Control the product shelf life • Control microbiological contamination level • Minimise the risk of product recalls	(Hayes et al., 1997, Cinar and Schlesser, 2005, Narinder et al., 2005, Srikaeo et al., 2005, Augustin and Minvielle, 2008, Mataragas et al., 2012, Alsaleh, 2007)
Improved cost savings • Reduced process waste • Reduced rework • Reduced scraps	(Mazu and Conklin, 2012, Hung and Sung, 2011, Knowles et al., 2004, Daniels, 2005, Gauri, 2003, Ennis and Bi, 2000, Grigg, 1998)

• Reduced number of inspectors	
Improved process visibility and understanding • More information can be extracted compared to pass/fail: -Process behaviour -Process stability -Warning signals for non-compliance	(Hung and Sung, 2011, Hersleth and Bjerke, 2001, Srikaeo and Hourigan, 2002, Ittzes, 2001, Grigg, 2008, Hayes et al., 1997)
Improved decision-making process • Enable to distinguish type of process variation • Able to pinpoint day/time that is out-of-control for corrective action • Facilitates people to identify areas for improvement • Improve communication between process actors	(Mazu and Conklin, 2012, Pable et al., 2010, Simoglou et al., 2005, Cinar and Schlesser, 2005, Hersleth and Bjerke, 2001, Orr, 1999)
Competitive advantage • SPC indirectly generates higher business sales through consistently to produce quality products • SPC is able to strengthen company's survival in the global market • Continuous learning through SPC, improve organisations competitive advantage	(Grigg and Walls, 2007a, Grigg and Walls, 2007b, Knowles et al., 2004, Psomas and Fotopoulos, 2010, Alsaleh, 2007)
Improved customer satisfaction • Food manufacturers satisfy their customers (consumers and retailers) by sustaining consistency of quality products through SPC application • Reduced customer complaints	(Rábago-Remy et al., 2014, Alsaleh, 2007, Gauri, 2003, Grigg, 1998)
Reduced product giveaway or underfill	(Grigg et al., 1998, Gauri, 2003)

• Prevents unnecessary rejection and overfill in food packaging	

Another type of indirect benefit is the opportunity to learn more about the process from the data instead of rational thinking, enabling the facilitation of the employees' ownership of the process and increasing the motivation of employees to undertake or apply the application of SPC under the CI culture (Rungtusanatham et al., 1997). Many food manufacturers considered certifications such as ISO 9000 and British Retail Consortium (BRC) as quality management initiatives in their businesses (Dora et al., 2013a, Paiva, 2013). However, given that audits were carried out annually, these certifications are arguably does not preach the culture of CI. The researcher also observes that implementation of SPC, which endeavours a CI culture in process management, enables the facilitation of the food manufacturers, which in turn reduces the burden on the efforts of getting the certifications of interest.

2.7 Motivations

This review unearthed that the SPC implementation in the food industry is inspired by two categories of motivational factors. Such factors are categorised under proactive (i.e. self-desire by the food producers), and reactive (response to regulations and threats whereby failure comply may result in adverse effects) (Grigg and Walls, 2007a, Brannstrom-Stenberg, 1999). In fact, the obligation of food producers to comply with food safety and food law and regulations is highly discussed in food control management studies (Jia and Jukes, 2012). The motivation factors were listed in Figure 2.9.

The results of this review strongly suggest that most of the food companies implement SPC on their own free will — to experience a greater extent of advantages; but when implemented as a defence mechanism against audits and to abide food law, it is more likely to provide only short-term improvements and restricted further long-term success (Brannstrom-Stenberg, 1999, Cheng and Dawson, 1998). Furthermore, the companies that were forced to implement SPC, commonly missed their opportunity to gain greater benefits such as understanding process behaviour, identifying process trends and subsequently defying process improvement opportunities (Dale et al., 2007)

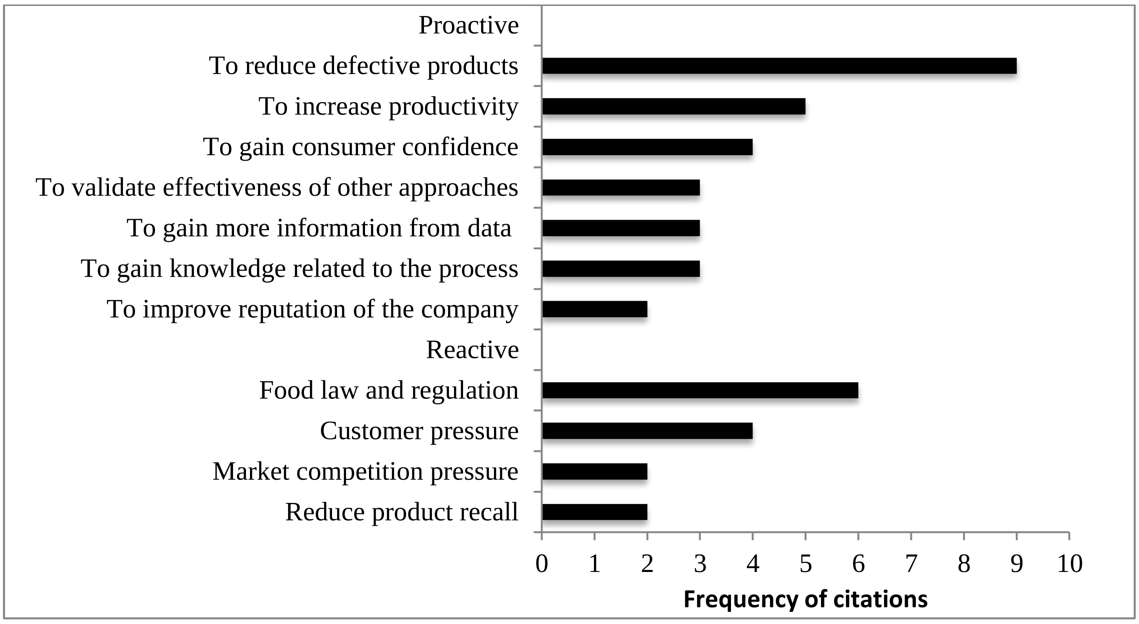


Figure 2.9 Motivations for SPC implementation

The results of this review are in synchrony with the outcome of a survey of CI practice in the Canadian food industry (Scott et al., 2009). Since introduced by governments, food laws and regulations are highly overseen and mandatory for compliance and are mostly circulated by food safety officers (Grigg and Williams, 2000). In fact, Psomas and Fotopoulos (2010) indicated that TQM implementation in the food industry took place due to the escalating demands of the consumers and the government in regards to food quality and safety. This review disclosed that although the SPC implementation in the food industry mainly relates to food safety, the adoption of SPC implementation in these recent years is also due to great interest in the process of the food production and quality improvement opportunities.

2.8 Barriers to SPC implementation in the food industry

The top three barriers discussed in the literature are the resistance to change, lack of sufficient statistical knowledge and deficiency of management support. More details on the barriers to SPC implementation in the food industry are provided in Table 2.5.

Table 2.5Barriers of SPC implementation

Barriers (frequency of citation)	References
Resistance to change Current food organisations have not fully accepted the need for CI techniques Fear of failure	(Dora, Van Goubergen, Kumar, Molnar & Gellynck, 2014, Jha et al., 1999, Hersleth and Bjerke, 2001, Srikaeo et al., 2005, Hung and Sung, 2011)
Lack of statistical knowledge Unfamiliar with the use of advanced statistical techniques	(Alsaleh, 2007, Hersleth and Bjerke, 2001, Bidder, 1990, Hung and Sung, 2011, Grigg, 1998)
Lack of management support Resistance to provide sufficient resources Lack of management awareness on SPC Improvement project activities are not at the highest priority Managing directors do not appreciate the value of SPC Lack of encouragement for employee involvement	(Grigg, 1999, Srikaeo et al., 2005, Jha et al., 1999, Hersleth and Bjerke, 2001)
Poor measurement system Lack of awareness the importance of capable measurement system	(Srikaeo et al., 2005, Gauri, 2003, Grigg, 1998)
Lack of practical guidelines There is no practical manual for food manufacturers to initiate SPC implementation	(Grigg, 1998, Grigg and Walls, 2007a)
Lack of employee empowerment A survey shows Norwegian food companies do not welcome suggestions and opinions from employees for quality improvement purposes	(Hersleth and Bjerke, 2001, Grigg, 1998)

Lack of trained employees A study in a high-volume production facility that applied extremely rigorous SPC abandons the technique due to lack of in-house expertise Many statistical techniques are perceived as too advanced for untrained staff in the food industry	(Hung and Sung, 2011. Grigg, 1998, Grigg and Walls, 2007b)
Lack of experience Lack of experience in using quality tools obstructs quality improvement initiatives in food companies e.g. Taiwan	(Hung and Sung, 2011)

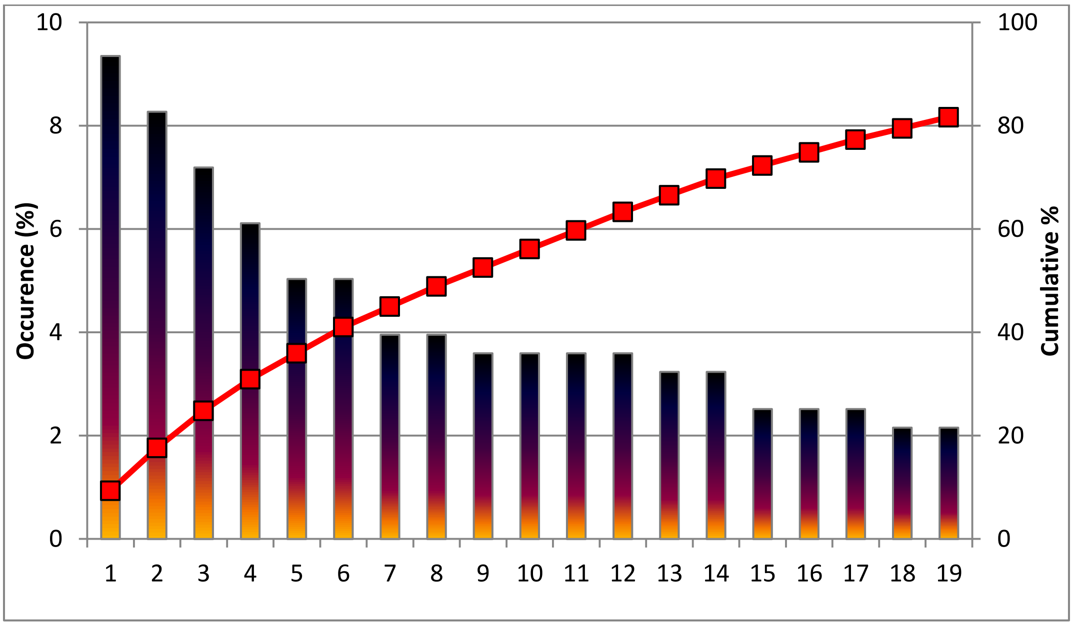
Similar to other industries, lack of top management commitment is the top barrier, however in the food industry; resistance is much more of a dominant issue (Surak, 1999). The resistance to change was contributed by the shop floor, where the shop floor perceives SPC as a short-term QC technique, while top management were reluctant to provide sufficient time for the employees to become involved in the SPC projects (Dora et al., 2015, Hersleth and Bjerke, 2001).

Lack of statistical knowledge has an alarming contribution to the fear of employees towards the technique. For example, 22% of Saudi Arabia (UAE) food companies are incognizant of quality tools (Alsaleh, 2007) and Dora et al., (2013a) reported that visual inspection is the most popular tool for QC in the food industry instead of SPC as it requires less statistical expertise and resources. One of the causes identified was the lack of a statistically based quality techniques introduced in current tertiary education (Grigg and Walls, 2007a).

2.9 Critical Success Factors (CSF)

The idea that there are a few factors can be ascertained which are decisive for the success of a company was introduced by Daniel (1961). Later on, Rockart (1979) elaborate the idea of critical success factors (CSFs) where he defines CSFs as the limited number of key areas where satisfactory results will ensure successful competitive performance for the individual, department or organisation.

The current study also identified that components in the existing SPC implementation frameworks developed based on the CSFs listed in the literature (Noskievičová, 2010, Kumar and Motwani, 1996, Does and Trip, 1997, Dogdu et al., 1997b, Krumwiede and Sheu, 1996, Antony and Taner, 2003). This review offers a compilation of the CSFs reported by the previous study in SPC implementation. 19 CSFs were identified as depicted in Figure 2.10.



1.Top management commitment	11.Data requirement
2.Training	12. Feedback and responsiveness
3.Measurement system	13.CI culture
4.Control chart application	14. Process description
5. Teamwork/ Implementation team	15.Program planning
6. Cultural change	16. Documentation
7.Identification of critical quality characteristics	17. SPC facilitators
8. Data management and SPC software	18.Customer satisfaction orientation
9.Process prioritization	19.Employee empowerment
10. Pilot study	

Figure 2.10 Pareto analysis of SPC CSFs

Top management has been the most prevalent factor associated with the success not just for SPC implementation system, but for any quality management system (Gordon et al., 1994). Top management commitment is a latent variable, which cannot be measured directly, however often viewed to provide adequate resources, commitment, support. (Gordon et al., 1994) and project approval (Rohani and Yusof, 2009), which these can be provided in a manifestation of top management to quality.

Training is an essential effort to overcome the resistance to change by the food companies towards SPC implementation (Surak, 1999a) as the sessions able to provide sufficient information and knowledge on the SPC implementation (Hersleth and Bjerke, 2001). Furthermore, through a study by Hersleth and Bjerke (2001) and Davis and Ryan (2005), the competence level of the employees in the food industry are averagely low and it was argues that it is correlated with the low ability to achieve statistical thinking. The operational definition of "competence" in the study was the combination of formal education, knowledge and experience. Hence, in the SPC implementation in the food industry, training plays a crucial role throughout its application to overcome the challenges factors describe in section 2.8 and reduce the SPC limitation factors (see section 2.10).

Only three journal articles are focusing on this theme in the SPC implementation within the food industry context (Grigg, 1999, Grigg and Walls, 2007a, Hersleth and Bjerke, 2001). A holistic view of the CSF of SPC in the food industry contains five core elements: management, training, technology, culture and statistics were presented in Figure 2.11.

Management	Training	Technology	Culture	Statistics
• Management commitment • Strategy for quality improvement • Financial resources	• Continuous training • Competence level • SPC facilitator	• Information technology (IT) availability • Data analysis software and tools	• Statistical thinking • Empowerment • Participation in a cluster or networks • Organisational size	• Project prioritisation • Data collection procedure • Control chart

Figure 2.11 Key components of SPC implementation in the FMI

External facilitator factors comprise sources (e.g. advice, sources and assistance), strategic alliance (facilitates filtering down the best practice) and unified food industry strategy, which strengthens the university or academic-industry relationship to enhance industrial performance in the global market. Although considerable research related to quality improvement has been carried out in the UK, it still lacks of focus on a unified food industry strategy, and UK falls below other countries such as New Zealand, Denmark and the Netherlands in this aspect (Grigg and Walls, 2007a). Such aspect constitutes cooperation between government, research-based institutions and industry.

The challenging factors in implementing SPC for the food industry are not only related to statistical theoretical and technical issues, but also involve non-mathematical levels such as cultural and human issues. This has led to the fact that even with a good data collection system, sufficient knowledge of systems, tools and methods, sufficient time and high motivation, the key to success remains complex (Hersleth and Bjerke, 2001).

2.10 Limitations of SPC implementation

The limitations of SPC implementation in the food industry were depicted in Table 2.6. Based on the results, the most cited limitation is the lack of ST culture in the food industry, followed by SPC being perceived as a tool advanced technique for non-statisticians, and a lack of applicable guidelines available in the food industry context.

Table 2.6 Limitations of SPC application in the FMI

Limitations Details/examples	References
Lack of statistical thinking (ST) • Decision-making based on data is not a customary practice in the food industry	(Dora, 2013b, Grigg and Walls, 2007b, Hersleth and Bjerke, 2001, Gauri, 2003)
SPC is considered too advanced • SPC is perceived as too advanced for the food industry • Multivariate control chart application is too challenging for the shop floor employees to handle	(Paiva, 2013, Srikaeo et al., 2005, Buco, 1990)
Existing manuals cannot comprehend food manufacturing applications	(Grigg, 1998, Gauri, 2003, Grigg and

• Current available manual within the food industry (BIS manual) for control and monitoring is arguably too complicated for real application in food manufacturing • Quality parameters depend on multiple factors, increasing the time needed for corrective action	Walls, 2007b, Psomasand Fotopoulos, 2010)
Costly technique • SPC is considered as a luxury option due to training and software requirements for its application	(Alsaleh, 2007, Gough, 1989)

The list of limitations in this review stressed that the lack of early education on SPC led to other limitations such as the lack of ST culture. ST core elements entail the realisation that all work occurs in interconnected systems, each process has variations and the key to success is to reduce these variations (Hersleth and Bjerke, 2001, Snee, 1990). ST has a critical role as a platform for the adoption of CI initiatives such as SPC and Six Sigma in the food industry (Grigg and Walls, 2007a, Srikaeo and Hourigan, 2002). It would also reduce the fear of statistics usage in the food sector and eliminate the perception that SPC is too complex for the users without a solid statistical education background. Because of lacking ST culture, food industry companies are unable to use statistics-based techniques with maximum effectiveness. This is partly due to lack of prerequisite knowledge and awareness among managers of the SPC method’s real purpose (Snee, 1990, Hersleth and Bjerke, 2001, Grigg and Walls, 2007a).

Grigg and Walls (2007a) and Hersleth and Bjerke (2001)are concerned with the lack of existed guidelines in SPC implementation within the food industry. It was observed, most of SPC activities in food organisations derived from the Department of Trade and Industry (DTI), now named as Department of Business Innovation & Skills (BIS) (Grigg, 1998). The usage is mainly focused on weight and measurement control, where operators, although not statistically trained, are able to follow simply the written procedure. However, although the manual works well for untrained statistical staff on a working level, it falls short of the full set of recommendations within the BIS manual (e.g. The Weights and Measures (Packaged Goods) Regulations 2006). It is recommended that to establish accurate measures large data sets and longer periods of data collection on an infrequent basis, after significant changes in a process or establishment of new processes are used.

The food industry provides a few number of specific existing codes of practice, such as the Codex Alimentarius Commission (CAC), the Campden Food and Drink Research Association (CFDRA) and the British Meat Manufacturers' Association (BMMA); however, while quality assurance aspects—such as sanitary hygiene are covered in detail, there is no specific information on SPC tools or methods for their application.To achieve ST within the food industry besides having systematic guidelines the organisation must be able to communicate both structural and cultural changes (Grigg and Walls, 2007a).

2.11 Organisational learning (OL) theory

Organisational learning (OL) accredited to the action learning process that Argyris and Schön (1978) postulated a dual structure of organisational learning. OL is defined as the process organisational change or modifies their mental models, processes, knowledge, rules, maintaining or improving their performances (Argyris and Schön, 1978).

Learning is viewed to start with experience (Argote and Miron-Spektor, 2011). There are dimensions of experience proposed by Argote and Miron-Spektor (2011), including direct and indirect experience. The understanding of learning experience contributing to the identification of the source of learning activities in transforming experience towards knowledge.

***Learning from direct experience* —** Learning can generally involve practicing through incremental procedures refinement that is incremental in nature (Argote and Miron-Spektor, 2011, Upton and Kim, 1998). The foundation of direct experience learning was based on direct observation on practices for process performance improvement. This type of learning can be iterative and it organisations commonly "choose from a pool of alternative routines, adopting better ones when they are discovered" and/or "trial-and-error experimentation" (Locke and Jain, 1995). Learning from direct experience examples are: initiatives in CI such as the DOE, Taguchi method, evolutionary operation, and *kaizen*. According to Locke and Jain (1995), practice-based theories of learning suggest that learning can be existed in "communities-of-practice", workgroups not necessarily formulated by the company, which emerged at the workplace. Such workgroups gained knowledge through enculturation (learn from other members of the community).

Learning from indirect experience ─ This type of learning involves of several ranges of activities observation of others to gaining knowledge from outside the company, and subsequently applying the knowledge to improve its processes and performance (Argote, 2013). Typically, government agencies, professional bodies, published information, transfers of employees from a different department, training sessions, consultants, benchmarking, and strategic treaties support this type of learning. For example, from the publicised successful problem-solving effort will encourage people to recognise and aware of the potential benefits of engaging in quality improvement activities(Tucker et al., 2002). The organisational units can practice learning activities from other business units, which this type of learning also called as knowledge transfer.

Based on the critical importance of OL theories, Chiva and Alegre (2005), Locke and Jain (1995) urged for further research in identifying the activities within the CI initiatives encouraging OL in an organisation.

Within the context of this study, learning is regards as the center of the CI activities of existing processes and the discovery of novel processes. Learning in such activities ensures mistakes are not repeated and more important it was applied in the existing processes and that of foundational knowledge on organisational systems encourages CI (Koh and Low, 2010). The literature shows that studies in organisational learning relevant to operations improvement may be grouped into several general categories;

- research in learning curve – relationship between performance and cumulative experience "learning by doing" (Arrow, 1962, Dada and Srikanth, 1990)
- function-based learning studies – effect of learning as it relates to particular features or functions within a production process (Jaber and Bonney, 2003, Lieberman, 1984).
- analytical learning theories –formal attempts to understand learning from an analytical viewpoint have been carried out by researchers in management science (e.g. Bayesian theory) (Mazzola and McCardle, 1996, Mazzola and McCardle, 1997, Jovanovic and Nyarko, 1995)

- learning microstructure studies− detailed mechanisms or 'underlying processes' by learning by doing (Argote et al., 1990), learning before doing (Pisano, 1994), learning 'new experience', in-process learning' (Jaikumar and Bohn, 1992)
- organisational learning (OL) theory – OL theory elaborates the characteristics and dynamics of learning in human organisations through *single-loop learning* and *double-loop learning* (Argyris and Schön, 1978) or adaptive and generative learning (Senge, 2006)

The interest towards the OL has arisen due to the increasing unstable environment in which organisations operate (Lee, 2000). Organisations were required to increase their ability to learn due to the restructuring of industries and the impact of information technology. The creation of learning and knowledge are claimed to be related to on how the organisation manages the cognitive processes of its members (Choo et al., 2007). Typically, learning opportunities in the food companies is related to the activities in the training department (Grigg, 2008; Hersleth, 2001), which highly concerning individuals skills and knowledge (Hewson, 1996; Gaspar, 2015; Cheng, 1998). Instead of simply treating training session as peripheral and times easily neglected, facilitating learning throughout the organisations currently becomes critical components facilitating organisational change. The world of industries is changing where different approaches of learning which encompass the whole organisation, is required (Lee et al., 2000). One of the objectives of this research is to understand the type of learning occurs in an organisation within the implementation of SPC explained by the OL theory where Argyris and Schön (1978) postulated a *single-loop learning* and *double- loop learning* model:-

- ***Single-loop learning*** − corporate that achieve their goal or correct an error without re-assessing their underlying values may be said to be *single-loop learning* Argyris (1995). According to Krüger (1999) from the quality perspective learning model relates to inspection approach, “fire-fighting” and troubleshooting activities, when operators were alerted to an occurring problem, corrective action were taken to bring the process back into control. Such approach provides limited opportunity learning from the experience of fixing the problem and lead to shallow understanding (Murray and Chapman, 2003), and it also will not necessarily prevent future recurrence of the problem (Upton and Kim, 1998). This is due to the level of learning in *single-loop learning* focuses on solving problems without any examination of the appropriateness of organisational practices that induced the problem. *Single-loop learning* is based on short-term rationality and immediate purpose. Therefore, *single-loop learning* occurs more frequently and incrementally (Upton and Kim, 1998). According to William et al. (1989), larger and stable organisations depend greatly on *single-loop learning* that is following the existing rules (i.e. bureaucracy).

- ***Double loop learning*─** *double-loop learning* focuses on questioning why the errors or successes occurred that it modifies an organisation's implicit norms and objectives (Marquardt, 1996, Buckler, 1996). In quality management perspectives, *double-loop learning* corresponds to modifying the process (altering principal variables within the system) to understand and eliminate the root causes of problems, prevent recurrence of problems and foster CI (Argyris, 1995, Gijo, 2005). According to Argyris (1995) and Blackman et al. (2004), *double-loop learning* necessity to occur for sustainable change (e.g. an implementation of SPC) in an organisation. Fine (1986), Fine (1988) stated that ignoring the learning potential of quality control activities may lead to under-investment in quality improvement activities and subsequently hinder quality competitiveness. Murray and Chapman (2003) claimed from their empirical studies that that quality control under TQM most successful when improvement are embodied in *double-loop learning* routines as a continuous learning journey.

Quality control is viewed as a task involving *single-loop learning* as it makes sure the processes are running in compliance with the standards and regulations. Similar with claimed by Grigg, 2007, Six Sigma efforts is viewed as a single-loop learning. The application of quality initiatives are effective in the refinement of existing technology and current customer needs, however it was viewed less effective in exploring the new technologies and understand emerging customer needs(Choo et al., 2007). However, according to Ogland (2014), quality improvement activities with challenging and improving the standards and procedures have indicated the *double-loop learning*. For instance, the usage of a structured problem-solving approach in Six Sigma with the applications of other quality techniques for variance reduction method suggests the strong orientation towards exploratory learning (Choo et al., 2007). In light of the process and effort to adopt SPC as a new technology in the food companies, *double-loop learning* is claimed required to take place for the change to be a success (Lee, 2000). During the process of implementing new technology such as SPC, individuals and the organisation's system and practices would undergo some transformation, which require shifts in the employees thinking and behaviour (Rusly et al., 2012). Through the application of SPC, the organisations may start to question about the target they set for themselves and the ways in which they are trying to achieve these targets, which portrayed the *second-loop learning* characteristics (Jeliazkova and Westearheijden, 2002).

The procedure of CI implementation process (step-by-step) seems to catalyse learning and push CI forward (Savolainen and Haikonen, 2007, Buckler, 1996) however; it does not mean a *double-loop* learning is achievable (Argyris and Schön, 1978). Therefore, from the perspective of this study, identifying and managing both type of learning is beneficial for the long-term development of SPC potential, since at diverse stages there will be a need for reinforcing (*single-loop learning*) and system change (*double-loop learning*) (Choo et al., 2007, Bessant and Francis, 1999, Grigg and Walls, 2007b). *Double-loop learning* is the hallmark of a learning organisation, and is the imperative means for converting individual and team learning into learning organisation (Buckler, 1996).

Although several studies have explored the underlying concept of OL and learning curve activities, majorities fall short of informing managers on the activities supporting OL for lasting process improvement (Upton and Kim, 1998). Savolainen and Haikonen (2007) also highlighted that the effective application of quality methods requires appropriate OL strategies. Based on the context of SPC, continues improvement is based on learning. Normally, the process of OL through SPC is viewed can be executed through converting data to information resulted from the relevant statistical analysis (Grigg and Walls, 2007a). Sustaining the quality advantage is the critical impacted from the consideration of learning and knowledge creation in CI initiatives for quality (Choo et al., 2007).

2.12 Limitations of this review

The scope of this review contains of two major domains, which are food industry and SPC implementation. The 'food industry' in this literature review is limited to the context of food manufacturing industry, which food services, the food supply chain, research centres and other food laboratories were not considered. Therefore, it is important to consider this limitation when the results are discussed.

The number of articles used in this SLR is considered small (42 to journal articles) compared with other literature review studies. The main reason is due to the articles' search and select process in SLR were guided by the inclusion/exclusion criteria which have caused some articles excluded from this study as they are not fulfilling the inclusion, yet met the exclusion criteria. Hence, there should be more urges to the researchers and practitioners to pursue and explore in this field of area.

The analysis of this literature review has not considered the meta-perspectives as per suggested by Houy et al. (2010). The attributes include within the meta-perspective are contributions per year, contributions per journal, contributions per country/region, contributions per researcher, participating authors per article, participating institutes from different countries/regions per article. It is an effective approach to describe results from the application of a selection of scientometric methods to measure the development of the research field (Houy et al., 2010, Hood and Wilson, 2001).

2.13 Summary

This review provides a consolidation the existing knowledge on the SPC implementation in the food industry based on the systematic review. The theoretical implications of this paper are the clear timeline of SPC in the food industry subsequently understand the roots underlying SPC philosophies and their implementation.

SPC implementation in the food industry is mostly motivated by the need to reduce process variations in the company and the conformance to food law's requirement. Food quality attributes are developed through a network of rules and legislation from government bodies, as well as safety requirements such as Food Safety Act (1990) and consumer preference. Meanwhile, the rising application of structured methodologies such as Six Sigma and Lean Six Sigma have sparked the awareness that process improvement initiatives have a significant and strong impact on quality and operational performance (Sousa & Voss, 2002).

This review disclosed that the most cited challenges for the food manufacturers to implement SPC are the resistance to adopting SPC, insufficient statistical knowledge and the lack of top management commitment. Such challenges can be addressed through continuous training, increasing the awareness and knowledge related to SPC implementation.

This review suggests that incorporating SPC to the other quality control programme such as HACCP could strengthen its application, given that most articles suggested that besides significant reduction of process variations, food safety control is also improved by integrating SPC and HACCP. The lack of statistical thinking in the food industry, the lack of practical SPC guidelines customised for the food industry, and the perception that SPC is too advanced to be applied caused slow widespread of SPC in this sector. It is the identification of these limitations that have opened a window of opportunity to draw the agenda for future research.

Up until now, very little research examining how to improve the current education modules to prepare the graduates with, at least, basic awareness of CI within the industrial setting. Arguments have been made that knowledge of quality improvement and statistics could reduce the challenges faced within the SPC implementation. The education on quality improvement in food industry management should start within tertiary education to develop early awareness in quality. The courses should cover quality assurance and SPC tools at least at an introductory level. Such skills are considered as the most desirable qualities in new graduates in the food industry.

This review discovered that the current research on *what to do* has provided only a static view of the implementation, offering only an indication of how the end results should look like especially in most of the empirical study. Research has failed to produce practical guidelines for the food producers to embark on an SPC journey and there exists a limited discussion on the method for its implementation. The development of a systematic, step-by-step roadmap of SPC implementation, customised for the food industry, would serve to overcome the lack of awareness and lack of knowledge of the implementation.

This review concludes that the food companies implementing SPC have attained significant benefits regarding continuous process control and process improvement activities. SPC is a powerful technique for managing quality in the food industry provided that its adoption is greatly facilitated and correctly implemented. Therefore, next chapter will entail a critical review of SPC implementation frameworks.

CHAPTER 3 — A CONCEPTUAL STATISTICAL PROCESS CONTROL IMPLEMENTATION ROADMAP

This chapter presents a conceptual implementation roadmap of Statistical Process Control (SPC) based on a comprehensive review on the SPC implementation in the food industry and a critical review on existing SPC implementation frameworks. The existing SPC implementation frameworks were later critically reviewed to accentuate the limitations of the frameworks, and such data will provide grounded theory in developing the conceptual framework of SPC implementation roadmap. Further, in completing the early phase of the SPC implementation or it is also known as 'unfreezing' phase coined by Lewin (1947), a review on the readiness in CI was presented to provide insight the most updated notable work in this topic and provide a proposition containing the hypothetical SPC readiness factors.

3.1 Introduction

The widespread of SPC in the food industry is slower compared to other sectors (Grigg, 1998). Dora et al. (2013a) stated that SPC is found to be the least applied technique when compared with other quality control (QC) tools used in the food industry (visual inspection and acceptance sampling). Previous studies on this topic also reported that the challenges of SPC implementation faced by food companies are due to lack of knowledge and guidance on the implementation aspect of SPC (Pena-Rodriguez, 2013, Grigg, 1998). To exploit the benefits of SPC application, the technique should be established as one of the quality techniques in the quality management system across the whole company.

SPC implementation requires commitment, knowledge, and a systematic strategy for its implementation. Current scientific evidence is vague regarding introducing technological change, which was identified as one of the causes for SPC failures (Bushe, 1988). Although there is specific guidance on using SPC on control of weights and measures by the DTI/BIS(DTI, 1979), there are concerns that there is a lack of industry-specific guidance on SPC implementation (Grigg, 1998, Grigg and Walls, 2007a, Grigg and Walls, 2007b). Furthermore, the introduction of SPC is not the only issue that is lacking in current literature, but the institutionalisation and sustainability of SPC practices in food industry are still in need of further research (Dora et al., 2013a).In this chapter, an SPC conceptual roadmap is presented, which reflected the SPC implementation roadmap in the food industry.

3.2 Critical review of SPC implementation roadmap

This section is primarily focused on the results of the comparative study of existing SPC implementation frameworks. Most of the SPC implementation roadmaps explained their key components. Some of the frameworks were in conceptual phase., which it was challenging to operate them for the practical implementation (Dogdu et al., 1997b, Noskievičová, 2010). Hence, the researcher provides an analysis of the existing SPC implementation framework roadmaps about the criteria that were developed by Roger's diffusion integration of innovation criteria and Yusof and Aspinwall (2000a)good framework' criteria so as to decrease the uncertainty of the SPC adoption.

In the diffusion of innovation theory, Rogers (1995) identified five quality criteria (relative advantages, compatibility, complexity, trialability and observability) which will help to decrease the adoption innovation uncertainty. The innovation of diffusion is a theory explains the spread and adoption of new technologies in culture (Rogers, 1995). In this study, SPC is referred as the technological innovation within the food companies (Gordon et al., 1994, Bushe, 1988). Meanwhile, Yusof and Aspinwall (2000) proposed the criteria of a good implementation framework for the TQM implementation. TQM is following the similar underlying principle philosophy as SPC, which is a continuous improvement (Barker, 1990, Xie and Goh, 1999). The existing SPC frameworks were compared and contrasted using the criteria listed in Table 3.1.

Table 3.1 Criteria for framework assessment adopted fromYusof and Aspinwall (2000b), Yusof and Aspinwall (2000a), Rogers (1995)

Criteria	Description
Methodical	The degree to which the framework provided a systematic step-by-step procedure in a fixed plan or system.
Coherency	The degree of the framework having a clear link between the elements or step outline
Simplicity	The degree the framework is perceived as simple and clear understanding to use.
Visibility	The level of the user able to see the results of the implemented practice

	forms the framework given. A framework has to assign some measure of relative value or work assessing its effectiveness
Compatibility	The framework is an appropriate to the environment of the client needs, idea, products and industry.
Trialability	The degree to which the framework may be experimented with on a limited basis they or an idea is. It deals with the possibility to experiment with the practice with smaller scale, less intensive scale.
Practicality	The framework is able to provide facts or details of a real situation, rather than general ideas or theories. The framework is implementable with answering the question of how to operate the framework.

To assess the framework in more deductive approach, the levels (low, medium, high) were assigned to the criteria in Table 3.1for each existing SPC implementation framework. The definition of each level was described in Table 3.2.

Table 3.2 Criteria for analysing existing SPC implementation roadmaps

Criteria/ Level	Low (Not emphasised)	Medium (Briefly mentioned)	High (Emphasised)
• **Methodical**	There is no step-by-step roadmap provided.	The steps provided are very general, and there are some missing steps.	A complete, systematic and discipline approach to SPC implementation provided
• **Coherency**	The steps were not linked to each other	Some of the steps were linked with each other	All the steps are clearly linked with the prior step
• **Simplicity**	Required advanced understanding of SPC.	Briefly listed steps and activities within each step, although there is a vague explanation of some of the steps involved.	The step was described in a systematic manner with a straightforward explanation.

• **Visibility**	No target and measurement to measure the effectiveness of the steps suggested.	There are measurements suggested to assess the effectiveness of SPC, but some of the measurement is not appropriate, as there were no guidelines provided on how to measure them.	Method, step or approach to assessing the success of SPC implementation were provided.
• **Compatibility**	Not customised for any industry or size of the company.	Developed with consideration to the size of the company.	Customised for a specific type of company (size and industry)
• **Trialability**	The pilot project not suggested.	Although pilot project is suggested, no details guidelines for the implementation are provided.	Suggested detail plan for the pilot project (how to choose a project, activities and people involved, suggested timeline etc.)
• **Practicality**	Real life application of the roadmap was not addressed.	Briefly explained the steps and tools for SPC implementation. However, there are more explanations required to operationalise the roadmap.	Thoroughly explained of the activities, tools, people, time, expected risk, tips and examples from real life situations on the implementation of SPC.

Table 3.2 shows SPC implementation roadmaps criteria and listed the level for each of the criteria. Such evaluation balances the analysis the roadmap with that of a standard set of criteria and levels (Amar and Davis, 2008). Although implementation framework was developed by Does and Trip (1997) was determined to be the most comprehensive, in terms of compatibility, the roadmap did not specify the type of environment (products and industry) appropriate for the use of the framework. Rockart

(1979) and Lagrosen and Lagrosen (2005) stated that the control system must be tailored to the specific industry, which the company operates. The features of the existing implementation framework were assessed against the criteria above as depicted in Table 3.3.

Table 3.3 Analysis of the existing SPC implementation frameworks

Criteria/ Roadmap	(Gaafar & Keats, 1992)	(Krumwiede &Sheu, 1996)	(Kumar &Motwani, 1996)	(Does & Trip, 1997)	(Antony &Taner, 2003)	(Noskievi èová, 2010)
Methodical	MEDIUM	MEDIUM	HIGH	HIGH	HIGH	LOW
Coherency	HIGH	MEDIUM	HIGH	HIGH	MEDIUM	MEDIUM
Simplicity	HIGH	HIGH	HIGH	HIGH	HIGH	LOW
Visibility	LOW	LOW	LOW	HIGH	LOW	HIGH
Compatibility	LOW	LOW	LOW	LOW	LOW	LOW
Trialability	HIGH	MEDIUM	MEDIUM	HIGH	HIGH	LOW
Practicality	HIGH	LOW	LOW	HIGH	MEDIUM	LOW

Department of DTI/BIS manual provides advice on sampling methods, calculation of standard deviation and control charts, however, it lack of details guidelines for the real application of SPC (Grigg and Walls, 2007). Hence, some producers merely opt for the conventional strategy of overfilling (Grigg, 1998). The existed SPC implementation frameworks were critically reviewed to accentuate the limitations of the existing SPC roadmap in the food industry context. The current existing frameworks:

- failed to address the different of employees' competency level issue in the training programme. In the food industry, a competency gap is noted to be one of the challenges that could create resistance culture, morals down and the implementation could be disrupted (Mensah and Julien, 2011, Bjerke, 2001).

- assumed that there are data availability and good measurement system, which is not the case in most of the food industry (van der Spiegel et al., 2003, Kovach and Cho, 2011).
- failed to address the development of SPC team (Pena-Rodriguez, 2013).
- vaguely address on the issue of a limited number of people, lack of statistical thinking culture, lack of awareness of the quality tools and high resistance to change (Davie and Ryan, 2005, Surak, 1999a).
- did not link SPC with the business strategy (Pena-Rodriguez, 2013, Rungtusanatham, 2001).
- failed to address as how to facilitate the sustainability of SPC implementation

3.3 Conceptual SPC implementation roadmap framework

The conceptual roadmap is developed by addressing the limitations of the existed SPC implementation roadmaps from the literature of SPC implementation in the food industry. To date, no research project published proposed a systematic framework to introduce SPC in food industry settings. This framework is developed by analysing CSF of past SPC experiences, critical review of SPC implementation frameworks from other industries and other relevant literature. The most challenging in SPC implementation is in answering *how* and *where* to get started the implementation. If the implementation is planned at the organisational level, the support of organisational scale must be prepared as well. Five phases were outlined in a step-by-step approach for such conceptual roadmap (Figure3.1), and the detail of the activities for each stage is as below:

A. Phase Awareness — Educating employees to aware on the values for SPC implementation in the company and guarantee top management commitment

a. Recognise the need to change -food industry viewed as a conservative industry regarding quality improvement (Surak, 1999b, Mann and Adebanjo, 1998).

- accurate performance measurement, which must be linked to the business bottom-line (Gordon et al., 1994, Owen et al., 1989)
- top management should be convinced that SPC has the ability to improve the company’s bottom-line (Does and Trip, 1997)

b. Awareness sessions— to enable the top management to become familiar with the fundamentals of SPC.

a) Points should be briefed(Does and Trip, 1997, Hubbard, 2003):

- Benefits of shifting from detection to prevention approach.
- SPC requires changes of management style with respect to the delegation of tasks and employee empowerment.
- SPC is a technique used to establish process capabilities.
- SPC is a technique to recognise, quantify, reduce and control variation.
- Top management should be the first recipients of the session.

c. SPC Training—Training is crucial for food industry as SPC is viewed as being relatively complex and too advanced by them and subsequently led to the resistance of its application (Hersleth and Bjerke, 2001, Grigg and Walls, 2007a). Some of the recommendations:

- Training of SPC in the food industry should be more than just once, as SPC involved both technical aspect and managerial aspect where the training is highly suggested to be delivered in level-by level within the organisation's hierarchy (Davie and Ryan, 2005, Grigg, 1998, Dogdu et al., 1997b).
- The training should include underlying philosophy of SPC, theoretical and management aspect of SPC, OCAP and other quality tools and technique.
- Although it is not much as a critical problem as it appears on the surface, language/terms used to train technical personnel who are required to collect and analyse data is highly suggested to be appropriate with the level of employees understanding (Hubbard, 2013).

B. Phase Preparedness

a. SPC team establishment

- There are very few articles discussed on the establishment of SPC team, despite the importance of teamwork in SPC implementation is highly recognised (Hubbard, 2013, Antony, 2000, Rungtusanatham, 2001, Deming, 1986).
- SPC team may consist of top management team, middle management team, steering team, process action team (Does and Trip, 1997, Watson, 1998, Motwani et al.,

1997, Elg et al., 2008, Dogdu et al., 1997b). It also consist of one problem solving team (Kumar, 1993, Hubbard, 2003).

- Type of employee's position is not the only factor necessary for the implementation, but also individual roles, and this is also supported by Belbin's Roles Theory(Senior, 1997, Meredith, 1997, Belbin, 1981).
- Multi-disciplinary team able to increase the effectiveness of the teamwork in SPC (Antony, 2000)

b. Plan for the SPC implementation

- SPC implementation is planned according to vision and mission.
- Such planning should cover several aspects such as people, time, tools, training, activities and resources for the pilot projects (Clute, 2008).

C. Phase Initiation

Pilot project provides clear evidence of the benefits of SPC implementation (Efstratiadis M., 2000).

a. Process prioritisation

- Select most critical project for SPC pilot project (Antony and Balbontin, 2000).
- Use Pareto analysis can be carried out to analyse and prioritise the process (Does and Trip, 1997).

b. Process description

- Identify key processes (Rungtusanatham et al., 1997).
- This step is can be carried out by using process flowchart, process mapping or VSM (Fortune et al., 2013, Mertens et al., 2009, Knowles et al., 2004).
- Comparing different work methods of different operators and engineering information increase the opportunity to detect cause of the problems at this stage (Does and Trip, 1997).

c. Process synthesis

- Identify critical process parameters (Antony, 2000, Does and Trip, 1997).
- This step can be carried out by cause-effect analysis, multi-vari chart and Pareto analysis are valuable in this step (Hung and Sung, 2011b, Hersleth and Bjerke, 2001, Saini et al., 2011).

- d. Measurement System Analysis (MSA)- is to measure the amount of variability due to gauges used for measuring quality characteristics (Montgomery, 2012, Dogdu et al., 1997b).
- GRR analysis to assess variability from the machine and variability of people in using the machine itself, respectively (Hung and Sung, 2011b, Srikaeo et al., 2005).
- The company may require re-calibrating the equipment/machines, preventive maintenance, updating the latest model of manufactured machines and increasing the training of operators as correction actions for incapable measurement system (Srikaeo et al., 2005, Kovach and Cho, 2011).

e. Control chart

- After the pilot project been identified, the next steps are constructing control charts and interpretation of the control chart (Hayes et al., 1997).
- Construction of control chart contains underlying steps; selecting the type of control chart, method of sampling and frequency of sampling (Donnell and Singhal, 1996).
- Twenty-five or more subgroups or more than a hundred individual readings give a sufficient good test for stability (Montgomery, 2012).

f. Establish Out-of-Control-Action-Plan (OCAP)

- One of the major problems in the FQM is problems due to the inappropriate corrective actions procedure (Luning and Marcelis, 2006).
- OCAP facilitates employees to systematically investigate root cause of the problem and solving it (Grigg and Walls, 2007b, Fortune et al., 2013).

g. Process capability

- Process capability needs to be determined on whether the process is able to meet customer specifications (Khan and Pervaiz, 2005).
- Process capability analysis measures the variability of a process based on these assumptions; (i) the process in state of statistical control (ii) the data is following normal distribution (Montgomery, 2012).

h. Reflection

- SPC steering team will assess the SPC implementation in the pilot project, which involve evaluation of process performance, financial savings and SPC action team activities (Antony and Taner, 2003, Does and Trip, 1997).

- A meeting with all the SPC steering team and the SPC action team should be held to announce and communicate the result and award the official reward for their results (Burrell and Morgan, 1979).

D. Phase Company-wide Implementation- the activities involved in broadening the SPC application to across the company.

a. *Communicate outcome of the project*

- Awareness and recognition towards SPC implementation is achievable through effective communication of successful SPC projects (Dora et al., 2013a).
- The news can be communicated through emails and bulletin board (Hubbard, 2003).

b. *Company-wide training*

- The most effective strategy through incremental approach and build up a bank of experiences and knowledge (Grigg, 1998).
- Efstratiadis M. (2000) suggested a successful formula for SPC training by suggested in-house training follow up by projects and workshops.
- The training materials should focus on statistical tools, leadership, change of culture, which wider attendance of participants should be encouraged at this point of training sessions (Efstratiadis M., 2000)

c. *Progress evaluation systems*

- SPC steering team is responsible to continuously monitor the performance of key processes (Does and Trip, 1997).

  Having a good performance measurement induce target areas with opportunity of improvement to be identified and has a key role in communication (Oakland and Tanner, 2007).

E. Phase Sustainability- efforts including maintaining the in-house SPC expertise and provide a mean of motivation for other employees to implement the technique.

a. *Maintenance of in-house expertise*

- Important as food industry has limited human resource expertise in statistical knowledge (Grigg and Walls, 2007).
- Continuous awareness training session and workshops can help the company to achieve such objective (Bidder 1990; Hubbard, 1999).

- It is imperative to make sure knowledge transfer within the organisation is actively progressing in order to increase the number of in-house expertise (Davis and Ryan, 2005, Grigg and Walls, 2007a).

b. *Towards learning organisation*

- Organisational learning is carried out through systems thinking, team learning, shared vision, individual mastery and the use of highly sophisticated mental models (Senge, 2006).
- Learning organisation in food companies are that learning became mainstream activity, constant learning leads to continual change and learning facilitates response to change (Grigg and Walls, 2007b, Martino and Polinori, 2011) .
- Past performance tendency should be monthly updated together with revised strategies (Raper et al., 1997).
- Benchmarking and learning from best-practice of internal and external competitors will continuously keep the company in the momentum for CI(Mann and Adebanjo, 1998).

c. Reward system

- One of the causes of failure in deploying and sustaining SPC is that the management has ignored the fact that the deployment of SPC can lead to unintentional improvements in intrinsic reward (Rungtusanatham, 2001).
- The management should provide rewards and recognition for successful project (Antony and Balbontin, 2000)

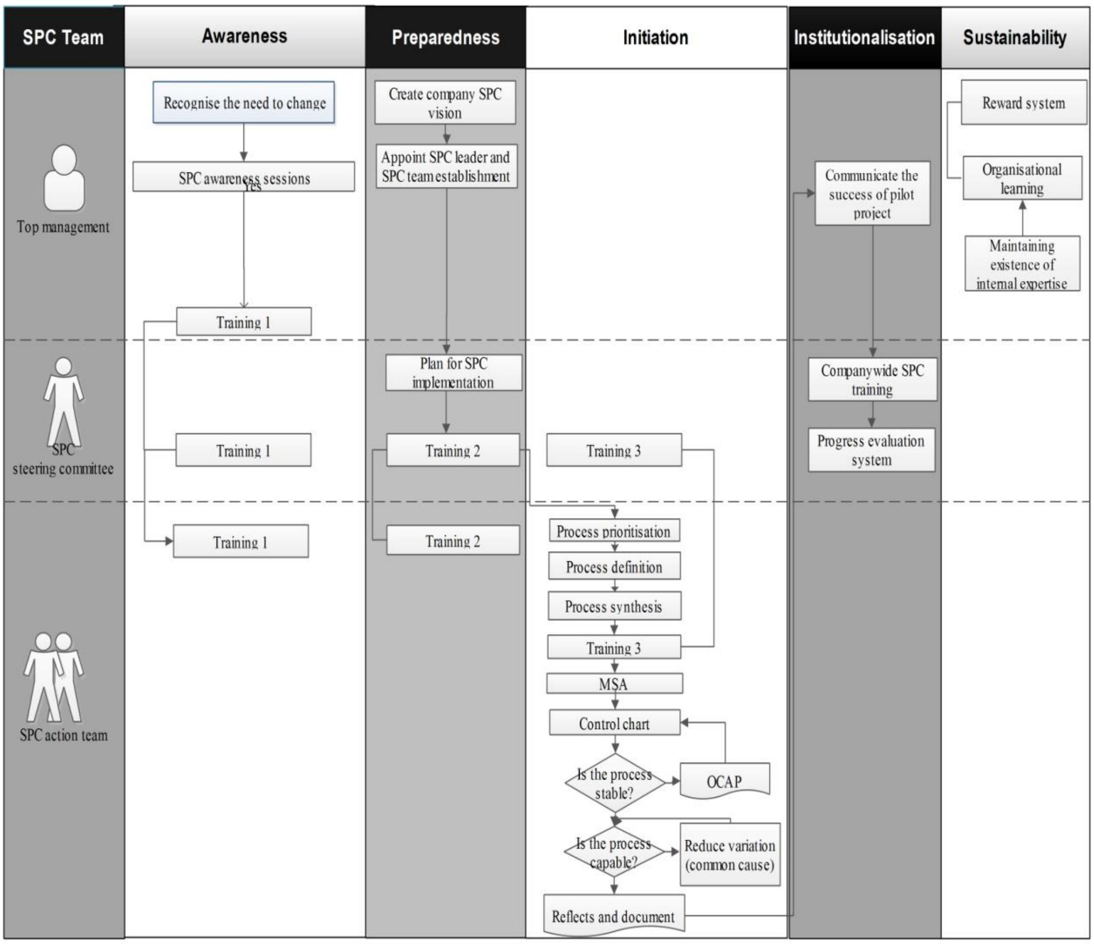


Figure 3.1SPC implementation roadmap

3.4 Organisational readiness SPC implementation

Despite to the success of SPC in the manufacturing industry (e.g. the automotive industry), the widespread of its implementation in the food industry has been slow (Grigg and Walls, 2007a, Lim et al., 2014). Similar to other CI tools/techniques, the literature depicted the organisational readiness is an essential ingredient required for efficient and sustainable use of the techniques (Radnor, 2011). The efforts for company-wide SPC application may inhibit the employees' resistance to organisational changes (Surak, 1999a). In fact, a failure to establish sufficient readiness represented half of all unsuccessful efforts towards organisational change (Gurumurthy et al., 2013). Therefore, it is important to consider whether the organisation is prepared to take SPC on board and this can be determined by assessing their readiness level (Antony, 2014, Lagrosen et al., 2011, Smith, 2005a).

If an organisation is to change the traditional ways of process management, then the companies and the people who work for them must be prepared for such an intentional change (Smith, 2005b). A failure to assess organisational readiness may result in managers spending a considerable amount of time dealing with resistance to change (Coch and French Jr, 1948, Self and Schraeder, 2009, Abdolvand et al., 2008, Antony, 2014, Lee and Lee, 2014). By ensuring organisational readiness before attempting the adoption of SPC the need for later actions to cope with resistance may be largely avoided (Coch and French Jr, 1948, Self and Schraeder, 2009, Kotter, 2008b, Kotter and Schlesinger, 2008). Positive force goes into creating readiness for SPC adoption and, consecutively, there can be a significant improvement in adoption behaviours (Armenakis et al., 1993). The readiness assessment is an approach to overcoming any resistance to change, which has been a critical factor challenging the adoption of the technique (Xie and Goh, 1999, Kerlinger, 1986, Holt et al., 2007a, Smith, 2005a).

3.4.2 Definition of organisation readiness

In the current literature on CI, there is no general definition of readiness given. However, in organisational studies, readiness is a critical study in organisational change theories where several researchers provided different definitions of readiness (see Table 3.4).

Table 3.4 Definition of organisational readiness

Author	**Definitions**	**Area of study**
Armenakis et al. (1993)	Readiness as the cognitive precursor to the behaviours whether to support or resistance to the changes.	Organisational change
Bernerth (2004)	Readiness as a state of mind reflecting a willingness or receptiveness for changing the way one thinks	A study of expanding understanding of change message
Parasuraman (2000)	Readiness is people's propensity to embrace and use new technologies for accomplishing goals in home life and work	Technology-readiness
(Weiner, 2009)	A state of being both psychologically and behaviorally prepared to take action (i.e., willing and able)	Organisational change readiness

(Antony, 2014)	Readiness factors are those essential ingredients, which will increase the probability of success of any CI initiative before an organisation invests its resources (financial, labour, etc.) heavily on the initiative.	Readiness of Higher Education Sector towards Lean Six Sigma

Based on Table 3.4 the author has defined SPC readiness as the organisational ability to accept and support the initiation of SPC as common practice for successfully implement SPC and to sustaining stability of their processes.

3.4.3 SPC Readiness: underlying theory

Originally, the idea of preparedness was discussed about the context of managers' actions towards addressing the issue of employees' resistance to change. The idea that managers could avoid their employees' resistance to change might have been first suggested in the key work of Coch and French Jr (1948). The term of readiness was pioneered by Jacobson (1957) and presented in a study emphasising resistance to change. He stated that although resistance to change had been frequently discussed, '*there is no analysis of readiness and no extended discussion on successful change*'. It was suggested that openness to change is a similar concept to readiness, which should be viewed as one's internal attitudes that precede behaviour when supporting or resisting change. Alternatively, they described resistance as external behaviours or actions taken to stop, delay, or otherwise jeopardise the successful implementation of organisational change. Therefore, Holt et al. (2007b) and Clarke (1996) reinforced the idea that readiness is a different concept to resistance and should be conceptualized as the antecedent to behaviours related to adoption or resistance of the change.

Similar to SPC implementation, which considered as new technology to be adopted in the food company, resistance to change was found to be the most barrier towards a successful SPC implementation (Lim et al., 2014, Surak, 1999a). Therefore, through the organisational theories explained above, readiness phase is significant to reduce the resistance to change (see Figure 3.2).

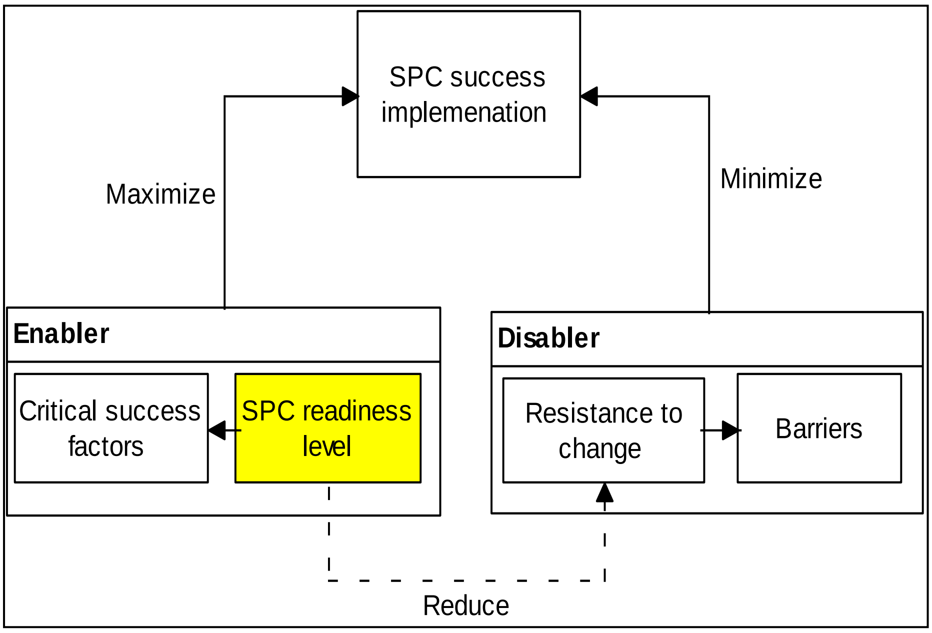


Figure 3.2: Positioning SPC readiness in SPC implementation

Lewin (1951) three-stage model of change stated change must initiate with readiness by 'unfreezing phase' the organisation (transforming the existing 'mindset' and developing the motivation to change). Actions thought to create readiness for change (i.e. unfreezing) include disconfirming organisation members' conceptions of the current situation, motivating their dissatisfaction with the status quo, creating an appealing vision of a future state of affairs, and fostering a sense of confidence that this future state can be realised (Armenakis et al., 1993).

Rusly et al. (2012) explained the involvement of three phases in change readiness, which are preparation for change, adoption of change and institutionalisation of change. They highlighted the fact that readiness consists of both a state and a process, which was originally suggested in a study by Dalton and Gottlieb (2003). Readiness for change can also be depicted by the integration of innovation diffusion and organizational change, as it is argued that both theories illustrate the importance of individual beliefs in successful organisational change (Rusly et al., 2012) (depicted in Figure 3.3).

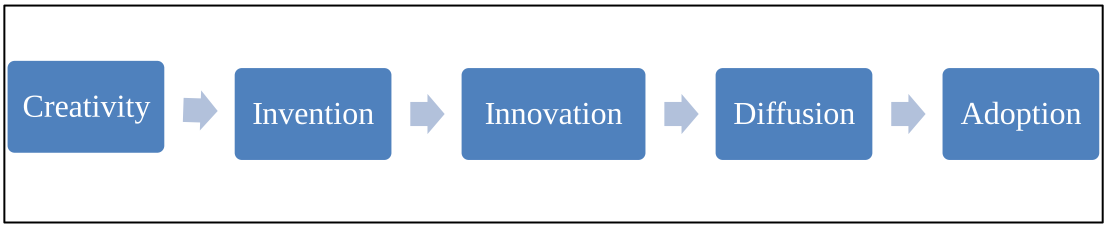


Figure 3.3 The innovation diffusion for change process

Based on readiness studies through innovation diffusion, Rogers (1995), organisational innovation combines the development and implementation of new ideas, systems, products and technology. According to Clarke (1999), the diffusion process is the spread of a new idea from its source of invention or creation to its ultimate users or adopters. Harcourt and Brace (2011) refers innovation as the act of introducing something new, in which a similar situation is depicted with SPC adoption, where food companies will be replacing the traditional way of managing process stability. In the innovation change process, adoption is led by the first introduction or implementation of innovation, which results from a diffusion process (Ehigie and McAndrew, 2005). In its core principle, SPC involves changes to organisational ways and practices in order to achieve the target of process performance (Xie and Goh, 1999). Similarly, Ahire and Ravichandran (2001) proposed an innovation diffusion framework of TQM adoption, depicting TQM as management innovation.

3.4.4 Organisational readiness factors for SPC through CI literature

The present study is exploratory in nature, and so a desktop research was carried out to analyse the structure or key components for SPC readiness factors (depicted in Table 3.5) through the literature in other CI initiatives that associate with SPC, such as Six Sigma, TQM, and Lean Six Sigma. The readiness factors determine in this review were listed in Table 3.5 described in detail as below:-

Table 3.5 SPC readiness factors

Dime-nsion	Factors	Reference
Leadership	• Understand and support SPC.	• (Dale and Shaw, 1992, Lameei, 2005)
	• Ability to communicate vision and mission.	• (Appelbaum et al., 1998, Lee et al., 2011)
	• Ability to influence cultural readiness for change.	• (Weeks et al., 1995, Lee et al., 2011, Lagrosen et al., 2011)
	• Willing to assess and accept changes.	• (Weeks et al., 1995, Lee et al., 2011, Elgamail, 1998, Elgamal, 1998)
	• Resilient and able to deal with	• (Lee et al., 2011)

	frustration.	
	• Customers, shareholders and employees as top priority	• (Lee et al., 2011)
	• Top management recognised the success of individuals and teams with rewards/incentives and recognition	• (Snee and Hoerl, 2003) • McNabb and Sepic, 1995, Lameei, 2005
Top management commitment	• Evaluate organisational/operational performance.	• (Lee et al., 2011, Lameei, 2005)
	• Top management provides resources, guidance, means and encouragement.	• (Lee et al., 2011, McNabb and Sepic, 1995)
	• Listen to employees feedback	• (Lee et al., 2011)
	• Top management participation in the quality improvement projects.	• (Lee et al., 2011, McNabb and Sepic, 1995, Antony, 2014)
	• Top management willing to participate in training.	• (Lee et al., 2011)
Employees management	• Training, coaching and learning opportunities.	• (Lee et al., 2011, McNabb and Sepic, 1995, Lameei, 2005, Lagrosen et al., 2011, Elgamail, 1998)
	• Organization encourages process ownership.	• (McNabb and Sepic, 1995, Lameei, 2005)
	• Organization promotes the involvement of all its employees in quality and CI.	• (Lee et al., 2011, Elgamail, 1998)
	• Employees feel free to report information on errors and defects.	• (Lee et al., 2011, Lameei, 2005)
	• Employees are motivated to self-enhance and adopt a learning culture.	• (Lee et al., 2011)
	• Commitment to SPC deployment.	• (Lee et al., 2011, Lameei, 2005, McNabb and Sepic, 1995)
Culture readiness	• Organization open to new ideas and encourage innovation.	• (Aksu, 2003, Elgamail, 1998)
	• Efforts and success of individuals and teams are recognized and appreciated.	• (McNabb and Sepic, 1995, Lameei, 2005)

Culture	• Encouraged to adopt a knowledge sharing culture. • Clarity of role and ownership of the process. • Work in cross-functional team. •	• (Lee et al., 2011) • (McNabb and Sepic, 1995) • (Lagrosen et al., 2011, Penland, 1997, Weeks et al., 1995) •
Measurement system and feedback	• Establish comprehensive measurement mechanism for the process and product performance. • Train employees to conduct the measurement. • Establish procedure to calibrate the measurement equipment and devices • GRR Repeatability and Reproducibility were carried out.	• (Lee et al., 2011, Hensley and Dobie, 2005) • (Aksu, 2003, Lee et al., 2011, Rosenweig, 1991, Grigg and Walls, 2007a) • (Lee et al., 2011, Montgomery, 2012, Antony and Balbontin, 2000) • (Rohani and Mohamad, 2010, Antony and Balbontin, 2000, Mason and Antony, 2000, Antony, 2000, Montgomery, 2012, Rungtusanatham, 2001, M. Rungtusanatham, 1999)
Strategic management	• Standardize procedures for problem-solving. • Experience with quality system • CI is aligned with business strategy. • Quality focus	• (Aksu, 2003, McNabb and Sepic, 1995) • (McNabb and Sepic, 1995, Lee et al., 2011, Hensley and Dobie, 2005, Elgamail, 1998) • (Lee et al., 2011) (Rungtusanatham et al., 1997) (Lee et al., 2011)

Customer focus	• Focus on customer satisfaction • Regular customer satisfaction evaluation • Feedback measures on customer complaints. • Customer priority • Able to understand customer needs	• (Lee et al., 2011, Lameei, 2005, McNabb and Sepic, 1995) • (Lee et al., 2011, Lagrosen et al., 2011) • (Lee et al., 2011) • (Lee et al., 2011) • (Lee et al., 2011, Antony, 2014)

The results in Table 3.5 shows the SPC readiness factors identified from the review, which later will be used to design a Delphi study to explore further on the SPC readiness factors. The result above are conceptual results and required to be validated by carrying out an empirical study to explore further the SPC readiness factors, by collection opinions and suggestions from SPC experts (academics, consultant and industrial practitioners)

3.5 Conclusion

SPC is a powerful technique for improving the process performance through the application of statistical tools and techniques. Despite its highly accepted in many other manufacturing industries with immense success, it has not yet equally proved to be as successful in the food industry. One of the fundamental limitations is the food companies have insufficient knowledge related to SPC implementation— "where to start", "how to implement". This problem can be overcome by developing a systematic roadmap for implementing SPC in the food organisations. The five-phase roadmap facilitates the managers and engineers understand the amount of effort and initial cost required and subsequently planning a strategic approach to undertaking SPC implementation.

Based on a review of articles relating to “organisational readiness” and “SPC and CI,” this paper has identified the readiness factors for implementing SPC in the food industry. SPC implementation requires a change in the practices of process management in the food industry and the resistance to change is one of the key factors. Using organisational readiness theory, readiness is claimed able to minimise the resistance to change. However, in order to prepare an SPC self-assessment tool, the criteria or readiness factors need to be determined. As this is being the initial study for SPC readiness, the review includes the CI programme that includes SPC as its main components such as Six Sigma, Lean Six Sigma and TQM. The review identified nine readiness factors, where the further empirical study is needed to validate the factors.

CHAPTER 4 — RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

This chapter discusses the underlying philosophy of the study and justifies the choice of methodology and techniques that were applied to achieve the research aim. This chapter discusses the importance of the link between research methods and research philosophy. The chosen research philosophy informs the choice of method and approach, and it also allows the researcher to develop a *research identity* and to be aware of research limitations and challenges that may impinge on the research.

4.2 Research aim

The research aim was to explore the SPC implementation in the food industry and to develop a customised SPC implementation roadmap (SPCIR) for the use of food manufacturing companies. This research aim required a research design that was exploratory in nature.

4.3 Research paradigm

The broad consensus is that research paradigms may be differentiated in terms of their ontology (assumptions about the nature of reality), epistemology (assumptions about the nature of knowledge and knowing) and methodology (Tashakkori and Teddlie, 2010, Easterby-Smith et al., 2011, Denzin and Lincoln, 2005, Guba and Lincoln, 1994, Cohen et al., 2000, Meredith et al., 1989). The researcher was cautious in choosing and justifying the research philosophy, as it is easy to fall into the trap of thinking one research philosophy is better than another is. Similar issues have led to the paradigm debates, which will be discussed in the next section.

4.3.1 Research paradigms debates

Tashakkori and Teddlie (1998) made a valuable contribution to summarise the chain of paradigm emergent by articulating the research paradigm wars, while Guba and Lincoln (1994) concluded that there are at least three principal paradigm wars; post-positivist-constructivists debating against positivism (1970-1990), the conflict between post-positivist, constructivist and critical theory paradigms (1990-2005) and the recent conflict between evidence-based methodologists and the mixed-methods, and the interpretive and critical theory paradigm (2005-present).

Although positivism is the predominant approach in OM studies, the practical value of much of this research is questionable.Buffa (1965)went so far as to claim that researchers who use quantitative modelling to address productivity problems are increasingly simply talking to themselves. On the other hand, it has been argued that in OM research, the ability to gain a deep understanding of a phenomenon is equally important than the capacity to generalise the results (Westbrook, 1995, Voss et al., 2002). Either way, the review of OM empirical studies conducted as part of this research revealed that research approaches have not evolved, and that, by and large, the results of these studies are not very useful to operations managers and practitioners (Meredith et al., 1989, Swamidass, 1991).

4.3.2 Pragmatism as the underlying research philosophy

According to Buffa (1980), pg 5, : '*The most promising future research in OM deals with issues reflecting multiple critical realities of the manufacturing and management world'*. This study adopts a pragmatic approach in the belief that this is the most appropriate paradigm for investigating these multiple realities and resolving the problems of implementing SPC in the real world (Rungtusanatham et al., 1999, Grigg and Walls, 2007a). Pragmatism has been described as a deconstructive paradigm that debunks the concept of truth and reality and instead focuses on 'what works' (Tashakkori and Teddlie, 2010, Hughes and Sharrock, 1980). It posits that concepts are only relevant where they support action, that meaning comes from individual experience, and that the importance of research lies in its practical contribution (Collis et al., 2003, Saunders et al., 2011, Meredith et al., 1989, Gioia and Pitre, 2012).

Dewey (1925) contends that positivism and interpretivism both aim to find the 'truth', whether it be objective or subjective. In this context, the possible dichotomy of positivism and interpretivism to address SPC implementation issues (pluralistic realities) were questioned (Feilzer, 2010, Goles and Hirschheim, 2000, Wilcox, 2004), hence it was suggested for an integration of quantitative and qualitative methods (Robson, 2011, Ahire et al., 1995, Swamidass, 1991).

Reductionism was rejected on the grounds that no theory can satisfy its demands (objectivity, experiment, etc.), and that any guidelines developed without experiencing the subject or phenomenal of study, risk being impracticable (Teddlie and Tashakkori, 2009, Tashakkori and Teddlie, 2010, Onwuegbuzie et al., 2009, Johnson and Onwuegbuzie, 2004). Given the lack of SPC implementation guidelines in the FMI, it was not possible for the researcher to develop a research design based on statistical hypothesis testing, though in any case, this approach would not have been able to identify and resolve management issues (Ackoff, 1979).

4.4 Research strategy

Research strategy may be defined as a systematic orientation to conduct data collection and data analysis, in order to collect reliable information to answer the research questions (Bryman and Bell, 2015, Saunders et al., 2011, Caruth, 2013).

4.4.1 Qualitative and quantitative research

Quantitative research, which is generally associated with positivism, takes an objective view of the world (Collis et al., 2003, Saunders et al., 2011). The causal relationships between variables are investigated within a value-free framework using a range of statistical techniques. Theory is generally tested deductively, but an inductive approach is also possible; in this case, the data are used to develop theory (Meredith et al., 1989).

Qualitative research is associated with the interpretive paradigm. In this case, the researcher seeks to make sense of the subjective, socially constructed meanings attached to the phenomenon under investigation (Denzin and Lincoln, 2005, Bryman and Bell, 2015). As part of this study's pragmatic approach, both quantitative and qualitative methods were employed as appropriate to the research questions.

4.4.2 Mixed-method

Tashakkori and Teddlie (2010) explain that in the mixed-method approach, the combination of quantitative and qualitative methods allows the researcher to compensate for their individual weaknesses and to select the most appropriate technique to address the research questions as the study unfolds (Johnson and Onwuegbuzie, 2004, Johnson et al., 2007). Researchers in OM suggest the use of a range of strategies, drawn from across the continuum, as appropriate (De Vaus, 2001, Easterby-Smith et al., 2011). Table 4.1 presents a comparison of the qualitative, quantitative and mixed-method paradigms.

Table 4.1 Differences between quantitative, qualitative and mixed-method research

General issue	Qualitative	Mixed-method	Quantitative
Research aim	Most involve the statement of research questions.	May involve the statement of both research questions and hypotheses (exploratory and confirmatory).	Involves research hypothesis/research questions or both.
Design tradition	Ethnography, grounded theory, phenomenological, biography and case study.	All designs are included, including unique mixed-metho design.	May be causal, comparative, quasi-experimental or experimental.
Sampling	Emphasises purposive sampling. May (less likely) involve probability sampling.	Includes both purposive and probability sampling	Emphasises probability sampling. May (less likely) involve purposive sampling.
Data collection	Involves unstructured observations, open-ended interviews, focus groups and unobtrusive measures.	All data collection strategies included.	Involves structured observations, closed-ended interviews, questionnaires and tests.
Data analysis	Thematic analysis, categorical strategies, contextualising strategies.	Both thematic and statistical analyses. Data conversion techniques are used.	Statistical analysis (descriptive, inferential statistics).
Validity	Emphasises trustworthiness, credibility and various authenticity criteria.	All inference and validity issues are subsumed under inference quality anc inference	Emphasises statistical conclusion validity, interna validity, construct validity and external validity.

transferability.

Adapted from (Creswell and Clark, 2007, Johnson et al., 2007, Tashakkori and Teddlie, 2010, Teddlie and Yu, 2007).

4.5 Methodological choice

OM researchers advocate the use of qualitative research to gain a better understanding of emerging phenomena in their real world setting (Voss et al., 2002, Collis et al., 2003, Meredith, 1998), but it was felt that in this case, both qualitative and quantitative methods were necessary to address the research questions. A quantitative survey was the best way to identify a general set of CSFs and barriers to SPC implementation in the food manufacturing sector. Qualitative methods were then employed to explain and complement these results. Other OM researchers have applied the QUAN-->QUAL paradigm to develop and assess statistical thinking in the food industry (Grigg and Walls, 2007a) and to develop Business Process Improvement Frameworks for SMEs (Khan et al., 2007) and Six Sigma implementation and sustainability frameworks in the SME sector (Kumar et al., 2011). A summary of the research design is presented in Figure 4.1, while the following sections describe the methods used in more detail.

4.5.1 Action research

Action research (AR) was introduced by John Collier in 1945 (Ottosson, 2003). However, it was Kurt Lewin, known as the father of AR, a psychologist and the developer of field theory, who popularised the method in 1946 (Huxham and Vangen, 2003, Eden and Huxham, 1996a, Dick et al., 2009, Westbrook, 1995). Among the AR projects carried out by Lewin was a study conducted in 1948 to investigate *how to implement technological change in the face of strong resistance*(Coch and French Jr, 1948). Since then, AR has been employed in several different research settings, such as education, nursing, information technology, organisation studies and OM (Creswell and Clark, 2007, Coughlan and Coghlan, 2002, Middel et al., 2006, Baskerville and Pries-Heje, 1999, Westbrook, 1995).

According to the literature, the key characteristics of AR are (Gummesson, 2000, Frost, 2002, Huxham and Vangen, 2003, Coughlan and Coghlan, 2002, Eden and Huxham, 1996b, Susman and Evered, 1978, Middel et al., 2006, Shani and Pasmore, 1985):

The researcher intervenes and takes action – in this case, as SPC facilitator or change agent;

- AR has both practical and theoretical goals – in this study, introducing SPC to food practitioners and contributing to the OM literature;
- AR involves the researcher interacting with the company – in this case, with the SPC team;
- AR is conducted in real time;
- The AR paradigm requires its own quality criteria;
- The emphasis is on empowerment, participation and learning.

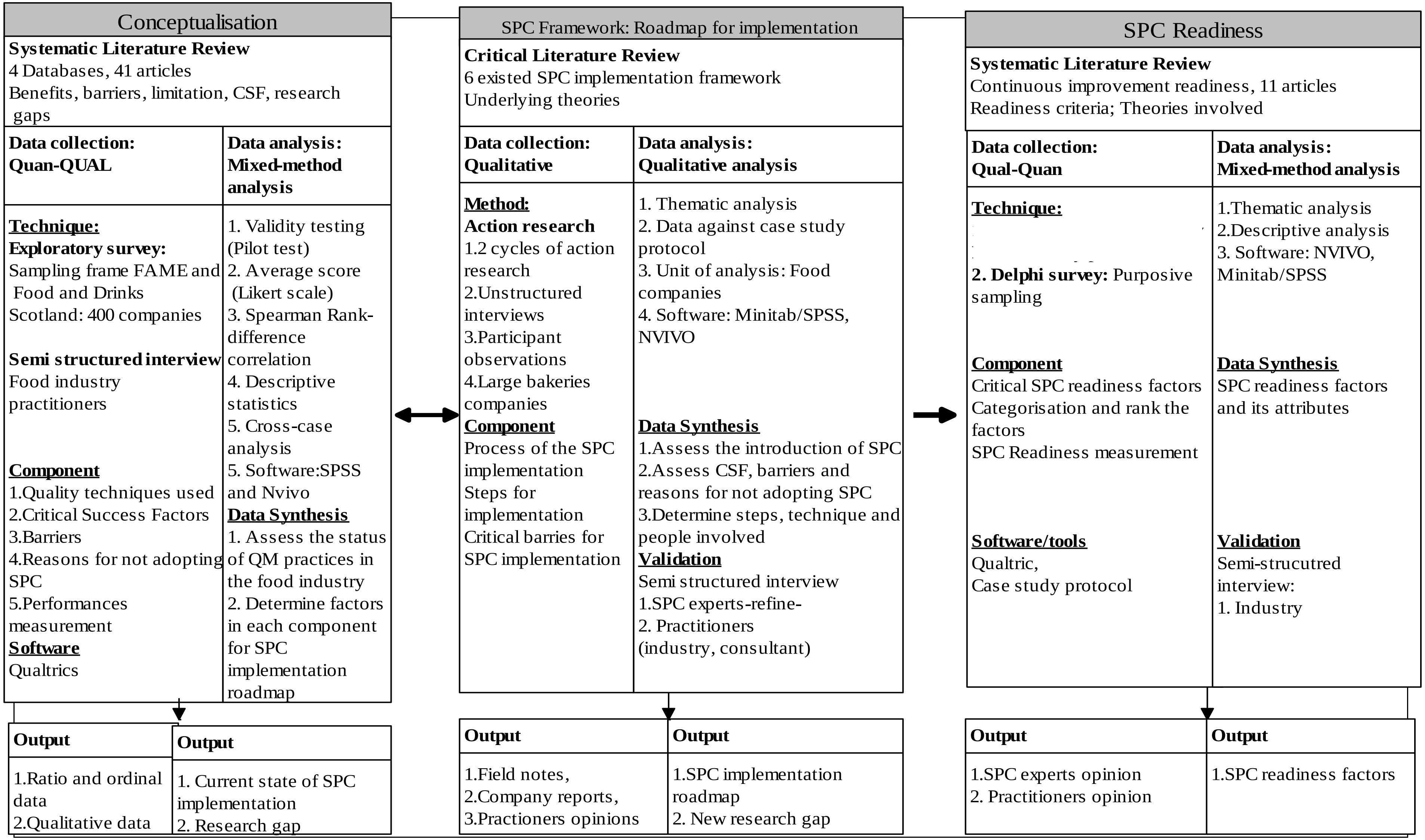


Figure 4.1 Research process and research design

4.5.2 Justification for the choice of method

Similar to a study by Lewin (1946) in technological change, SPC is considered as the technology, and this research aims to develop a roadmap towards the success of its implementation (involve a change in process control and improvement practices) in the company (Coch and French Jr, 1948). To develop a practical implementation roadmap for SPC implementation, an appropriate instrument to collect the data that are reflecting the context of industrial application, is crucial (Voss et al., 2002, Filippini, 1997, Lewin, 1946, Westbrook, 1995). This research requires the participation of the researcher in the implementation and development of each step of the framework (Hales et al., 2006).

Compared to surveys, AR has the applicability in assessing a specific phenomenon and examine the experience and actions of employees at all levels within a single firm (Rungtusanatham et al., 1997, Flynn et al., 1994, Prybutok and Ramasesh, 2005). As for case study, it is a non-intervention method where the researcher is not allowed to involve within the context of the study (Yin, 2008, Huxham and Vangen, 2003). It is difficult to study the effect of the action in each phase of SPC implementation without intervening in the current process control techniques Westbrook (1995).

AR is crucial for the development of SPCIR because of its orientation towards technology change (Xie and Goh, 1999). Coughlan and Coghlan (2002) and Zuber-Skerritt and Perry (2002) also concluded that AR is the best choice of research method when research questions relate to describing an unfolding series of actions as in this case the steps of SPC implementation.

4.5.1.2 Case company

In this AR project, the unit of analysis was the process improvement project and the context was the production line. The sampling criteria were that the case company should be a large food manufacturing company whose management wanted to adopt SPC in their plant. The company chosen for the AR project is one of the biggest food manufacturing companies in Scotland, AlphaCo. The company's manufacturing director explained that AlphaCo has a nationwide supply chain and other sister companies producing similar products in England and Scotland and that its production operations involve a range of materials, resources and suppliers (the AR focused specifically on the company's bakery products). Manufacturing priority is given to the company's biggest customers, and it currently operates minimal CI activities. In 2013, the company had approximately 1,200 employees. Annual revenue had increased by 9.4% since 2012, with adjusted pre-tax profits rising to £6.5m from £5.8m over the same period. The company implemented price rises in 2013 in order to protect margins as the costs of key ingredients (e.g. sugar and eggs) were also increasing.

4.5.1.3 Action research design

Deming (1986) and Montgomery (2012) highlight that SPC is cyclical activities examining the existing processes change and the processes are then re-examined, which is similar to the AR cycle (Coughlan et al., 2001, Argyris, 1995). Researchers have described several types of AR cycle (see Table 4.2).

Table 4.2 Cycles of action research

Design	References
Diagnosing-Action planning-Action taking-Evaluating-Specifying learning	(Baskerville and Pries-Heje, 1999)
Plan-Action-Observe-Reflect	(Kemmis and McTaggart, 1982)
Plan-Act-Observe-Reflect-Collect data-Analyse data-Contribution-Literature review	(Perry and Zuber-Skerritt, 1994)
Abstract conceptualisation-Active experimentation-Reflective observation	(Kuit et al., 2001)
Context and purpose-Data gathering-Data feedback-Data analysis-Action planning-Implementation-Evaluation	(Coughlan and Coghlan, 2002)
Inputs-Develop and testing-Sense making, theory building and writing-Research outputs	(Huxham and Vangen, 2003)
Test-Experiencing-Reflecting-Generalise	(Cowan, 2006)

Many researchers integrate theory and practice with the aim of improving practice through 'systematic self-reflective' scientific inquiry (McKernan, 2013). In this study, the AR interlinks practice and theory through an AR cycle which involves the aspects of AR and learning through the reflection of SPC implementation activities (Dick et al., 2009). A distinct characteristic of AR is the research cycles of problem identification and problem solving (Coughlan and Coghlan, 2002, Zuber-Skerritt and Perry, 2002). In achieving the research aim (development of SPC implementation roadmap), iterations of the cycle of this AR (Figure 4.2) must focus upon process issues, though interpreting theories-in-use instead of espoused theories by reflection process (Argyris, 1993).

The PDCA cycle of SPC implementation suggested by Deming (1986) is similar to the AR cycles depicted in Table 4.2. Dewey and Boydston (1988) claim AR cycles have their origin in systems theory; it focuses upon on the improvement of OM and subsequently cause a change that again, due to its background in system theory enable to study the phenomena of changes and improvement in an organisation. The significant difference between PDCA and the AR cycle used in this study is that PDCA was used as a framework for the SPC pilot project while AR cycle emphasised learning from the PDCA SPC pilot project; it is called as a meta-learning of SPC implementation (Karlsson, 2010). The AR framework used in this study is demonstrated in Figure 4.2.

<u>Diagnose</u>

Involved the articulation of the theoretical foundations of action in the SPC adoption, such as seeing a prototype as a manufacturing process in its own right. Involved collaborative endeavour; the researcher engaged with the AlphaCo team (head of quality, head of the process, manufacturing engineers, quality manager, technical manager, production manager and manufacturing director).

The action was outlined in the conceptual SPCIR (Chapter 3).

<u>Plan</u>

Planning of action should be:

consistent with the context (food manufacturing) and purpose (implementing SPC) of the project. Problems should be defined, and the scope of the project should be identified collaborative (Middel et al. (2006); planning and data gathering should be joint activities (Middel et al., 2006).

<u>Implement-observe</u>

The team and other relevant employees were briefed on the objectives of and processes involved in SPC to ensure everyone understood them. Actions were implemented by

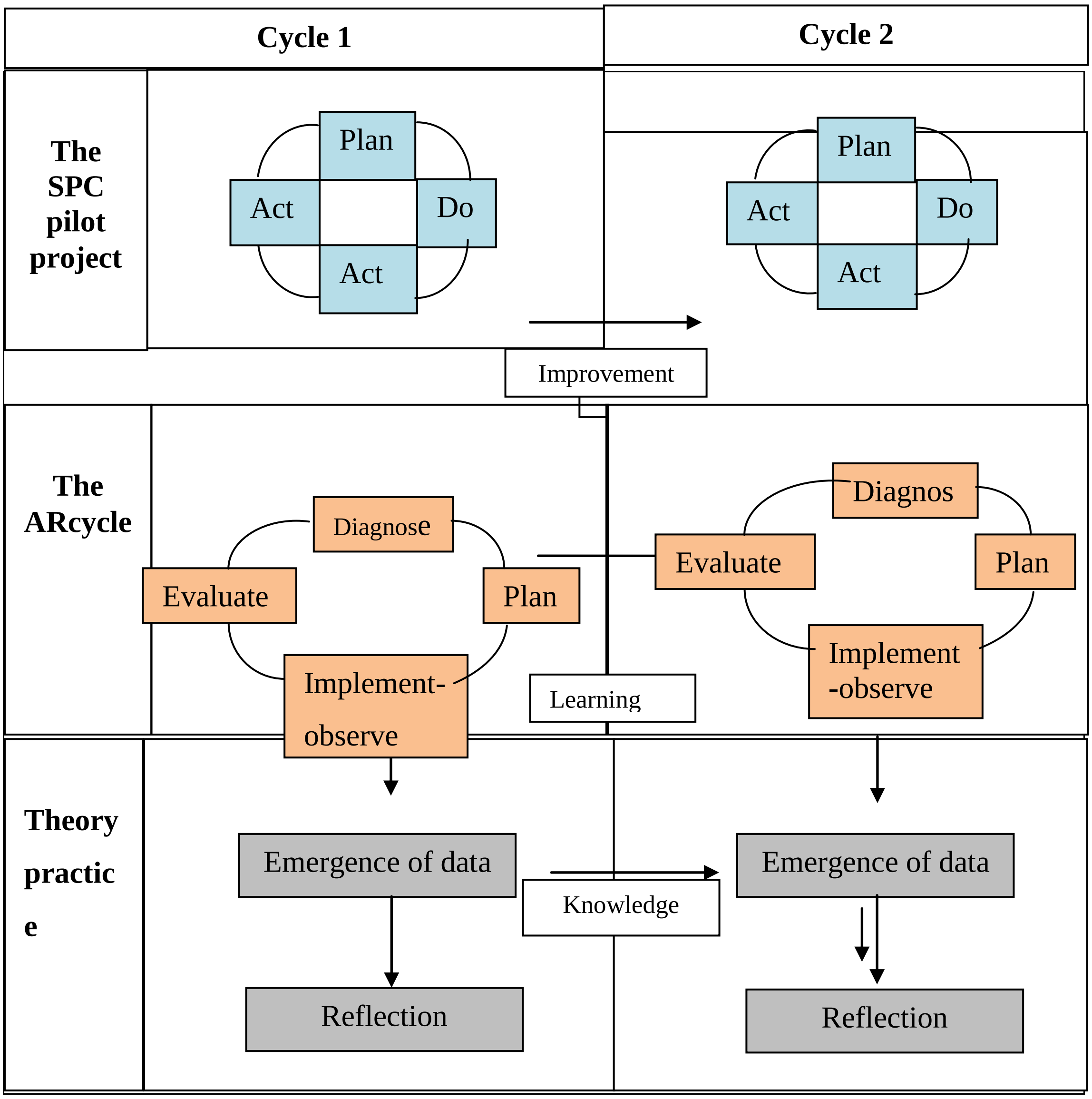


Figure 4.2 Delphi study design

the SPC team (actions included process improvement activities, data collection, measuring the bottom-line, experimentation and control charting), sometimes with the participation of the researcher. The researcher's primary role was to observe situations within the research scope (Middel et al., 2006).

The observation of peoples' responses and perceptions throughout the SPC implementation generated rich data (Coughlan and Coghlan, 2002, Schein, 1999).
Observations were carried out in formal settings, including meetings and interviews, and in more informal settings, such as over coffee, lunch and other activities (Meredith, 1998).

Evaluate

The evaluation phase involves reflecting on the outcomes of the action taken in the SPC project (intended and unintended) and reviewing the process of SPC implementation. These reflections inform the next cycle of planning and action. This step is the key to enabling learning in AR; without evaluation, actions may continue, regardless of whether they fail or succeed. Actions taken in this study were evaluated to ascertain whether the original diagnosis was correct; whether the correct actions were taken and whether this was done in an appropriate manner. The findings fed into the next cycle of diagnosis, planning and implementation. Data for AR may be gathered by means of participant observation, recorded interviews/conversations or questionnaires, or retrieved from the archives (Dick et al., 2009). Table 4.3 shows how data collection was carried out in this AR.

Table 4.3 Data collection in the AR (AlphaCo)

Data Collection Technique	Description
Participant observation	Field notes, reflective journal Notes were made on responses and challenges throughout the implementation
Recorded conversations	Recorded video and audio Semi-structured interviews Discussions Conversations (shop floor employees, middle managers)
Archive data	Waste percentages Ratio of ingredients Yield percentages Standard operating procedure (SOP) Recipes for the selected products Critical quality characteristics/parameters

4.5.1.4 Limitations

AR is often criticised as insufficiently scientific because it is statistically unsophisticated and does not lead to defensible generalisability (Mctaggart, 2006).

However, since the main purpose here was to introduce the application of SPC, generalisability was not a primary concern. Another potential limitation is that the researcher's personal involvement may bias the results (Middel et al., 2006). Efforts were made to minimise this risk by adhering closely to the AR cycle.

4.5.3 Survey

Surveys are frequently employed in empirical statistical research (Scudder and Hill, 1998) as a way of collecting opinions and other information from a large number of people (Malhotra and Grover, 1998, Easterby-Smith et al., 2011a). This quantitative instrument is carefully structured and standardised to allow investigation of the relationships between key variables. To be considered useful, the results collected from a sample group must be generalisable to the whole population.

4.5.3.1 Justification for the choice of method

The purpose of the survey in this study was to gain insight into the current status of quality improvement and SPC implementation activity in the food manufacturing industry (RQ1). The low rate of SPC implementation in the food industry has been noted before (Grigg, 1998, Grigg and Walls, 2007a, Surak, 1999a, Mann et al., 1999), but there is still little empirical literature on this issue. The few exceptions include Scott et al. (2009) investigation of CI in the Canadian food sector, Alsaleh (2007) study of quality tool application in Saudi Arabia's food industry, and Dora et al. (2014) study of lean manufacturing in European food SMEs, including the perceived benefits of and potential barriers to implementation. Since a survey allows more food companies to be examined than a case study, the results for RQ1were more likely to be generalisable (Dillman, 2000, Marsden and Wright, 2010, Scott et al., 2009, Dora et al., 2014).

4.5.3.2 Questionnaire layout

The survey instrument was adapted from published literature by quality improvement practitioners and academics (Evans and Mahanti, 2012, Rungasamy et al., 2002, Grigg and Walls, 2007a, Mohd Rohani et al., 2009, Maneesh, 2010, Antony and Balbontin, 2000). Input was also sought from the researcher's supervisor and a leading specialist in OM studies, Prof Cipriano Forza of the European Institute for Advanced Studies in

Management (EIASM). The questionnaire was structured in six sections: demographics; quality improvement tools, techniques and methods; SPC tools; barriers; critical success factors; and performance measurement. The details of each section are as listed in Table 4.4 and the questionnaire is included in Appendix B.

Table 4.4 Questionnaire layout

Section	Purpose	Question theme (Number of attributes/categories)	Type of question
Demographic -11 questions	To categorise the companies according to their characteristics To investigate the quality improvement practices that are common to these food manufacturing companies	Name of the company Country of operation Size of the company (3) Details about its main product (12) Existing quality system/ certification (4) Quality awards received by the company (4) Quality/process improvement method/programme/philosophy (4) Existence of quality department Existence of problem-solving team	Open-ended Multiple answers
Quality tools/techniques -3 questions	To assess which quality tools are common and relevant to companies To assess the degree of SPC usage in the companies	Basic tools (23) Advanced tools (7) SPC/non-SPC user Reasons for not using SPC (optional) (7)	Likert scale: 1-5 1= Never been implemented-5=Frequently implemented 1= Not useful - 5=Extremely useful
SPC tools -1 question	To determine the common and relevant SPC tools in the companies	Frequency and usefulness of SPC tools (13)	Likert scale 1= Never been implemented - 5=Frequently implemented 1= Not useful - 5=Extremely useful
Barriers	To assess common	Barriers faced by the food	Likert scale

- 1 question	barriers to SPC implementation	companies when implementing SPC (11)	1= Strongly disagree - 5=Strongly agree
CSFs - 1 question	To identify critical factors for successful SPC implementation	Critical factors for successful SPC implementation (10)	Likert scale 1= Least important - 5=Most important 1= Never implemented - 5=Fully implemented
Performance measurement - 1 question	To identify the metric most commonly used to analyse performance	Type of measurement the company uses to assess performance (15)	Likert scale 1= Worsened -3 =No change - 5=Improved

The questions were a mixture of open-ended, multiple-choice and 5-point Likert scale (Prybutok and Ramasesh, 2005, Chileshe, 2007). It was imperative that the Likert scale generated adequate variance among respondents for the statistical analysis. Hinkin (1995), in a review of 75 articles from leading academic journals, found that majority (49%) of the reviewed studies used a five-point Likert scale; accordingly, this was applied in section 2 to section 5 of the survey.

4.5.3.3 Data collection approach

The design of a questionnaire will be influenced by the amount of contact the researcher has with the respondents (Saunders et al., 2011). Self-completed questionnaires were employed in this study because they allowed respondents to complete the instrument when convenient. The survey was internet-based as this was the cheapest and quickest option, but Qualtrics software also provides a user-friendly layout (Dillman, 2011) and the resulting data are easier to input into SPSS than data from postal surveys (Pfeffermann and Rao, 2009). The fact that email contact details for quality managers and operations directors were readily available was another incentive to use an internet-based survey.

4.5.3.4 Sampling strategy

The choice of unit of analysis is crucial as it determines who or what is studied (Rungtusanatham et al., 2003). In most quality management research, the unit of analysis is the company(Scott et al., 2009, Rungtusanatham et al., 2003). The survey was distributed to food manufacturing companies, each of which was represented by either a director (managing/operation) or manager (quality/operation/production/technical). These employees were considered the best placed to provide the required information about process management practices in the company (Dora et al., 2014, Malhotra and Grover, 1998). The invitation letter for the survey is included in Appendix A.

A sampling frame is a complete list of target population members (Bethlehem and Biffignandi, 2011). The sampling frame for this study was compiled from the Financial Analysis Made Easy (FAME) database. This ensured that the list was accurate and up to date (Dillman, 2011). The list identified 1608 food companies.

Probability sampling was chosen over nonprobability because of the fundamental problem associated with the latter: the validity of the inferences drawn from such a sample is neither assured nor testable, making any generalisation questionable (Pfeffermann and Rao, 2009, Dillman, 2011, Marsden and Wright, 2010). Probability sampling, which may take the form of systematic sampling, simple random sampling, stratification or multi-stage cluster sampling, aims to minimise survey costs while controlling the uncertainty associated with key estimates (Pfeffermann and Rao, 2009). In this case, systematic random sampling was applied; starting at a random point and selecting every fourth company, 400 companies were invited to participate the survey, from the original 1608 companies (Malhotra and Grover, 1998).

Fifty-nine usable questionnaires were returned, making a response rate of 14.8%. This sample size and response rate are comparable to previous surveys published in the quality management field: (Scott et al., 2009) secured an11% response rate (48 respondents), (Dora et al., 2014) 15.2% (35 respondents) and (Kumar et al., 2008) 12.8% (64 respondents). The respondents were chief executive officers, directors, quality managers, production managers, CI managers, general managers, Six Sigma Black Belts and Six Sigma Green Belts.

4.5.3.5 Limitations

One of the limitations of a survey is potential sampling error, though this can be controlled by carefully selecting the sample population and increasing the sample size (Assael and Keon, 1982). Additional errors may arise from non-responses and the misreporting of answers. These survey-related errors can have a knock-on effect on other areas of the research, which prevention actions are required (see Table 4.5) (Assael and Keon, 1982, Dillman, 2011, Robson, 2002, Fowler Jr and Mangione, 1990)**.**

Table 4.5 Limitations of the survey

Limitations	Description	Preventive action taken in this research
Specification error	Data elements do not align with objectives Invalidity Question not linked to the research purposes	Answer options were taken from official documents and literature (e.g. SIC, company size categories). Question structure also followed the literature.
Frame error	Omission Erroneous duplication Faulty information	The sampling frame was derived from FAME database. The samples were divided according to company size (SME and large).
Non-response error	Whole unit Within unit Item Incomplete information	Respondents were instructed to answer all the questions.
Measurement error	Information system Setting Mode of data collection Respondent Interview Instrument	Respondents were chosen for their job title (in a position responsible for quality control and improvement) to ensure they had the knowledge to answer the questions.
Data processing error	Editing Data entry Coding Weighing Tabulation	The data transferred to SPSS automatically from Qualtrics. Data entries were then screened manually for accuracy.
Inaccurate/ dishonest answers	Confusion on question Confidentiality	The purpose of research was clearly explained (i.e. for academic purposes only). Respondents were assured of the privacy of their contact information.

The main limitation of the survey method is that results are restricted to numerical descriptions rather than detailed narrative, so they provide less detailed accounts of people's perceptions (Meredith, 1998). The survey answers were able to give only a limited insight into respondents' behaviour, attitudes and motivations regarding SPC implementation (Rungtusanatham et al., 2003).

4.5.4 Case study

A case study may employ multiple data collection methods (e.g. observations, interviews and documentation) to assess a phenomenon in its natural setting (that is, without experimental controls or manipulations) (Meredith, 1998, Voss et al., 2002). The findings from a single case study are not generalisable (Yin, 2008, Eisenhardt and Graebner, 2007) and may be liable to bias. The study overcame this by analysing multiple cases (eight UK food companies), which allowed the comparison of quality management practices across SPC and non-SPC companies (Nonthaleerak and Hendry, 2008).

4.5.4.1 Data collection: Semi-structured interviews

The primary sources of data in the case studies were interviews and observations; these enabled the researcher to capture the stories within organisational practices on process improvement (Palmberg, 2010). Bogdan and Biklen (1998) describe interviews as purposive conversations that may be conducted in a structured, semi-structured or unstructured way (Stuckey, 2013, Robson, 2002, Denzin and Lincoln, 2005, Easterby-Smith et al., 2011). In a structured interview, the interviewer adheres strictly to pre-prepared questions. At the opposite extreme, an unstructured interview has no prearranged questions and the conversation develops freely. It can be completely informal. Between the two lies the semi-structured interview, which was the option chosen here. A standard set of questions is prepared as a guide, but deviation from the sequence is allowed and additional questions may be asked to follow up on interviewees' answers (Smith, 1975, Denzin and Lincoln, 2005) (see Appendix E). The flexibility of the semi-structured interview was useful here because respondents did not all describe situations in the same way (Louise and While, 1994).

4.5.3.2 Justification of case study approach

The case studies followed Haikonen et al. (2004), (Huq and Stolen, 1998) in examining quality improvement practices in the FMI and uncovering the reasons for food companies does nit implement SPC. The paucity of discussion on SPC issues in the FMI renders case studies such as these especially useful; exploratory studies come before the theory-building stage and lead to the emergence of new research ideas and hypotheses (Nonthaleerak and Hendry, 2008, Voss et al., 2002, Yin, 2008).

The primary strength of the interview technique is that it allows interviewees to respond in their own words (Bogdan and Biklen, 1998, Carruthers, 1990). Furthermore, although interviews are time-consuming, a much smaller sample is required than for a survey, making it possible to achieve a much higher response rate (Louise and While, 1994). Finally, the interviews give the researcher an opportunity to follow up on results from the survey (Creswell and Clark, 2007, Nonthaleerak and Hendry, 2008).

4.5.3.3 Interview design

Since CSFs, motivations, benefits and barriers are the key factors highlighted in SPC implementation studies, these were taken as the themes for the case studies (Oakland and Tanner, 2007, Antony and Taner, 2003, Chakravorty, 2009, Watson, 1998, Jeyaraman and Teo, 2010, Noskievičová, 2010, Nonthaleerak and Hendry, 2008). Among the CSFs listed in the literature (Chapter 2) and survey (Chapter 5), training was highlighted as one of the most important factors in SPC implementation and the biggest challenge for the food industry (Lim et al., 2014, Grigg and Walls, 2007a). The literature review (Chapter 2) revealed that there is very little information on SPC team development, SPC leader selection and process performance measurement and type of learning under the state of SPC implementation (Lim et al., 2014, Grigg and Walls, 2007a).

As with the survey, interviewees were selected for their knowledge of process control and process improvement activities. They included managing directors, quality managers, process managers and technical managers – shop floor employees were excluded. Each interview lasted approximately 90 minutes and was recorded. Stuckey (2013) suggests that this allows the researcher to maintain focus on the interviewee and build a connection, encouraging dialogue.

Table 4.6 Interview topic guide

Demographic details	Occupational details Company type, size and years of operation Type of product
Quality management practice	Definition of quality Food quality management certifications Quality management programme Quality tools and techniques applied
Team	Existence of quality improvement team SPC leader Team members Size of the team
CSFs, barriers, reasons for not implementing SPC	CSFs facilitating SPC implementation Challenges and impediments to SPC implementation Reasons for implementing SPC
Training	Training plan Selection of people for training Facilitators
Performance measurement	Process performance measurement criteria
Organisational learning	Type of learning in SPC implementation

4.5.3.4 Sampling strategy

Purposive sampling is primarily used where the unit of analysis is the company – participants are selected according to predetermined criteria relevant to the research questions (Malik and Blumenfeld, 2012).The sampling criteria used in this study were that the company must be a food company, its main operation must be manufacturing food products, and it must be medium (50-249 employees) or large (>250 employees) in size (these companies are likely to have better quality practices than small companies)

(Grigg and Walls, 2007a).Only CEOs, directors or managers (quality/production/technical) appropriate to participate the interview sessions where an LSS consultant with 30 years' experience in the food industry was asked to nominate the samples who would make suitable interview candidates. The participating companies are described in Table 4.7.

Table 4.7 Profile of the companies and the interviewees

Company	Products	Size of company	Type of process involved	Number of interviewees (Position in the company)
A	Confectionery	Large	Automated	2 (Quality directors and production manager)
B	Spices	Medium	Automated	2 (Quality and technical manager)
C	Poultry	Medium	Semi-auto	1(Quality manager)
D	Poultry	Large	Semi-auto	2(Quality and production manager)
E	Seafood	Medium	Semi-auto	1 (Technical manager)
F	Seafood	Medium	Semi-auto	1 (Quality manager)
G	Bakery	Large	Automated	2(Managing director, production manager)
H	Bakery	Large	Semi-auto	2(CI manager, technical manager)

4.5.3.5 Limitations

The major drawback of this qualitative method is that the findings cannot be generalised to the wider population (Yin, 2008, Noor, 2008, McCutcheon and Meredith, 1993). Several steps were taken to minimise its other limitations, as shown in Table 4.8.

Table 4.8 Limitations of the interview

• **Limitations**	• **Steps taken to overcome these disadvantages in this research**
• Lack of standardisation (semi-structured interview allows changes to the wording and sequence of questions) raises concerns about reliability and research bias (interviewer and interviewee) (Louise and While, 1994)	• Interview protocol was developed in order to compare and contrast answers (see Appendix D and Appendix E) (Yin, 2008) • In data analysis, the interviews were compared and contrasted based on the 'meaning' rather than word-by-word transcription of the sentences (Louise and While, 1994) • Interviewees clearly informed that the objective of the interview was academic research only (Saunders et al., 2011) • Interviewees were given sufficient information about the nature and scope of the interview beforehand (Barratt et al., 2011) • To reduce interviewer bias, multiple interviewers were used (Barratt et al., 2011, Dubé and Paré, 2003, Meredith, 1993)
• Time-consuming to get access and arrange	• Requested help of a senior Lean Six Sigma practitioner in the FMI to get access for interview sessions
• Time-consuming data	• The process of data analysis was aided by the

analysis, as transcribing the data is a major task (Teram et al., 2005, Saunders et al., 2011)	application of software packages such as Nvivo, which enables the researcher to systematically store and transcribe the recorded interviews (Easterby-Smith et al., 2011, McLellan et al., 2003, Yin, 2008)
• It is costly for the researcher to travel to interviews	• The researcher used the research allowance offered by the University of Heriot-Watt
• Small sample size makes generalising the results difficult (Bartholomew et al., 2000, Bryman, 2003, Saunders et al., 2011)	• Triangulation of data sources (Barratt et al., 2011, Scandura and Williams, 2000, Eisenhardt, 1989, Al-Mashari and Al-Mudimigh, 2003)

4.5.5 Delphi study

A Delphi study is a way of structuring the group communication process in order to systematically solicit, organise and structure experts' opinions on a complex subject (Dalkey et al., 1969, MacCarthy and Wasusri, 2001).

4.5.5.1 Justification of the selected method

The Delphi method has been widely applied in OM research for the purposes of exploratory study, concept development and ranking/prioritisation (Klassen and Whybark, 1994, Heras Saizarbitoria, 2006, MacCarthy and Atthirawong, 2003, Ogden et al., 2005, Padhy et al., 2011, Snyder-Halpern, 2001, Minkman et al., 2008, Anderson et al., 1994, Schmidt, 1997).The paucity of research on organisational readiness in CI meant there were no presupposed organisational readiness factors to test (Ziglio, 1996, Okoli and Pawlowski, 2004, Hsu and Sandford, 2007, Hasson et al., 2000), while the case study approach would have yielded exhaustive information, but the results would not have been generic (Miles et al., 2013, Schmidt, 1997). Since the research problem (RQ 3) did not lend itself to precise analytical approaches due to its exploratory nature, the Delphi method was chosen as the most appropriate research instrument (Baines and Shi, 2015).

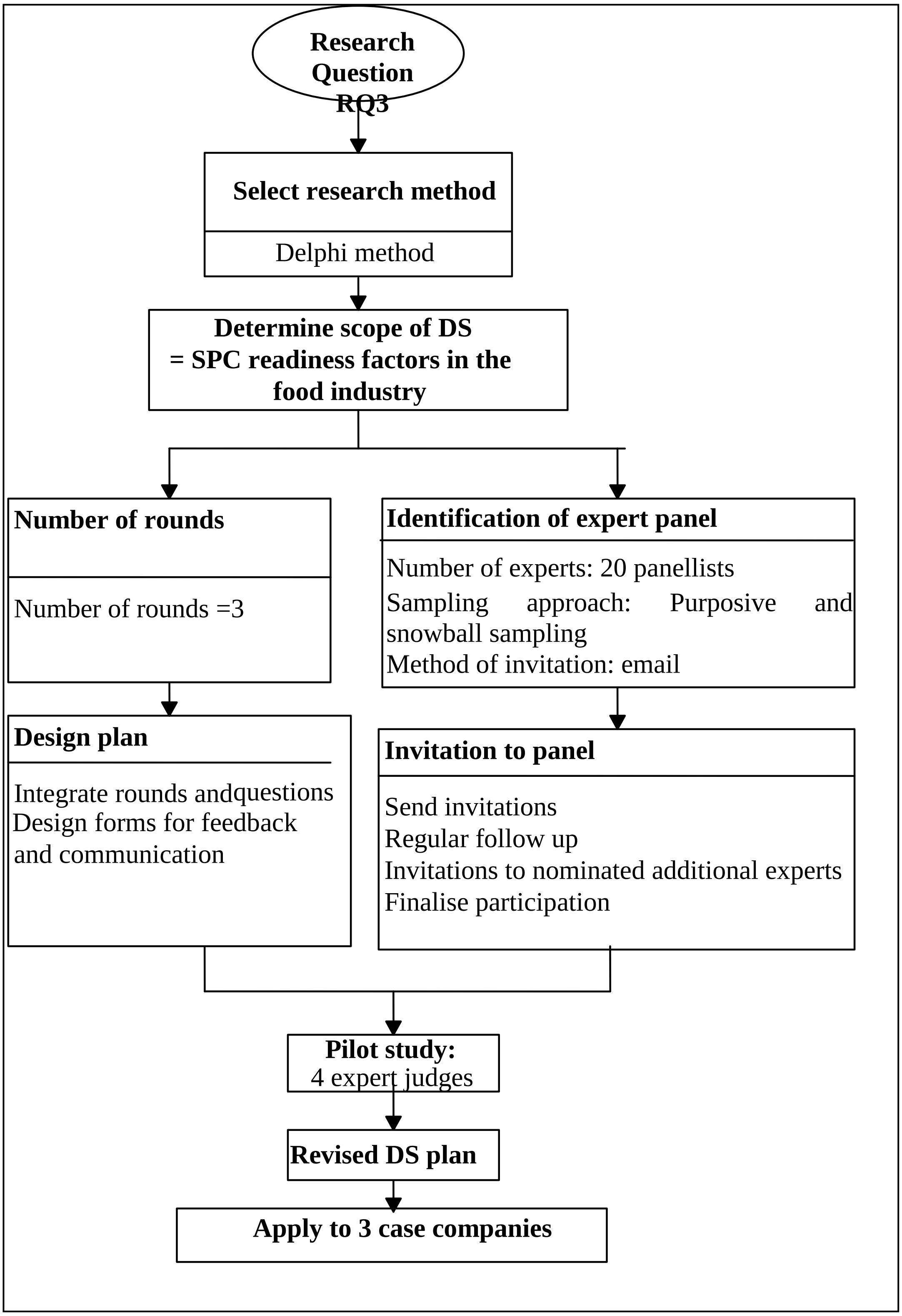


Figure 4.3 Delphi study design

4.5.5.2 Delphi questionnaire layout

The Delphi study was carried out in three rounds: the first round questionnaire had four sections, the second had two sections and the last had one question. The questionnaire design is summarised in Table 4.9.

Table 4.9 Design of Delphi questionnaire

ROUND 1		
Section	Purpose	Questions
Demographic -4 questions	To identify experience and knowledge of the experts	Name Number of SPC projects Years of research
Explore SPC readiness factors -1 question	To identify SPC readiness factors	Suggestions for SPC readiness factors
Confirm SPC readiness factors -7 questions	To confirm SPC readiness factors adapted from the literature	Suggestions whether to retain, modify or delete the SPC readiness factors
ROUND 2		
Review selected organisational factors for SPC implementation in the food industry		
Establish agreement on the factors collected from the previous cycle	To improve accuracy of the results	Suggestions whether to retain, modify or delete the SPC readiness factors
Explore the SPC readiness attributes - 7 questions	To explore the attributes for every identified SPC readiness factor from the first cycle	Suggestions for the attributes for each identified SPC readiness factor
ROUND 3		
Confirm the selected organisational factors for SPC implementation in the food industry		
Establish agreement on the factors collected from the previous cycle	To improve accuracy of the results	Suggestions whether to retain, modify or delete the SPC readiness factors

4.5.5.3 Development of an anonymous expert panel

The Delphi group size does not depend on statistical power, but rather a group dynamic for arriving at a consensus among expert (Okoli and Pawlowski, 2004). However 7-30 experts were suggested for the size of sample in Delphi studies (Denzin and Lincoln, 2005, Snyder-Halpern, 2001).

This study carried out non-probability sampling (purposive), as the respondents were selected not to represent the generality of the context, but to represent the expert ability to answer the research questions (Skulmoski et al., 2007). The experts panel should be selected for their capabilities, knowledge and independence (Okoli and Pawlowski, 2004, Baines and Shi, 2015). The criteria for SPC experts judges' selection were adopted from previous Delphi studies in quality management research (Minkman et al., 2008, Anderson et al., 1994): (1) multiple years of experience with quality improvement through SPC in food industry settings (average five years), (2) authoritative in SPC implementation, (3) associate with an institution that conducting research, delivering SPC training, applying training.

Thirty SPC experts invited to participate, 20 experts took part in the first round and the second and eighteen third round. They were drawn from a range of backgrounds (e.g. academics, consultants and food industry practitioners) from different countries (e.g. UK, USA, India, Malaysia, Netherland) to reduce the risk of sample bias. The sample size which Martino (1993) suggested is 11 experts, while Okoli and Pawlowski (2004) suggested 10-18 experts are sufficient. Results are unlikely to vary significantly between panels as long as they are truly representative of the expert community (Martino, 1993). But, panel experts who have a diversity of perspectives produce more accurate judgments than homogenous experts, which then this study stratified the sample among the three groups (industry, consultation and academia) (Klassen and Whybark, 1994, Sackman, 1974). The distributions of experts across the three categories (A= academics, I= Industrial, C= Consultants) participated in this study depicted in Table 4.10.

Table 4.10 Participated SPC experts

Experts	Years of research/practice SPC	Number of projects	Position in the company
A1	14	6	Professor
A2	7	2	Senior lecturer
A5	27	25	Assistant professor

A6	25	20	Senior lecturer
A7	10	3	Senior lecturer
A8	18	50	Researcher
C1	15	6	Consultant
C2	20	50	Consultant
C3	7	5	Consultant
C4	25	20	Consultant
C5	11	7	Consultant
C6	7	5	Consultant
C7	9	6	Consultant
I1	20	15	Six Sigma Black Belt
I2	10	4	Quality Manager
I3	12	4	Head of quality
I4	12	9	Head of quality
I5	10	4	Six Sigma Black Belt

The researcher developed the questionnaire based on the previous literature in readiness and other Delphi study (Sackman, 1974, Snyder-Halpern, 2001, Padhy et al., 2011, Minkman et al., 2009, Heras Saizarbitoria, 2006, Klassen and Whybark, 1994). Following the completion of the Delphi study design, the researcher commenced a pilot study (with four experts) to elicit feedback regarding the Delphi questionnaire design. To validate the survey, this study considering the suggestion from literature in Delphi study where the piloted five experts, (Heras Saizarbitoria, 2006, Mohamad, 2009), 10%-20% of the sample size (Baker and Risley, 1994). The pilot study leads to the modification of the design to reduce participant dropout and increase the quality of the data(Clibbens et al., 2012). The modifications of the questionnaire include:

- from four sections of questions, including demographics, reduced to three, as it was viewed to be repetitive;
- The term 'readiness' was interchangeably used with 'preparedness', which provides less complexity and provide understandable terms for the practitioners such as consultants and industrial SPC experts to understand the questions;

- Definition of *SPC readiness* in the context of this study is added in the questionnaire to provide a clear objective and scope of the questionnaire.

4.5.5.4 Limitations

The prominent limitation of this method is the lack of a standard approach for operation management studies when setting the criteria for choosing the experts (the respondents) (Gupta and Clarke, 1996). In order to overcome this limitation, the researcher adopted the expert selection criteria as used in previous Delphi studies in quality management: the experts were chosen based on their years of experiences (5 years average) and involvement in SPC implementation (number of projects), as listed in Table 4.12 (Anderson et al., 1994).

4.6. Data Analysis

4.6.1 Survey data

This section will explain the process for quantitative data analysis from the survey questionnaire. The completed surveys were then exported from Qualtrics to SPSS (Statistical Package for the Social Sciences). The data were analysed using statistics analysis and statistical test (e.g. t-test, chi-square, Paired Wilcoxon Signed-Rank test, T-test) detailed findings are discussed further in Chapter 5.

4.6.2 Delphi study

In the Delphi survey, a thematic analysis (adopted from the content analysis) was carried out to identify and validate organisational readiness for SPC adoption (Krippendorff, 2012). The objective of this analysis was to reduce the number of indicators with similar content and meaning.

Round 1: The researcher sorted the factors into ten groups based on the literature and created a preliminary SPC readiness factors label for each grouping. The number of readiness factors required to be suggested by the panellists were not specified, although based on the preliminary review and the analysis, three or four attributes could be easily identified.

Round 2: The researcher integrates the result from the literature review and the round 1 and subsequently validated preliminary dimension themes (Snyder-Halpern, 2001). The indicators that acquired >50% of the frequency of the participants were chosen(Okoli and Pawlowski, 2004).

Round 3: The panel experts were provided a list of potential attributes for each of readiness factors. Similarly attributes which accounted more than 50% were selected as the attributes for each of the factor.

4.6.3 Case study (semi-structured interviews)

Data analysis in interviews is defined as the process a researcher uses to reduce data to a story and its interpretation, or to make sense of the data (LeCompte and Schensul, 1999, Patton, 1990). Data analysis is viewed as the heart of theory building, especially with interviews; it is the one of the most difficult tasks in research and also the least codified part (Eisenhardt, 1989). Qualitative data analysis provides ways of discerning, examining, comparing, contrasting and interpreting meaningful patterns or themes (Miles and Huberman, 1994). Meanwhile, Miles and Huberman (1994) sourcebook highlight that there are many different techniques for analysing the same data for different purposes:

- Matrix of categories;
- Data display (flowcharts);
- Putting data into different arrays;
- Tabulating frequency of various events;
- Examining the complexity of such tabulations;
- Categorising information by chronological order.

The most appropriate approaches for this study are tabulating frequency of various events (thematic analysis) and matrix of categories. Adopted from Miles and Huberman (1994), Easterby-Smith et al. (2011), Thomas (2006),the steps in data analysis are as following,

Step 1: Recorded audio transcription (Verbatim transcription)

The first step of analysing qualitative data is the transcription of the interviews from the recorded audio (McLellan et al., 2003) which provides a verbatim account of the interview. The level of transcription depends on the level of the analysis; in this case, the analysis was based on the themes (Figure 4.4) (Drisko, 1997). While the interview is designed to involve the collection of audio recording, the researcher has decided that the data analysis will be supported by transcription and backed up by field notes. Such approach is very lengthy. However, it provides richer data on the SPC implementation process from the view of practitioners in the industry (Patton, 1990).

Step 2: Data familiarisation (Understand the data)

While reading the data transcripts, the unrecorded information, such as field notes, are considered. In this study, field notes or additional memos were used as the additional information to support the recorded audio data and strengthen the quality of the interview Glaser (1978).

Step 3: Data reduction (Extracting the essence)

The simplest form of data reduction is eliminating data not relevant to the analysis at hand, or retrieving the data that are relevant (Namey et al., 2007). In this study, the researcher generated a case study summary from raw data that were categorised based on the themes outlined in the interview protocol and thematic analysis (Patton, 1990). Codes are short phrases that assign symbolic meaning to the descriptive or inferential information compiled during a study (Miles and Huberman, 1994, Saldaña, 2012). This and inductive analysis (Frechtling and Sharp, 1997). The researcher starts this by developing an initial list of codes prior to the field work, or it is called deductive coding (Miles et al., 2013).

For the case study, the researcher developed master codes, including SPC IMPLEMENTATION, and FRAMEWORK. For the AR data (journal, field notes, recorded audios), the master codes (the elements relevant to the SPC implementation) included INTRODUCING SPC, STEPS IN SPC IMPLEMENTATION, FOOD QUALITY MANAGEMENT, CSFs, CHALLENGES, READINESS and ORGANISATIONAL LEARNING. While initial themes were shaped by pre-established research questions, the researcher remained open to inducing new meanings from the data available through inductive coding (e.g., a master code emerged from semi-structured interview ─ SPC READINESS) (Frechtling and Sharp, 1997). Once these codes were created, the information in the transcription could be sorted.

In recent years, a great proliferation of software packages has been used to facilitate analysis of qualitative data, most of them are reviewed by Weitzman and Miles (1995). Nvivo, a Computer Assisted Qualitative Data Analysis Software (CAQDAS) (McLellan et al., 2003, Easterby-Smith et al., 2011), is applied to facilitate the coding process through the creation of the coding template. At this stage, both the data from the transcribed interviews and the field notes will be entered through the coding process to finalise the codes and subsequently reveal the emerging themes (13 nodes were found). Although Nvivo is helpful in marking, coding, and moving data segments more efficiently than can be done manually, the researcher took notes for which the software was unable to determine a meaningful category or define salient themes (Weitzman and Miles, 1995).

4.7 Quality of research methods

The quality research method was commonly outlined through reliability and validity of the research design. The validity of data refers to whether the data collected can measure what the researcher set out to measure while reliability refers to consistency in the data measurement (Leedy and Ormrod, 2005). More details on the validity and reliability of the research methods applied in this study will be described in Table 4.11.

Table 4.11 Reliability and validity of this study

Methods	Reliability	Validity
Case studies	• The value of this type of research method is derived from the flexibility that may be used to explore the complexity of the topic (Saunders et al., 2011) • Used topic guide/ interview protocol (refer to Figure 4.4) • Developed case study database	• High validity was achieved when the interviews were conducted due to the scope to clarify questions, to prove meanings and to be able to explore responses from a variety of angles (Saunders et al., 2011, Creswell, 2012, Patton, 1990, Eisenhardt and Graebner, 2007, Eisenhardt, 1989, Voss et al., 2002) • Use of multiple sources of evidence (triangulation) (i.e., survey for quality management practices in the food industry) • Established chain of evidence: literature review, survey • Provided the interviewees

		with a review summary of the interview • Submitted publication for feedback of peer review
Survey (Exploratory SPC survey and Delphi survey)	• Reliability in a survey refers to the respondents consistently interpreting a question in the same way (Malhotra and Grover, 1998) • Test the internal consistency using Cronbach's alpha value; all questions achieved higher than 0.70 (Malhotra and Grover, 1998, Rungtusanatham et al., 2003, Dora et al., 2014)	• Representativeness and suitability of the questions (Malhotra and Grover, 1998) • Questionnaire was adopted from similar published studies (Scott et al., 2009) • Requested experts' opinion (two academics and two industrial practitioners) • Triangulation with the case studies (Nowack et al., 2011, Skulmoski et al., 2007)

In contrast with quantitative research methods, it is important to note that the findings from qualitative research are not necessarily intended to be repeatable since they reflect reality at the time they were collected (Saunders et al., 2011, Kvale and Brinkmann, 2009, Marshall and Rossman, 2010). As explained in the previous section, this research embraced the use of data source triangulation, through a mixed-method approach, to enhance the reliability and validity of the research.

Meanwhile, action researchers take another approach: they describe AR quality in terms of its contribution to the improvement of current practice of SPC (Susman and Evered, 1978, Eden and Huxham, 1996b, Huxham and Vangen, 2003, Reason and Bradbury, 2001).AR should be justified by its own terms and criteria, particularly those who argue that the data generation and the emergent theories cannot be addressed by alternative approaches (Eden and Huxham, 1996b, Coughlan and Coghlan, 2002, Middel et al., 2006).

Hence, within its terms, there is a reluctance to use the term 'validity', but instead, the 'quality' of this AR should be assessed by the criteria below (Coughlan and Coghlan, 2002, Middel et al., 2006, Levin, 2003):

- The intervention of SPC must be due to genuine problem concerning the company, and the employees involved in the research project should be guided by a concern to practical and real-life outcomes (Huxham and Vangen, 2003, Levin, 2003). For instance, AlphaCo is highly concerned with the instability of their product quality (height of the cakes), which leads to high waste percentages and the risk of losing the customers.
- Researcher's participation (Levin, 2003).
- The teamwork involving the researcher and employees of the AlphaCo in the SPC team to drive the SPC adoption process depicts high cooperation and participation of both sides throughout the project.
- Joint-meaning construction (Levin, 2003)..
- The activities of interpreting the problem, articulating meanings of the results and action taken and generating knowledge about the process and SPC show a collaborative process between the researcher and the members of the company.
- Workable solution (Levin, 2003, Eden and Huxham, 1996b, Argyris et al., 1985).

The SPC team has designed the SPC implementation roadmap, articulated based on the team members' real experience in the adoption of SPC and the reflections on the conceptual SPCIR developed in Chapter 3. The team members have provided workable solutions for challenges faced for the SPC implementation especially in the training, measurement system, SPC leader and team development that aligned with the company's environment.

4.8 Ethical considerations

Ethics in research concerns the appropriateness of the researcher's behaviour in relation to the rights of those who become the subject of the research or are affected by it (Saunders et al., 2011).This research is likely to have more ethical questions due to the nature of research in OM being highly dependent on the collaboration of people for access to the real-world data (Barratt et al., 2011, Karlsson, 2010, Filippini, 1997, Swamidass, 1991, Flynn et al., 1990, Buffa, 1980, Chase, 1980).

There is increasing pressure from other areas of study, such as psychology (American Psychological Associations Ethical Principles of Psychological and Code of Conduct (1922)), anthropology (American Anthropology Association's Code of Ethics (1998)), education (American Educational Research Association Ethical Standards (2001)) and medicine (American Nurses Association Code of Ethics for Nurses' Provisions (2001)) to adopt a definite ethical code and practice. There are ten principles of ethical practice analysed by Bell and Bryman (2007); the first seven are about informants' protection, and the final three are intended to decrease bias and ensure accuracy of the research results.

This research considers ethical issues by having a signed Non-Disclosure Agreement (NDA) with the senior management of the company, which guarantees the confidentiality of data related to the company's intelligent properties. The respondents were clearly guaranteed anonymity protection, and this was mentioned in the invitation letter. In the AR, a Project Charter and Project Proposal were discussed and agreed by both sides (the research and the company team) to clarify a clear research objective, to avoid dishonesty about the nature or aims of the research and to ensure this research gains the fully informed consent of the participants and stakeholders. This study also has received ethics approval from University of Strathclyde and Heriot-Watt University.

The reports of the research output were clarified and discussed in a monthly review meeting with the company's project team members and the senior management team to avoid misleading or false reporting of research findings. Triangulation approaches were undertaken to ensure the accuracy of the data gathered through the designed steps for data analysis, for both qualitative and quantitative approaches (refer to Section 4.9).

4.9 Limitations

This research involved the usage of both qualitative and quantitative approach through the mixed-method research. Typically, mixed-method research is more complex, time consuming and costly than single-design studies. Moreover, the researcher has to acquire the knowledge to analyse and interpret both types of data (Caruth, 2013, Creswell and Clark, 2007, Johnson et al., 2007). The researcher has a good understanding of the quantitative analysis from her Bachelor Degree of Mathematics, and she has taken classes for interpreting qualitative data using Nvivo in for data analysis.

Nevertheless, with the integration of both types of data collection, the limitations of each other were cancelled out. The result is triangulated as well, leading to a much more solid study compared to the usage of one method only. Another limitation for this research was that mixing methods mean that one paradigm can conflict with another (Greene and Caracelli, 2003). However, as mixed-method, research is not limited by epistemological and ontological assumptions that restrain mono-method (refer to Section 4.4.2), the researcher is able to choose the most suitable approach to produce a workable solution and answers based on the research questions.

4.10 Summary

This chapter provided the research design that governs the use of appropriate strategy and methods employed in this study and that connect the empirical data to the research questions. Therefore, it was imperative for the researcher to understand clearly the concept of research design and its impact on the outputs. As a pragmatist, due to the different needs each of the research questions, the researcher carefully design survey, case study, action research and Delphi study to be implemented in order to answer each of the research questions.

To this end, this chapter justified the philosophical research paradigms and their assumptions outlining this research and correlates with the research methods used to address the research questions. This chapter also highlights the limitations of each research method in the light of learning from empirical studies in the literature review.

This chapter depicted that this study meets the characteristics of the pragmatism paradigm and this is reflected by the application of a mixed-method approach to address each of the research questions appropriately, which has been acknowledged by OM researchers as a powerful approach in OM research. The subsequent chapters will present the results of the empirical studies.

CHAPTER 5 — EXPLORING SPC IMPLEMENTATION IN THE FOOD INDUSTRY: A SURVEY AND MULTIPLE-CASE STUDIES

5.1 Introduction

This chapter presents the findings from the exploratory survey and multiple-case studies conducted in the UK food manufacturing industry. The survey was designed to evaluate the extent to which the SPC were applied to the various commodities in the industry throughout the UK. This study assessed the extent of quality management practices in this industry across different commodities and company sizes and subsequently focused on SPC implementation themes (challenges, CSFs and the reasons for not implementing SPC). This study provided us with an exceptional opportunity to study two different patterns of practice and their operational performances (with SPC and non-SPC) (Garengo and Sharma, 2014). Using SPSS, descriptive statistics and hypothesis testing was conducted to validate the differences between SPC and non-SPC companies in quality management tools and technique application and the gap analysis between the degree of implementation and the importance of quality tools. Then, cross-case analysis were carried out; the researcher is hypothesising an association between the theoretical replication and the interview answers; from this, we could further depict the pattern of themes within the SPC implementation (Miles et al., 2013). To guarantee anonymity, the case companies were identified as Company A, Company B, Company C, Company D, Company E, Company F, Company G and Company H (Miles et al., 2013).

5.2Key findings from the survey

The results in Figure 5.1 depicts that the majority of responses came from England, with 28 respondents, followed by Scotland (19 respondents), Wales (9 respondents) and Northern Ireland (3). This study has carefully addressed the potential bias issue based on the consideration of different location of companies across the UK, different size and various food commodities. The respondents were entailed of Directors, Quality Managers, Production Managers, CI Managers, General Managers, Six Sigma Black

Belt and Six Sigma Green Belt as the representative of the food companies (each company is represented by one respondent).

The survey response rate was 14.75%, representing 59 food-manufacturing companies, 52.54% of which were local firms, 40.68% joint ventures and 6.78% subsidiaries of multinational companies. This sample size is comparable to previous surveys published in the quality management field, including (Kumar et al., 2008) 12.8%, 64 respondents, (Scott et al., 2009) 11%, 48 respondents and (Dora et al., 2014) 15.2%, 35 respondents.

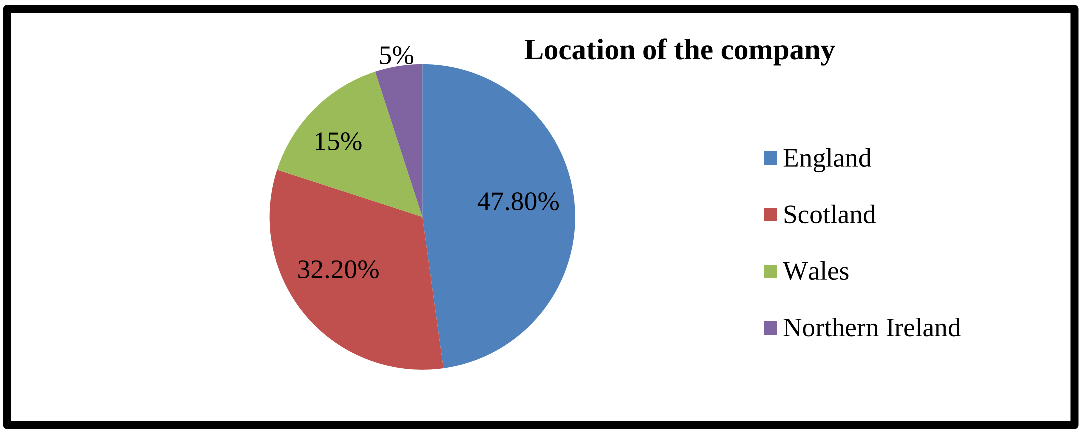


Figure 5.1 Type and location of sample food companies in the UK

According to McDermott (1997), the acquisition saturation within the food industry is due to the companies' perception that the principal factor to future growth is to acquire the most global brands, or to acquire brands that could become global. The purchase of subsidiary companies has implications for its working practices; the firm may subsequently inherit advanced manufacturing techniques and methods from the parent company. These subsidies are companies operating at different locations, and having diverse commodity.

The results show that 45% of the respondents implemented SPC in their current company, across various food commodities (Figure 5.2) and company size. The latter factor was categorised according to the number of employees: small (11-50 employees), medium (51-249 employees) and large (more than 250 employees) (Prosser, 2009, White, 2013). In this survey, the majority of companies responded to the questionnaire, with 55.9% categorised as large, 27.11% as medium, and finally 16.95% as small companies. Among the respondents that had applied SPC, 3% were from small, 14%

from medium and 29% from large companies. Trienekens and Zuurbier (2008) argued that quality management adoption in the food industry depends on organisational factors such as company size and type of products, which leads to the following hypothesis (H_1).

H_1*: Company size has a significant impact on the adoption of SPC in the food manufacturing sector.*

The results for the Chi-square analysis provide a p-value= 0.011<0.05, thereby indicating that there is a statistical evidence company size has a significant impact on the adoption of SPC. The companies were also categorised according to the main food product produced, following the guidelines set out in the UK Industrial Standard Institution Report, ISI 2007. As such, dairy, bakery, fish, crustaceans and mollusc commodities represented the highest number of respondents. The principal commodities with SPC users were dairy, bakery, chocolate and sugar confectionery, and meat processing. A systematic literature review on SPC implementation depicted a similar trend, as SPC case studies were mostly carried out in the dairy and bakery categories (Lim et al., 2014). On this basis, we suggest the following hypothesis (H_2).

H_2*: The type of food commodities influences the SPC adoption in the food manufacturing sector.*

Based on the Chi-square analysis, it was determined that the p-value= 0.029<0.05, which indicated that there are statistically significant differences in the adoption of SPC implementation, based on different types of food commodities.

Figure 5.2 illustrates type of company (SPC or non-SPC) food commodities, SPC implementation in companies processing fresh products, such as fish, crustaceans, molluscs, fruit and vegetables, significantly lagging behind other commodities.

The results of this survey revealed that the SPC companies have been using the technique for about nine years on average, with a range of 2 to 15 years. Companies that had applied SPC for more than ten years were mostly large multinational companies, arguably with a higher level of quality management maturity.

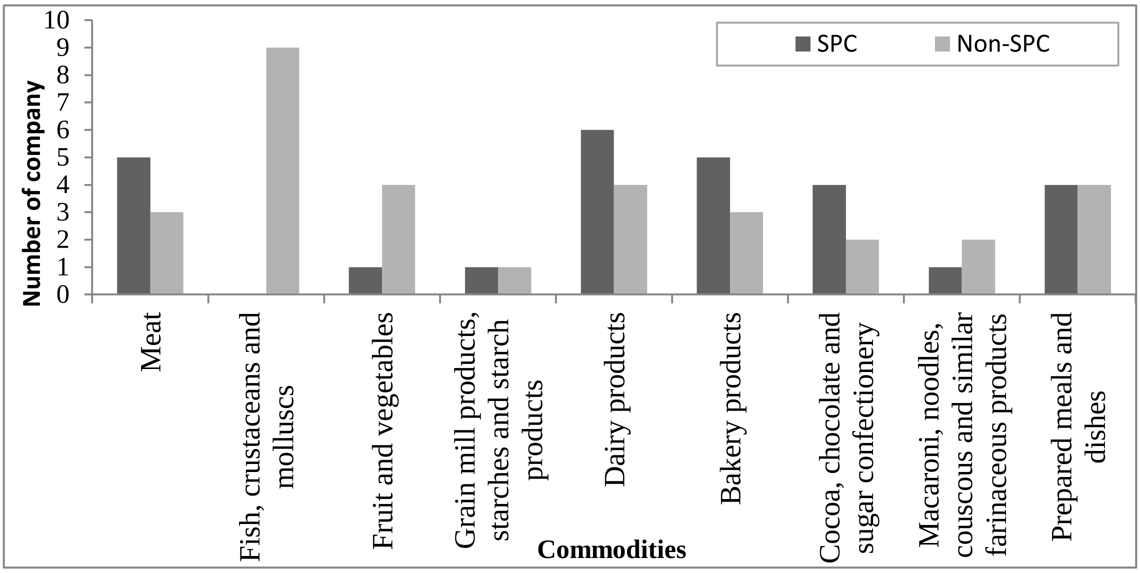


Figure 5.2 Type of commodities

It was observed that SPC adoption is slow in this sector, bearing in mind the fact that the big wave of SPC implementation in western manufacturing companies began 35years ago (Deming, 1986). Such results corroborate the arguments in the literature that the food industry is conservative in nature and slow to change in its quality control/improvement practices (Surak, 1999a, Mann et al., 1999).

This research is also interested in determining who is responsible for leading and spearheading SPC implementation (Figure 5.3). The respondents were asked to state the leader of SPC implementation in their company.

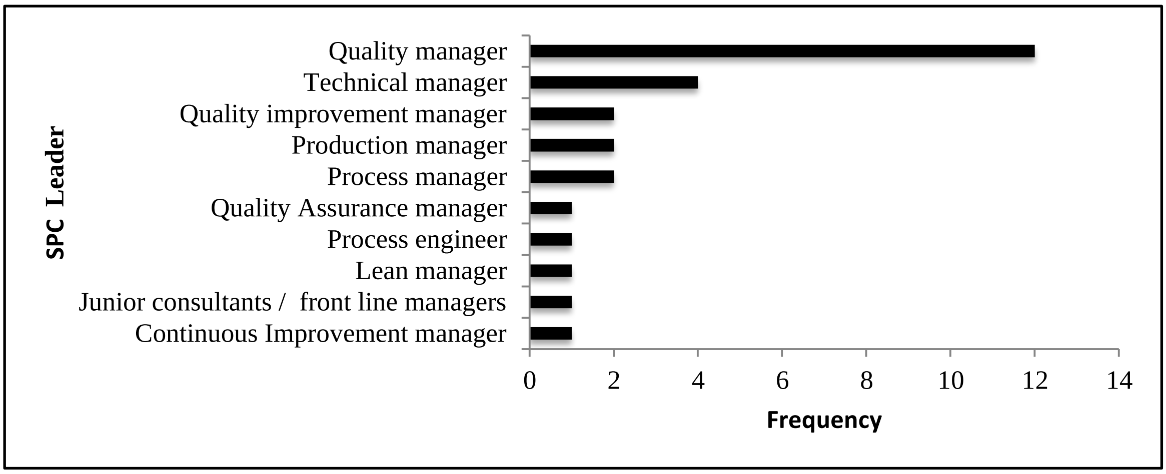


Figure 5.3 SPC leader in the food companies

The respondents suggested that most food companies appointed quality managers (20.34%) followed by technical managers (6.78%) to manage and lead their SPC programmes. Quality managers typically were trusted with the responsibility for managing all quality issues in the company, as they are expected to have more knowledge and experience on this subject compared to other personnel, despite the complexity of the food processes (Hubbard, 2003). Furthermore, they are the people most likely to receive quality improvement training (Wallace et al., 2012, Does and Trip, 1997, Hewson et al., 1997).

5.2.1 Quality tools

The respondents were asked to choose the quality tools employed in their respective company, and later they were asked to rate their degree of implementation (1=Never implemented to 5= Frequently implemented) and usefulness (1=Not useful at all to 5=Extremely useful). Table 5.1 depicted the results for basic and advanced quality tools/techniques.

Table 5.1 Quality tools application in the food industry

Quality tools	Practice	Usefulness	Gap	p-Val
Basic quality tools				
Checksheets	4.528	4.306	0.222	0.539
Pareto analysis	4.286	4.524	0.238	0.170
Customer complaints analysis	4.250	3.861	0.389	0.101
Brainstorming	4.313	4.063	0.250	0.141
Pie/bar chart	4.172	3.966	0.206	0.801
CEA/Ishikawa/fishbone diagram	4.115	4.423	0.308	0.101
Histograms	3.708	3.667	0.041	0.800
Arrow diagram/critical path analysis	3.640	3.680	0.040	0.230
Force field analysis	3.000	3.933	0.933	0.038*
Box plots	2.450	2.750	0.300	0.309
Run chart	3.792	3.708	0.084	0.543
Single minute exchange of dies (SMED)	3.429	3.952	0.523	0.023*
Matrix diagrams	3.389	3.444	0.055	0.693
Matrix data methods	3.385	3.462	0.077	0.206

Value stream mapping (VSM)	3.250	3.667	0.417	0.008*
Time series plot	3.095	2.905	0.190	0.825
Scatter diagrams	3.091	3.364	0.273	0.116
Affinity diagram	3.000	3.438	0.438	0.083
Systematic diagram/tree diagrams	2.955	3.045	0.090	0.229
Relation diagram	2.222	2.556	0.334	0.120
Stem and leaf plots	1.643	1.929	0.286	0.056
Advanced quality tools				
Benchmarking	3.763	4.053	0.280	0.400
Cost of quality	3.400	4.083	0.683	0.105
FMEA	3.160	3.520	0.360	0.136
QFD	3.00	3.087	0.087	0.700
Poke-Yoke	2.950	3.292	0.342	0.059
DOE	2.833	4.187	1.354	0.010*
Taguchi method	2.200	3.700	1.500	0.032*

*$p<0.05$ result significant at 95% confidence level

Based on the results above, checksheet is found to be the most common quality tool applied in the food industry. This is because a checksheet is viewed as the simplest tool, as there is no heavy calculation required in its application and thus it attracts employees who may lack statistical skills, which is especially true in this particular sector (Dora et al., 2013a). It is used in the inspection of the raw materials and the quality of the end product, and for monitoring critical parameters in the HACCP programme (Dalgiç et al., 2011, Srikaeo and Hourigan, 2002). The results also revealed that Pareto analysis is viewed as the most useful basic quality tool in the food industry. The respondents also suggest the use of basic statistical measurements (e.g., standard deviations and means) to monitor process performance in the food industry. However, the researcher argues that such practice inefficient in measuring the true process performance, e.g., in the stability and capability process. It was observed that there are gaps in terms of the degree of practice and the 'usefulness' of the tools, which in turn leads to the hypothesis below (H_3):

H_3*: There are significant differences between the degree of basic quality tools/techniques applications are used and their usefulness in an FMC.*

The paired t-test analysis indicated that the mean differences in the degree of 'practice' and the 'usefulness' of quality tools were statistically significant for forced field analysis, Single Minute Exchange of Dies (SMED) and Value Stream Mapping (VSM). This implies that, although such tools were found to be useful, the degree of their application was still relatively poor. In the food industry, checksheet is typically applied to calculate the number of product defects and faults in a process. The researcher argues that such practice is incapable of capturing the stability and capability of the process correctly, which in turn epitomises current practice ineffectiveness in assessing process performance.

Respondents (SPC companies) were asked to assess the SPC charts that have been applied in the company in terms of the frequency of their implementation, or ‘practice’ (1=Never implement to 5=Frequently implemented), and ‘usefulness’ (1=Not useful at all to 5=Extremely useful) and the results were analysed as in Table 5.2.

Table 5.2 Application of SPC charts

SPC charts	Practice	Usefulness	Gap	Asym. Sig. (2-tailed)
$\overline{x}$-R chart	3.916	4.600	0.683	0.012*
$\overline{x}$-S chart	3.850	4.900	1.050	0.001*
p-chart	3.500	4.188	0.688	0.021*
np-chart	3.476	4.350	0.874	0.001*
c-chart	3.588	4.315	0.728	0.001*
u-chart	2.377	3.077	0.700	0.030*
CUSUM chart	2.455	2.800	0.345	0.096
Moving Averages chart	3.824	4.625	0.801	0.004*
Multivariate charts	2.286	3.800	1.514	0.019*
EWMA chart	2.667	3.727	1.061	0.018*
Individual-Moving Range(x-MR/I-MR) chart	3.00	3.778	0.778	0.157

*p<0.05; result is significant at 95% confidence level

Based on the results in Table 5.2, both the $\bar{x}$-R chart and the $\bar{x}$-S chart were rated as the most frequently used control charts. Although there were gaps between practice and usefulness, both charts consistently topped the mean score value, which led to the next hypothesis.

H_5*: There are significant differences between the frequency of how frequent SPC charts are practiced and their usefulness in an FMC.*

Paired Wilcoxon Signed-Rank test was carried out to assess the significance of the gaps between the "practice" and perceived "usefulness" mean scores for SPC charts. The results show that, although there are differences between the practice and usefulness of all the control charts, only I-MR and CUSUM charts are reported to be not statistically significant, as the p-values = 0.096 and 0.157> 0.05.

5.2.2 CSF of SPC implementation

SPC users were asked to rate the "importance" and "practice" of CSFs of SPC implementation according to their experience in implementing SPC, from 1=Not important at all to 5=Strongly important, and its actual 'practice' (1=Never implemented to 5=Frequently implemented). These results are depicted in Table 5.3.

Table 5.3 Critical Success Factors

Factors	Important	Practice	Gap	Sig
Top management commitment	4.461538	4.038462	0.423076	0.078
Reliable measurement system	4.269231	3.629630	0.639601	0.034*
Understanding of statistical thinking	4.198461	3.621538	0.576923	0.017*
Leadership	4.192308	3.884615	0.307692	0.084
Continuous training sessions	4.098462	3.384615	0.713847	0.010*
Empowerment	4.076923	3.653846	0.423077	0.098
Availability of SPC expertise	4.153846	3.230769	0.923077	0.004*
Prioritisation of process	3.100001	3.869232	0.769231	0.458

Project management	3	3.769231	0.769231	0.249

*p<0.05, result significant at a 95% confidence level

Top management commitment was determined as the most important factor among the CSFs for SPC implementation, while project management received the lowest mean value of importance. This result is consistent with the SPC literature, where top management is often viewed as the most critical factor (Scott et al., 2009, Grigg, 1998, Lim et al., 2014). Table 5.3 shows that there are gaps between the 'importance' of the factors and the degree of implementation (practice), where 'importance' was found to have a higher mean score for every CSFs listed. Further analysis on the gaps is placed into the following hypothesis (H_6).

H_6*: There are significant differences between the perceived importance of CFSs and the degree of how much CSFs were practiced in an FMC.*

The results for the paired Wilcoxon Signed Rank test, to address hypothesis H_6, are shown in Table 5.3. It was determined that the differences between importance of the factor and how much they were practiced statistically significant for three factors (e.g. a sound measurement system, continuous training sessions, the availability of SPC expertise and statistical thinking).

5.2.3 Common barriers of SPC implementation

The respondents were asked to rate the most fundamental barriers of SPC implementation in the food industry, with scores rated from 1=Strongly disagree to 5=Strongly agree. The challenges in Table 5.4 were developed based on the literature and the answers of the pilot study (open-ended questions).

Table 5.4 Barriers in implementing SPC

Barriers	Mean
Insufficient training sessions on SPC implementation	4.33
Employees lack awareness of SPC and its benefits	4.30
Lack of top management support	3.11
Poor measurement system	3.11

Lack of a data collection system	3.11
Lack of experience in quality improvement tools/techniques/methods	3.07
Lack of knowledge for SPC implementation	3.04
Lack of ability to apply SPC in the real world	3.00
Lack of systematic and practical guidelines for SPC implementation	3.00
Resistance to accepting SPC as a process improvement technique	2.89
Lack of employee empowerment	2.85

Insufficient training sessions in SPC implementation is found to be the greatest challenge faced by the food companies in implementing SPC, followed by a lack of top management support, a poor measurement system and lack of a data collection system. The result indicates that the lacking awareness of CI techniques and poor statistical knowledge are major issues in this sector.

5.2.4 The reasons for the food companies not applying SPC

Based on the systematic literature review conducted in a previous study, it was concluded that SPC application in the food industry is minimal (Lim et al., 2014); therefore, it is crucial to understand the reasons for not implementing SPC as a process improvement technique as depicted in Table 5.5.

Table 5.5 Reasons for not implementing SPC

Factors	**Mean**
Not aware of the benefits of its application	4.30
Inadequate statistical knowledge to apply SPC	3.66
SPC is too advanced a quality improvement technique to be applied	3.34
Lack of understanding of the concepts of SPC	3.38
Lack of financial resources	3.28
Insufficient time	3.17
Top management does not support its implementation	2.41

From the results depicted in Table 5.5, the most prevalent reasons for not applying SPC were that most food companies were ‘not aware of the benefits of its applications’ and had a ‘lack of statistical knowledge to apply SPC’. This result certified (Mason et al.,

1994) argument that there is a need for the involvement of employees to intervene in maintaining consistency in production and wastage; hence, the knowledge required to fulfil such a purpose should be provided. Consequently, such reasons could be reduced by providing training to the employees on SPC and how its application is advantageous not only to the company, but to employees. The SPC system and its theoretical background can be daunting to those without sufficient training, and this can cause resistance to its application (Grigg, 1998, Grigg et al., 1998). Davis and Ryan (2005) stated that the qualifications of employees are low throughout the industry, a notion proved by the lack of awareness of SPC and its benefits, as depicted in this survey.

5.2.5 Process performance measurement

The respondents were asked to choose the metrics used to assess the process performance. This question was accompanied by a multiple-choice selection of answers, from which the respondents were asked to choose performance variables relevant to the company. There is a dearth of publications addressing the performance metrics reflected in the success of SPC implementation. Therefore, the performance variables listed in Table 6 were built based on the literature in CI related to SPC (e.g., Six Sigma, TQM) (Jeyaraman and Teo, 2010, Neely et al., 2005). This survey was intended to differentiate the performance advantages between SPC companies and non-SPC companies. The respondents were also required to rate the process improvement level achieved by their company in Table 5.6, by using a Likert scale (1=Very poor, 2=Poor, 3=Fair, 4=Good, 5= Excellent).

Table 5.6 Process Performance

Process performance measurement	SPC companies	Non-SPC companies	Mann-Whitney U test (Asymp. Sig)
Waste reduction (Over-fill/giveaway/under-fill)	4.64	3.32	0.000*
Product consistency	4.32	3.67	0.004*
Customer complaints reduction	4.24	3.48	0.000*
Competitive advantage	4.14	3.79	0.273
Defects percentages reduction	4.12	3.18	0.001*

Productivity improvement	4.09	3.43	0.002*
Rework percentages	4.08	3.20	0.002*
Company image	4.06	3.92	0.276
Quality awareness	4.05	3.53	0.044*
Customer loyalty	3.94	3.90	0.975
Process cycle time	3.95	3.51	0.052
Cost of quality	3.90	3.36	0.054
Customer satisfaction	3.52	3.34	0.180
Pp/Ppk*	4.27		
Cp/Cpk*	4.17		

*Cpk/Cpk and Pp/Ppk not relevant to non-SPC companies

This result reveals that the performance metrics commonly used in the food companies were customer satisfaction (64.41%) and customer complaints (62.71%). Most respondents agreed that waste reduction is the greatest advantage gained from SPC implementation, followed by improvements in product consistency. ‘Under-filling’ is a crucial issue in food products as it relates to consumer trust and breaching this measurement would lead to customer complaints and penalties for breaching food regulations (e.g., Food Safety Act 1990, Weight and Measures Act 1979). Hence, the most typical strategy for overcoming such a problem is by exceeding the target volume (over-filling), which leads to wasting raw materials.

Table 5.6 also demonstrates that SPC companies have better process performance scores for all performance metrics compared to the non-SPC companies. Therefore, this study carried out an assessment on the significance of the differences between SPC and non-SPC companies in this respect through Mann-Whitney U test. The hypothesis is as below.

H_7*: There are significant differences between SPC and non-SPC companies regarding key process performance indicators.*

The results show that there are significant differences between SPC and non-SPC companies in relation to waste, product consistency, customer complaints, defect rates, productivity, rework percentages and quality awareness. Based on cognitive mapping, introduced by Grigg (1999), these chains of benefits are rooted in reducing variations in key processes through a statistical process monitoring and quality improvement program. Furthermore, the use of such a process control system allows the opportunity to improve awareness of quality aspects within processes, instead of focusing on product quality only. Table 5.6 also shows gap analyses were not carried out for any process capability index (C*p*, C*pk*, P*p*, P*pk*); the pre-requisite to carry out process capability analysis is that the process must be statistically stable (Brannstrom-Stenberg, 1999, Castagliola, 2007, Ittner and Larcker, 1997, Montgomery, 2012).

5.3 Key findings from the multiple-case studies

The multiple-case studies consist of four SPC companies and four non-SPC companies. Their details are shown in Table 5.7.

Table 5.7 Characteristics of the case companies

Company/ commodity/ number of employees	Case study details
A **Confectionery** **1500**	• Start SPC 2001 • Critical key processes • Applied at the production line • Visible to all employees • The target of zero-waste by the year 2018saves approximately £120,000 per year in landfill tax in achieving the efforts
B **Spices** **230**	• Start SPC 2005 with target to reduce rework and waste percentages • Applied at packaging to comply with food law and regulations and to improve customer satisfaction • QM leads the implementation and plans the corrective action
C	• Start SPC 2010

Poultry 278	• External SPC leads the implementation • Lack of leadership and insufficient allocated time for SPC activities inhibit its progress due to the non-existence of an SPC leader
D **Poultry 695**	• Start SPC 2013 • Control chart applied at the packed meat weight checker to prevent product giveaway/underweight, and to detect the meat fat • There is no leader assigned to manage SPC implementation, which then causes slow progress of SPC
E **Seafood** **288**	• Basic quality tools (e.g.checksheet) are used for quality purposes. • The employees are unaware of advanced quality techniques • The customers use the company's quality control data sheet to compare to specification limits
F **Seafood** **224**	• In 2014, a few basic lean tools were applied • Invested in in-house training for quality improvement • Inspection has been carried out to ensure the weight of packaging is correct before the products are sent to the customers • Checksheet is applied to monitor the quality of the product • The quality criteria relate to organoleptic characteristics such as raw texture, taste and visual appearance
G **Bakery** **products** **242**	• The vision is to create quality and convenient solutions that make food more enjoyable and life easier • The level of automation in production has increased and some low-margin products, such as Scottish rolls, were delisted from the production in 2012

H **Bakery 1129**	• 2012 initiate Lean implementation (e.g., 5s) • Quality improvement techniques was hardly promoted • In 2007, £3 million was invested to expand and improve the plant facilities to increase productivity • In 2013, the Lemon Cake was delisted due to the failure of the company to follow the customers' requirements.

5.3.1 Quality improvement efforts

Quality initiatives in the food companies were assessed in terms of quality certification and the implementation of quality management techniques, methodology and philosophy (Dora et al., 2015). Particular attention was brought on quality certifications as it emerged in this study that, certifications is considered quality improvement effort by the food industry, although it is unlikely to happen most of the time. The researcher argues that certifications provide quality improvement activities in a checklist manner, which hardly promote a continuous quality improvement. The summary of quality initiatives in the case companies is depicted in the Table5.8.

Table 5.8 Quality initiatives

Company	Certification	Quality initiatives	Product quality criteria	Process performance measurement
A	BRC, ISO 9001:2008, ISO 17025, ISO 14001, ISO 22000	Lean, Six Sigma,	Weight, taste, colour, shelf-life	P*p*, P*pk*, *Yield, (defects per million opportunities) DPMO*
B	BRC, ISO 9001:2008, HACCP	Lean, SPC and basic quality tools, quality circles	pH, weight, size	Waste percentage of yield
C	ISO 9001:2008,	Quality circles, SPC, basic	Microbiology count, colour,	Yield, waste percentage

	HACCP	quality tools	chicken net weight, temperature, moisture	
D	BRC, EFSIS, FDA, MSC	Lean, SPC, basic quality tools	Weight, colour, packaging	Yield, Cp, defects of percentage
E	BRC	Basic quality tools	Weight, colour, texture, shelf-life, microbiology count	Yield, waste percentage
F	BRC, EFSIS, ISO 9001:2008	VSM, basic quality tools	Weight, microbiology count	Yield, waste percentage
G	ISO 9001:2008, BRC, EFSIS	Basic quality tools	Colour, taste, weight, texture	Yield, waste percentage, defects percentage
H	BRC, ISO 9001:2008, ISO 14001	5S, basic quality tools	Weight, height, colour, texture and packaging, viscosity, microbiology count	Waste percentage, yield, defects percentage, Cp

One of the most troubling issues emerged from the case studies is the managers variously perceived quality as product-oriented, process-oriented or user-oriented, though it was most commonly defined in terms of food safety (Grunert, 2005). Thus, quality practices in the food industry mainly revolve around certification and efforts to comply with national and international food safety regulations (e.g. BRC and HACCP). Such certifications only affected the uptake of basic quality tools, not the advanced quality tools (Grigg and Walls, 2007a).

The over-emphasis on food safety as the prime criterion for food quality has led to other aspects of food quality, such as process variations and product consistency, being given a lower priority. The amount of required labour often forces managers to choose between food safety assurance and other quality improvement initiatives (Manning and Baines, 2004).

Another critical issue is that inspection was heavily relied as a quality control tool. It is arguable that inspection is a quality improvement activity as there is not further feedback action contributing towards process improvement through its application (Gordon et al., 1994, Schippers, 1998, Deming, 1986, Parkhideh and Parkhideh, 1998).

Among those case companies that do operate SPC, understanding of its technical aspects is limited. For example, two of the companies monitor their processes using specification limits in the control charts. However, specification limits are the upper and lower limits set by customers; the control charts should actually be using the control limit (voice of the process) to assess the process performance (Montgomery, 2012). Those managers who acknowledged this malpractice explained that as their current process is unable to meet customers' specifications, it was decided to take a gradual approach and work towards achieving the customer specifications and then the control limits. However, achieving 'process in control' through specification limits, it does not infer process stability; nor does it allow process capability to be assessed, which defies the primary purpose of SPC.

5.3.2 Common barriers of SPC implementation in the food industry

Most barriers for SPC implementation determined in this study were congruent with those in the previous SPC literature although, by comparison, top management commitment issues, lack of knowledge and lack of training were accentuated in this industry, which this is clearly depicted similar to the results in survey.

SPC was viewed as an additional burden to the daily job of staff members. In Company A, initially, SPC implementation involves much effort and is time-consuming. It is due to the additional work such as data computation, plotting, checking against the out-of-control condition. All case companies stated that the food industry has a high employee turnover, a consequence of which is that the management has to re-invest in training other employees to fill the void of departed staff. Training required costly investment from the company (Luning and Marcelis, 2007). Company A employed SPC experts (Six Sigma Champion and Black belt) under the deployment of

Six Sigma to introduce SPC and to develop an in-house training system. Company B reported CI efforts sometimes have to be put on hold when new priorities emerge or resources run out.

The results support the argument that the food industry is a conservative industry in terms of adopting new technology due to resistance to change (Surak, 1999a). Companies C and Company D reported that employees perceived the changes in practice as burdensome, while some saw the ability of SPC to reduce inspection activities as a threat to their job. Company E explained that employees typically resist using new techniques over those to which they are accustomed:

“Many of the employees understand and comfortable with inspection being a quality control approach for more than ten years; hence, it is not easy to convince them to change to a new approach”- Quality director, Company E.

The non-SPC companies were identified as having poor awareness of their current measurement systems, and most of their data were collected based on quality parameters set by customer requirements. SPC relies on data, and these data must have minimal variability if false alarms are to be avoided and out-of-control points detected (Grigg and Walls, 2007a, Doganaksoy and Hahn, 2014, Montgomery, 2012). As the case companies struggle to provide quality data, it is also argued that they are not ready to implement SPC as a quality control technique in their company (Rungasamy et al., 2002, Montgomery, 2012, Srikaeo et al., 2005, Antony, 2000, Lim et al., 2014).

"Based on the employees' awareness and knowledge of quality culture and measurement systems, we are not ready for SPC. SPC is too advanced to be applied by the company in its current state. We believe that in five years’ time, we will probably be able to embrace the application of SPC in our processes" Manufacture Director Company G.

The case evidence also shows that food companies (mostly non-SPC companies) refused to invest in training their employees on quality improvement techniques. Table 5.9 depicts the listed barriers from the interview.

Table 5.9 Summary of SPC implementation barriers

Barriers	A	B	C	D
Lack of top management commitment		X		X
Lack of communication between departments	X	X		
Lack of training in SPC and quality improvement techniques	X	X	X	X
Lack of time allocated for SPC implementation			X	X
Lack of knowledge in statistics		X	X	X
Lack of manpower		X	X	
Lack of employee empowerment		X		
Lack of understanding the underlying philosophy of SPC			X	
High employees turnover	X	X	X	X
Lack of SPC awareness		X	X	X
Employees resistance to change	X	X		X
Poor measurement system		X		X

5.3.3 CSF of SPC implementation in the food industry

The idea of determining a set of CSFs for managers to prioritise was introduced by Rockart (1979). CSFs are defined as the limited number of areas that are suggested to result in improved competitive performance, if they are satisfactorily implemented(Rockart, 1979). The result in survey is similar with the result found in this chapter except that SPC leader is observed to be the emerging CSF in this industry. Further explanation on the factors found in previous chapter and this chapter is as below:

5.3.3.1 Top management support and commitment

Both MDs in Companies A and Company B claimed that SPC application tends to fail because the top management fail to support and commit to SPC adoption. The level of support by top management differs for each SPC company. Because the top management in Company A is convinced with the advantage of SPC, resources, time and training were made available. The commitment of top management in Company C was exemplary where the employees were encouraged to involve themselves in CI activities. Annually, the top management supplies resources to the selected CI project proposal. The result shows that, for most companies, the top managers delegated management of the SPC implementation process to the middle managers, limiting their (top management) involvement in assessing the progress of SPC projects. Although top management in Company D supports the idea of SPC adoption, they failed to commit to its implementation (i.e., top management did not assess the SPC progress and its impact toward operation performance).

5.3.3.2 The SPC leader

The interviews revealed that the SPC leader is responsible for implementing and sustaining SPC in the company. This SPC leader is given the authority to make SPC implementation related decisions and must, according to the quality manager from Company B, be diligent, enthusiastic and passionate about SPC implementation. The MD in Company A comments the consequence choosing wrong SPC leader.

"The SPC leader in our company initially was forced to lead the implementation. There is slim chance for the employees to be motivated if the SPC leader doubted this technique and its potential benefits"-MD, Company A

In Company A, the leader of Six Sigma project is also responsible for SPC implementation. In Company C, the SPC leader was provided with training in SPC, quality tools, leadership and project management skills. Company C explained that when SPC was introduced, an SPC leader was not formally appointed; rather, it was assumed by employees that the Quality Control Department was responsible for any quality improvement efforts. The case evidence shows that the lack of leadership of the SPC project caused the implementation progressed slowly. The SPC leader’s job is to plan the SPC adoption, solicit the support and the resources which they need to implement SPC. Quality manager in Company B, Company C and Company D, suggested that it is not necessary that the SPC leader is chosen from top management, but the support of senior management is nevertheless crucial for the success of its implementation and its sustainability in the company.

5.3.3.3 Training programme

This study shows that there is a lack of training opportunities on quality improvement techniques, where most of the case companies only provide training alongside employees' job training. Company A began SPC adoption by providing training to a few quality managers, who were then instructed to manage SPC implementation; initially, this involved bringing external consultants to train employees, while later, this was enforced by the Six Sigma Black Belt in the company.

In Company B, training was given across the company, including on leadership, project management, food quality and safety. The headquarters consultant conducts the training sessions, because it is a key criterion in their performance assessment. Company C brought in an external consultant to provide initial training to shop-floor employees. They then faced difficulty in obtaining further guidance for implementing SPC after the training sessions ended. The training programme in Company D offered food quality and safety aspects updates and information to the selected employees in the quality department. By contrast, Company E and Company F did not provide training on quality tools and techniques to their employees, so their awareness of these tools is very limited. Company E assumed the training for HACCP is sufficient for quality improvement.

"At the moment, we don't feel the need to provide training on quality tools to the employees; food safety aspect is much more critical" Company F.

Company G and H, meanwhile; use external training to managers and CI team members in quality improvement techniques, such as Design of Experiment (DOE).

5.3.3.4 Team development

Given the complexity of food quality management, food companies are generally advised to set up an SPC quality team consisting of employees from several related departments (Paiva, 2013, Luning and Marcelis, 2007, Pereira and Aspinwall, 1991). The result shows that the SPC team was built in the early stage of implementations; however, in the food industry, the team was not necessarily only responsible for SPC. For example, while Company A appointed several teams engaged in quality improvement activities (includes SPC implementation), Companies B, C and D appointed teams on a project-by-project basis, although this may jeopardise its sustainability. Company A's quality programme involved employees at all levels — from senior management to the shopfloor, where each level accounted for a specific task to drive the SPC implementation. Most of the case companies developed an HACCP team under their company's food safety management, and members of this team regularly involved in quality improvement projects. The interviews revealed that very few of the case companies have dedicated and multidisciplinary teams for quality improvement. However, teamwork is a big concern in Company B due to the lack of communication and trust issues as each department is competing with each other. Therefore, the reward system to recognise the best department annually has backfired and resulted in the poor work culture. Company C faced difficulties to develop a team as they were short of skilled and knowledgeable employees to carry out quality improvement projects. Table 5.10 depicted the type of SPC team and other related team for quality in the company and their training programme.

Table 5.10 CI team configuration and training in the case companies

Com-pany	**SPC team**			**Training**
	Current team	Personnel	Leader	Quality-oriented training
A	Operational Master Plan (Top management) Management team, Shop-floor team	Production engineers, quality control representatives Top management	Six Sigma Black Belt	Hands-on training Max. 3 hours per session Modules: quality tools, leadership, SPC External and internal trainer (e.g., Six Sigma Black Belt)
B	n/a	Production engineers, quality control and assurance representatives Research and Development	Quality manager	Leadership training, project management, food quality and safety control, food handling, corrective action Provided by General

		Department representative, Marketing Department representative		Affairs Department
C	Problem-solving team -almost every department has its own team	SPC Expertise Voluntary	Quality manager	Start with awareness training Annual training SPC, quality tools, lean manufacturing Managers and problem-solving team members Trainers are external consultants Leadership and project management skills
D	CI team	Quality Department staff	Quality manager	Training in food safety to all employees Training in quality improvement
E	n/a	Quality Department staff	Quality manager	Training in food safety to the production and quality employees
F	n/a	Quality control and quality assurance managers Selected line supervisors	Quality Manager	Training in food safety aspects

G	CI team	Six Sigma Black Belt, Green Belt, Lean manager, Production manager, CI manager and CI team members	Six Sigma Black Belt	Training in lean tools application
H	CI team	CI team members, Technical Department representative, Quality Department representative	CI Manager	Training in quality tools and techniques Training in food safety to all employees

5.3.4 The reasons for the food companies not applying SPC

One of the most understudied topics in the literature of SPC is the reason for not implementing the technique. Such information is valuable for the academics and managers understand the real reason for the lack of implementation of SPC in this sector. The non-SPC companies claimed that the most common reason for not implementing SPC was lack of awareness of its advantages (the interviewees from Company E and F were not even aware of SPC's existence). Many viewed SPC as too advanced and impractical for application in the food manufacturing industry. Deterred by the need for statistical knowledge, they preferred inspection (the traditional approach) and simpler techniques for quality control purposes. Hence, Companies F, G and H prefer to apply Lean, which they see as a simpler, more straightforward CI programme, and Company E claimed that their current process performance is satisfactory, implying that there is no urgent need for the implementation of SPC.

Moreover, most of non-SPC companies argued that they are not ready to commit to SPC implementation. This study shows that it was due to the complexity of the technique, lack of sense of urgency and the shortage of employees with sufficient skills. However, none of these companies objectively measuredtheir readiness, which may cause their aforementioned claimed on their SPC readiness, is debatable. The quality manager in Company A, C and F strongly suggests that it is important to understand the factors that imply preparedness of a company to commit to SPC before investing in the adoption of the technique.

5.3.5 Process performance measurement

In SPC implementation, the main objective is to control the stability of the process, rather than the quality of the product. Measuring process performance is therefore crucial to the company's ability to learn and improve their processes. It is evident that the SPC companies are using process performance index reflecting to the voice of process compared to the non-SPC companies. For instance, Companies A, B, D, H use process capability indexes (Cp, P*p*, P*pk*). However, when asked to describe how their company measures process performance, the interviewees from Companies C and D explained that they use specification limits provided by customers to monitor processes through SPC charts. The usage of specification limits is for measuring process capability, however process stability monitoring requires control limits (Montgomery, 2012).

All the companies' measured waste, scrap and productivity (variously called yield or throughput),but, the productivity is calculated differently in each company: either by (1) taking the total number of good products; or (2) integrating other factors such as reworks, energy and raw material. Theoretically, productivity has been classified to total factor productivity, partial factor productivity and multifactor productivity which each involved different factors for the calculation. However, the case companies do not specify type of their productivity and it can be interpreted in different ways can cause confusion and lead to misinformation within the companies.

5.4.6 Type of learning in SPC implementation

Although there are several ways to define OL found in the literature, the centre of the definitions is that it is a change in knowledge as the organisation acquired the experiences. The question is what type of learning occurred, especially in this case, the experience in implementing SPC? Identifying the type of learning occurred in the SPC activities will magnify the importance of such activities to be implemented in order to harvest valuable knowledge and subsequently facilitate the sustainability of process improvement activities (Locke and Jain, 1995, Savolainen and Haikonen, 2007). Company B and C claimed that process control activists provide them important information that enable them to control their processes. However, Company A, C and D claimed that such learning activities do not contribute to radical changes in an organisation.

"The learning process in the activities related to the controlling the quality of the process, especially if it is due to special cause, will not change the way the production was run or any organisational policy related to the process...however it did contribute to process improvement, which is also a great output." Quality Director, Company C.

However, several types of activities, which associate to the SPC implementation, were reported to create a potential to experience second-loop learning. Company C explained how measurement system analysis (MSA) enables the changes in their business.

"After several times that MSA were carried out in the company, the management has realised how bad the quality of their data for all is time and realised the quality of the data is important...statistical thinking was introduced within the CI activities. The management urged the employees to improve their data collection practices, which now any new employees were required to be trained for the data collection purposes, and standard procedure for data collection at each station was documented and make it visible to the employees. Such changes will not occur if there is no assessment of the measurement practices."- Quality manager, Company C

Company B explained, the most radical type of learning in SPC implementation will occur when the out-of-control situation leading to the need to reassess the company's system, policy or regulations in order to gain the process stability.

Several of the case companies (e.g. Company E and F) commonly weighed the samples of their product to assess the average and variation of net weights for the particular batch of product. However, this measurement fails to specify a significant problem in the process; the data were stored for the purpose of inspection. The stored data were not assessed nor used to improve the process trend or its inherent capability. Companies G and H explained their companies have been facing problem in the production where waste due to inconsistencies of the-the process. They have tried to try and error for almost a year and six months, however, there is no progressed, and valuable information is not systematically stored that cause the never-ending experimentation with no results — portrayed classic example of zero learning, when there opportunity for single-loop learning if the data is managed, analysed, discuss and action is carried out.

5.4 Discussion on the findings

The objective of this study was to explore SPC's application in the UK food industry and identify the issues relevant to its implementation, such as CSFs, the SPC leader, applied basic and advanced quality tools, various types of SPC charts, challenges, reasons for not adopting SPC and the impact of SPC on process performance measurement. Instead of drawing a general conclusion, this study was intended to form the basis for future research on SPC implementation in the food industry. However, prevalent trends can be extrapolated from the cross-analysis based on the SPC implementation themes:

- Effects of the organisation's characteristics on the adoption of SPC
- Basic quality tools were preferred compared to the advanced quality tools
- People's focus as the main ingredient for the success of SPC implementation;
- Sufficient training sessions reduce the barriers for SPC implementation and reasons for not implementing the technique.
- Key ingredients of SPC implementation
- SPC encourages learning from experiences

5.4.1 Effects of the organisation's characteristics on the adoption of SPC

Based on the responses to the survey, almost half of the food companies have applied SPC in their processes. This industry shows consistency with the results in other CI implementation studies, the application of SPC increases with the size of the company. It was determined from the literature on quality management in the food industry that the size of company influences the adoption of SPC, possibly due to different levels of the quality maturity depicted by the respective size of the company. Furthermore, the prominent reason restricting small organisations from adopting SPC is lack of resources - particularly time, budget and personnel (Dora et al., 2013a). This lack of resources may force small food companies to prioritise their quality techniques, thus resulting in more food safety activities being practiced instead of advanced process control techniques such as SPC, due to their obligation to comply with food laws and regulations. HACCP is one of the major quality certifications used by the FMCs for the food safety purposes, however SPC, which operate almost in similar manner, is less likely to be applied in the food industry. This is also true for medium-sized food companies, although they are more flexible, compared to small and large companies, when it comes to adopting new techniques. Moreover, it was also observed in an empirical study that management teams in small companies do not have sufficient theoretical knowledge to recognise the potential of statistical techniques such as SPC (Deleryd et al., 1999).

From another point of view, it was also determined that the type of company (based on main products/commodities manufactured by the company) has a significant impact on the adoption of SPC. It is largely due to the different levels of complexity involved in manufacturing the respective type of products, the shelf-life of the product and the strictness of food law to a certain type of food commodities. For instance, fresh food products typically involve fewer processes, which give the impression to quality managers that such processes do not require advanced techniques for the design of operations centred on sanitation and food safety, and higher production speeds through automation and product traceability (Lamikanra, 2002).

The results demonstrate that the FMI is struggling to embrace practices related to statistical knowledge and engineering skills. The primary reasons regarding those issues are the lack of knowledge and understanding of SPC, and the fear of using statistics in the food industry (Hersleth and Bjerke, 2001, Lim et al., 2014). Food companies have always prioritised food safety, which means that the training sessions for quality improvement tools and techniques have been viewed as the least important avenue. In order to improve the practices of the aforementioned factors, sufficient training must be provided to technical managers and quality managers to create awareness of SPC's benefits, expected costs and critical principles (Grigg and Walls, 2007a). This will eventually lead to the company's commitment, with support of top management, to use SPC for process analysis, backed up by sufficient resources and training programmes.

5.4.2 The application of quality tools and SPC charts

Quality control (QC) is not an optional or extra activity in food manufacturing, and the quality tools are used not only for QC, but also for quality improvement initiatives (Dalgiç et al., 2011). It was observed that food companies commonly used checksheet, while Pareto analysis is found to be the most useful basic quality tools. Some of the respondents suggest basic statistics, such as the mean and standard deviations of a product's quality characteristics (e.g., height, weight) used for process performance by comparing such data with the specification limits set by customers. It was argued that such a practice is incapable of capturing the 'voice' of the process, and it has been proved that this practice incapable in improving the process performance and, subsequently, the quality of products (Montgomery, 2012).

The survey shows that food companies preferred to apply simpler quality tools, although they were aware of other effective and powerful techniques available for similar purposes. For instance, for new product development (NPD) and problem-solving activities, trials/experiments were typically carried out through the application of the one-factor-at-a-time (OFAT) approach, which is similar to the hit-or-miss approach. Compared to OFAT, the DOE and the Taguchi method require a higher level of statistical knowledge to be able to design and interpret results from trials. However, unlike OFAT, DOE allow less number of trials, minimised use of resources (time, energy and raw materials), improved understanding on the interactions between factors and effective estimation of optimal settings (Czitrom, 1999, Montgomery et al., 2000). Hence, although OFAT is not economical and is clearly far ineffective compared to DOE, the food industry is known to be more receptive to straightforward approaches, which involving less mathematical jargon (Dora et al., 2013a).

However, for SPC companies, it was observed that both Shewhart's $\overline{x}$-R chart and $\overline{x}$-S chart have been mostly applied in the food industry, albeit without sufficient understanding of the technical aspects of these control charts (e.g., assumptions of the charts, sampling plan and appropriate type of control chart) (Grigg, 1998). This would lead to the wrong selection of control charts and incorrect sampling plans, which would subsequently affect the effectiveness of the charts. In typical SPC training sessions, most trainers introduce both of these charts as the simplest and most basic control options (Hewson et al., 1997). Hence, employees may not familiar with other different types of control chart, due to the abnormality of data, batch processes and short production runs in the food industry.

5.4.3 People's focus as the drive for the success of SPC implementation

The common ground among all SPC companies was their efforts on educating people on the idea of *statistical thinking* and the adoption of SPC. SPC implementation is viewed as a sociotechnical phenomenon (Rungtusanatham, 2000). People's focus consist of employee empowerment, training sessions and teamwork, all of which are considered important in the SPC programme (Oakland and Tanner, 2007).

The survey identified the most common barriers, namely lack of employees training. According to Cheng and Dawson (1998) and Davis and Ryan (2005), prominent barriers to provide training sessions are 'lack of provided time' and 'lack of financial resources', which usually due to the lack of top management support. It is argued that insufficient training leads to other inhibiting factors, as depicted in the survey results, such as the lack of awareness and knowledge of this technique, and the resistance of employees to its adoption.

Top management support in SPC implementation is viewed as the action performed and policies instituted by the top managerial personnel to support and drive the implementation of SPC in the company (Rungtusanatham et al., 1999). However, it is their degree of understanding and appreciation of SPC that might have a bearing on the amount of time and involvement that they are personally prepared to dedicate to it. Realistically, previous studies suggest that SPC was implemented from bottom to top, where the technique were implemented without top management support at the initial stage . However, it was observed that there is a need for it to be led and supported from the top, not only for its successful company-wide deployment, but to sustain the application within the company (Hubbard, 2003).

The new emerging barrier factor identified in the multiple-case studies is high employees' turnover in food companies, where it caused difficulties in maintaining trained employees to sustain its implementation. Including 'knowledge in quality improvement technique' as one of the criteria for employment may facilitate such issue(Lim et al., 2014). This is a contextual factor as regardless of SPC or non-SPC companies, all of case companies reported similar situation.

This study identified that, although the lack of training and knowledge in SPC are the most common barriers for implementing SPC in the food industry, the lack of commitment from top management is the root cause of other barriers. Until it becomes apparent to all employees that the application of SPC is important to top management, it may be challenging to achieve a co-ordinated effort (Rungtusanatham, 2001). Any changes will invariably meet with a certain amount of resistance. However, SPC philosophy suggests that without employees' acceptance and involvement, quality improvement efforts are bound to fail (Deming, 1986, Kitapci and Sezen, 2007). Over-burdened workers and time-consuming labour caused employee resistance towards SPC implementation. Therefore, the application of online-SPC has been seen as being able to overcome such issues, that way, most of the data collection, calculation and interpretation can be carried out automatically by SPC software (Dogdu and Santos, 1998).

Agreeing withEckes (2002), the results shows that blame cultures and lack of communication caused employees resistance against implementation. In reducing the communication gaps, most of SPC companies organise short meetings involving managers and shopfloor employees, just before the production starts and at the end of the production and this consistent with conclusion in Dora et al. (2015). The production department in most large SPC companies was restructured into a work team, which helps to build an improvement culture through teamwork, with the appointment of an SPC leader. Furthermore, compared to non-SPC companies, most of SPC companies empowered their employees to conduct their job and enable speedier actions to be carried out. Meanwhile, it was prevalent, 'firefighting' dominant the non-SPC companies problem-solving approach as they tend to fix isolated problems instead of looking the at the problem holistically. This reflected more to cultural problems in the company and is, such the responsibility of top management (Hersleth and Bjerke, 2001).

It was observed that the appointment of an SPC leader is an emerging CSF for SPC implementation in the food industry as this has not appeared in the previous literature. The SPC leader is responsible for motivating team members, reducing the blame cultures, assigning tasks, guiding employees to use the technique, securing sufficient resources and making sure the project is delivered within the expected timeline. Therefore, one can also view SPC leader as the change agent as discussed by Dora et al. (2015). Planning SPC training programme is one of the main tasks of the

SPC leader. Many food companies regarded training as critical for SPC implementation, as the lack of statistical knowledge is an alarming issue in the food industry, impacting on the adoption and progress of the implementation (Davis and Ryan, 2005, Grigg and Walls, 2007a).

Top management is strongly suggested to set realistic goals when deciding to introduce SPC(Ahire and O'shaughnessy, 1998),and it is equally crucial that this is communicated effectively to employees (Barker, 1990, Dale and Cooper, 1994, Ittner and Larcker, 1997, Does and Trip, 1997). The findings suggest that top management commitment is not limited to the provision of resources, but also involves the creation of a company culture that encourages effective continuous quality improvement efforts(Ahire and O'shaughnessy, 1998, Grigg and Walls, 2007a, Rungtusanatham et al., 1999).

As there is still confusion between top management and leadership roles, Kotter (2008a), differentiates between the two by explaining that management produces consistency, while leadership produces movement. Das et al. (2011)point out that there is often confusion about whether leadership in this context refers to the SPC team or the organisation as a whole. The study depicted that, in this context, the leadership should refer to the person who manages and lead the SPC implementation on an organisational level.

5.4.4 Sufficient training reduces the barriers for SPC implementation and reasons for not implementing the technique.

Based on the results, the major reason for food companies not implementing SPC is the lack of SPC awareness. The results highlight that FMI are struggling to practise activities related to statistical knowledge and engineering skills, although such activities (establishing a reliable measurement system and continuous training sessions) are perceived as critical in ensuring a successful SPC programme. Lack of awareness of any quality improvement technique or programme restrained its implementation, create misconceptions, doubts and negative impact on company’s competitive ability (Al-Turki and Andijani, 1997). This is not unusual among manufacturing companies, many of whom claim that SPC is not appropriate for their operations prefer inspection(Lockyer et al., 1984). In establishing SPC in the packaging operations, the DTI code of practice, or now known as BIS code of practice is one of the major sources of advice especially for sampling the data (Grigg, 1998). Although senior managers are aware that quality is vital for business survival, they are unable to figure out how to start. The literature suggests that one potential remedy to the implementation issue is to organise regular andhands-ontraining sessions for the employees (Al-Turki and Andijani, 1997, Kaspi et al., 1997).The case companies reported that food safety training was the most common training provided and training in quality was assumed less important. Compared to the SPC companies, non-SPC companies offered less opportunity training session for quality improvement techniques. These companies mostly define food quality as food safety due to their obligation to comply with food law and regulation. Therefore, training in quality improvement is considered less important compared to food safety training (Dora et al., 2013b, Lim et al., 2014). Instead, Surak et al. (1998) have urged the food companies to integrate SPC with the food safety efforts, which proven brings better result than SPC as a standalone technique.

5.4.5 Key ingredients of a successful SPC implementation

The identification of CSFs in the empirical studies has provided the information on key ingredients required to facilitate a successful SPC implementation in the food industry. Based on the thematic analysis of the interview, the key ingredients were categorised and later the results were validated by the interviewees. The key ingredients for SPC implementation in the food industry are depicted in Table 5.11.

Table 5.11 Key ingredients towards a successful SPC implementation

Top management commitment	Providing adequate resources to implement, investing in people and financial resources, assigned a higher priority to quality over cost or schedule, act as a mentor and critic, provide access to various arenas and technology, consider quality in employees’ performance and provide rewards and recognition to the deserving employees,
Training programme	Follow-up training, SPC facilitator, Hands-on approach, brief on the integration of HACCP and SPC
Statistical	Data collection and sampling plans, selection and

knowledge	interpretation of control charts, statistical stability and capability.
Engineering skills	Process prioritisation, measurement system analysis, identification of critical process parameters and activities taken for the out-of-control situations.
Teamwork skills	Establishment of SPC teams for planning and carrying OOC feedback activities, brainstorming for the decision making activities, companywide understanding of SPC, sharing assumptions,
Organisational culture	Employees understanding of statistical thinking, efforts and priorities the tasks and CI, employees empowerment and involvement in CI activities and communication and interdepartmental liaison roles, rewards and recognition.
SPC leader	Monitor the SPC project progress, ensure the sustainability of SPC implementation, passionate in implementing SPC, understand the underlying philosophy of SPC, and report to the top management of the SPC activities.

5.4.6 Impact of SPC on the process performance improvement

Up to this point, the study has identified the distinction between SPC success and also concluded that it is linked to process performance improvement. It is argued that the success of SPC implementation is crucial for its continuance (Rohani and Teng, 2007). Result shows SPC companies measured process performance on product quality and operational criteria, rather than on business performance criteria such as customer satisfaction and customer loyalty. The outcomes of this study accentuate the poor process performance measurement, especially the lack of process capability indices' application (e.g., Cp/Cpk and Pp/Ppk) as process performance measurement. The encouraging results obtained from the SPC users compared to non-SPC companies shows that SPC has an advantage in operational performance measures (e.g., waste reduction, defect rates, rework rates).

5.4.7 Types of organisational learning through SPC implementation

Under SPC, knowledge is created through explicit learning, which implies a formal improvement programme/approach. Increasing interest is being shown in the literature in how quality improvement can help organisations learn from their experience (Malik et al., 2012, Malik and Blumenfeld, 2012, Lee and Lee, 2014). According to OL theory, at a practical level, the ability to learn and adapt is critical to the performance and long-term success of organisations (Argote and Miron-Spektor, 2011, Linderman et al., 2010, Lee and Lee, 2014).However, based on current literature, there is still general constraint to confirm the relation between adoption of a learning culture under SPC and improvement of process performance(Wang and Ahmed, 2002). Types of learning are explained as below:

5.4.7.1 Zero learning

Zero learning is a conditioned response; it demand act in response to stimuli, but it does not make changes based on information (Bateson, 1972), which implies no changes in the group or organizational explicate order(Tsakanikos, 2006).

In the process management situation, zero learning occurred when problems arise within processes. However, no feedback action is taken to deal with the problem, and, therefore, no associated learning can result (Romme and Van Witteloostuijn, 1999). Such situation occurred due to the lack of systematic approach forproblem solving.Many cases like this depicted the failure of the companies to use the data from the process to the usable information or type of information that may not be acted upon in a fashion that promote process learning (Grigg and Walls, 2007b).

As expected, the non-SPC companies find it difficult to explain learning experience from their current approach in monitoring the quality of product — inspection. Company E, F and G agreed that the inspection only provide "defect/non-defect" information. There is no information on how the process performed. Company H agreed that it is challenging to carry out corrective action when there are defective products, as there is no information indicating the type of variations they are facing.

According to Grigg and Walls (2007b), for the process being labour intensive (e.g. craft bakeries, craft chocolates), quality of the products highly depends on the operator's skill, which therefore variability of end-product (output) does not necessarily illustrate quality issue. An obvious zero learning depicted in the situation whereby control charts are in practice being used solely for evidential purposes. Such type of control chart application was viewed as a bureaucratic and defensive practices in due diligence for keeping the record.

5.4.7.2 Single-loop learning

Applying Argyris and Schön (1978) definition of single-loop learning to the context of SPC, is described as the capability to detect and correct the out-of-control parts of a process within a given set of governing variables and then, if the corrective action does not work, to take an alternative feedback action. This type of learning is an improvement on zero learning because the learner can use the feedback from SPC to taketake corrective action(Argyris and Schon, 1974).

Employees follow the organisation's procedures and instructions without question and seek to control process performance within the context of these instructions. In this kind of problem solving, employees learn new skills incrementally by controlling the variables back to the in-control state "how" rather than "why" questions(Savolainen and Haikonen, 2007). SPC can be seen as a fitted type mechanism for single-loop learning at the operational level, which assists continuous improvement practices. In Companies E and F, employees are required simply to collect data on the quality characteristics that are demanded by customers (e.g. weight of the product) and to inform the quality supervisor if there is a quality issue. The Quality department team will then take over and solve the problem. Employees in food industry are trained specifically to perform their specific own job(Moy et al., 1994, Davis and Ryan, 2005); they have no understanding of the overall process and are not expected to assess process performance.

5.4.7.3 Second-loop learning

In second-loop learning, employees question why an output occurs (Marquardt, 1996) and select tools and techniques to respond accordingly. This kind of learning requires employees to understand the process, customer requirements, national and international regulations and procedures, and to be aware of what Argyris and Schön (1978) call the defensive routine.

Although it was observed that majority of current quality practices in the case studies reflected zero learning (e.g. inspection) and single-loop learning(e.g. application of basic charts for process performance), there are opportunities to carry out double-learning, especially when the application of process control pointing towards the need for the change of policies, system or manufacturing practices of the company.

Following the cross-case analysis this study listed the 'Do's and Don'ts' in Table 5.12. as a guide for the managers in the food industry to implement SPC.

Table 5.12 Do's and Don'ts in SPC implementation

Do's	Don'ts
Top management support and commit to SPC	Top management hand-over the SPC deployment effort fully to the managers.
Provide trainings in SPC and quality improvement techniques to the key employees.	Assume food safety training is sufficient for quality improvement purposes. Implement SPC without understand its underlying philosophy.
Appoint and announce SPC leader for the implementation	Assume SPC application can be continuously maintain without SPC leader.
Develop a multidisciplinary SPC team	Assume the quality department solely responsible for quality issues.
Assess the performance of measurement system	Assume machineries and measurement tools are always in good shape
Priorities the pilot project by select critical processes	Initiate SPC implementation at several processes at once
Empower the employees to carry out corrective action. Carry out short meetings (manager and shopfloor employees)-before and after production	Blame the employees Underestimate the criticality of employees' opinions and suggestions.
Identify critical parameters	Collecting data without understand the importance of the process parameters towards process performance.

5.5 Conclusions

This exploratory study provided a detail picture of the current status of SPC implementation in the food industry through an online survey and multiple-case studies in the FMI. The adoption of SPC was highly influenced by the size of the company, where large companies are more capable to invest in training and educating their employees to use SPC, compared to the smaller companies. Compared to the past three decades since SPC has been introduced to the manufacturing industry, its implementation in the food industry is considered slow and still in its infancy stage. The high resistance to change, lack of training related to quality improvement and shortage of statistical knowledge and skills has acted as the constraints to the SPC implementation in this sector. In order to gain successful SPC implementation, the study confirms the critical factors are; top management commitment, SPC team development and a robust training programme. Sufficient training reduces the reluctance to adopt SPC and enables the food industry personnel to implement a successful SPC technique. The contribution of this study is its proof that there are findings aligned with the previous studies; nevertheless, some findings are counterintuitive to existing knowledge. It was depicted that the appointment of an SPC leader has emerged as a new CSF for SPC implementation. Therefore, from an operational aspect, attempting to implement SPC does not only involve the adoption and implementation; sustaining the application is equally critical, and can even be viewed as a complex stage within the implementation. Availability of SPC leader is found to be crucial and may sometimes viewed as the change agent, not only to manage the pilot project, but also to lead the institution of SPC in the company under the food quality management.

It was argued that the food industry has a low maturity quality management practices as FMI mainly prefer to use basic rather than advanced quality tools. There are significant differences in the degree of implementation and the usefulness of the quality tools perceived by food practitioners, and this is especially true for force field analysis, SMED, VSM, DOE and Taguchi method. For the companies that have applied SPC, $\overline{x}$-R and $\overline{x}$-S chart were found to be the most common charts implemented, which were also found to be the most useful SPC charts. Almost all of the SPC charts listed in this study were determined to be inadequately applied, despite their effectiveness towards the process improvement.

A crucial issue observed in the interviews is that the managers are confused regarding the implementation process (e.g. where to start, when to start (SPC readiness),how to start, who should involve, what to control, when to adjust, etc.) to achieve satisfactory results on process performance based on SPC practices. There is a crucial need to develop a practical SPC implementation roadmap customised for food industry in order to address the aforementioned questions. Provided with the effective implementation approach, SPC able to act as a process management technique allows the food industry to manufacture and provide consistent high-quality food products to the consumers.

Overall, compared to non-SPC companies, SPC companies were observed to have higher performance levels, which is especially significant in terms of waste reduction, product consistency, customer complaints, defect rates, productivity and rework percentages. Evidence is now emerging to show that SPC provide benefits to the FMI, in a similar fashion to Deming's chain reaction model. The Deming chain commonly starts with process variability reduction and ends with the companies surviving, staying in business and improving the ability to return on business investment (Deming, 1986).Finally, it was observed that the implementation of SPC encourage the practices of organisational learning with single-loop learning. Although it is rarely occurs, there is potentials for second-loop learning provided the signal from the SPC implementation indicates the need to review and the organisation policy and system for further improvement.

The sampling framework for the survey and the multiple-case studies focused only on food manufacturing companies, which led this study to exclude food service companies and food laboratories. SPC in food service companies may face different challenges, use different processes and require the unique approaches of SPC implementation to improve quality. Therefore, there are opportunities to explore SPC implementation in the food service sector and subsequently to compare and contrast the results with the output of this research (on food manufacturing). The literature suggests that there is limited information to explain the results from this survey, which highlights the necessity to carry out a qualitative study.

This study supplements the literature supporting the effectiveness of SPC in food industry and highlights the need of a systematic guideline for SPC implementation in the food industry covering to increase the adoption of SPC in this sector. Such information can be valuable to the managers, and can serve as an important guideline for the implementation of SPC. The results help in realising that there is a need to consider the possibility of widening the scope of SPC application in the food industry. The food industry can gain greatly by successful SPC implementation through the consideration of barriers and CSFs within the implementation which can provide an initial basis for food companies to apply SPC.

CHAPTER 6 —INTRODUCING SPC TO A FOOD MANUFACTURING COMPANY

6.1 Introduction

The action research described in this chapter is an extension of the conceptual framework described in Chapter 3 and it is the second phase of this doctoral research (explained as Research B in Chapter 1). In contrast to other manufacturing industries (e.g. the automotive, electronics and pharmaceutical industries), the food industry has been slow to adopt SPC, even though quality control is crucial in this sector ─ the mishandling of food production processes threatens the lives of humans and raises costs. The low implementation rate of SPC in the food industry is mainly due to a lack of knowledge among practitioners (see Chapter 5) and the lack of practical guidelines for food company managers (see Chapters 2 and 6). This chapter goes some way towards addressing this gap by testing the conceptual SPC implementation roadmap (SPCIR) developed in Chapter 3 on an SPC pilot project undertaken by AlphaCoand reflecting on the results.

6.2 Theory-in-use

Theory-in-use is one of the theories of action, posits a classic perspective on *what we say* (espoused theory) as opposed to *what we do* (theory-in-use) (Argyris and Schon, 1974) where its central proposition: "*In a particular situation, to achieve a particular consequence, do particular actions"*. It requires consideration of the following elements:

- Action strategies: The measures outlined in the implementation framework to implement SPC.
- Consequences: The results of the action, whether expected or unexpected. If the outcome is expected, then the theory-in-use is confirmed. Where the outcome is not what was intended or expected, this may lead to single- or double-loop learning (Argyris and Schön (1978), Argyris and Schon (1974).

Theory-in-use can be made explicit by reflecting on the action, though the act of reflection is itself governed by theory-in-use. According to theory-in-use, reflection may give managers a better understanding of the activities involved in SPC implementation and the factors that inhibit or facilitate success.

6.3 Reflections of the action research in AlphaCo2

Reflection is the process of stepping back from an experience to articulate what the experience meant, with a view to planning further action(Coughlan and Coghlan, 2002). This is a key learning tool in this research – it reflects upon the SPC projects (described in Appendixes H, I and J) with a view to identifying what was planned, experienced and actually achieved in each project. Whether the project succeeded or failed is not the chief concern, both are considered crucial sources of knowledge. Thus, one of the projects considered in the study was a failed SPC project that was carried out in BetaCo in 2013 (see Appendixes H and I). Reflection on this project may also generate knowledge and enable others to benefit from this company's experience.

Following a similar study by Platts et al. (1998) (adoption of new manufacturing strategy), researcher in this study was obliged to generate actionable knowledge by testing the process of SPC implementation rather than the outcome of the implementation (i.e. whether the adopted framework enabled the adoption of SPC in the company rather than solely focus on whether the company improved its performance). Karlsson (2010) and Middel et al. (2006) advise researchers to reflect on content (what is done), process (plans, procedures and how things are done) and premise (the assumptions and perspectives underlying implementation). The reflections presented below were discussed with AlphaCo2's SPC team after the first pilot project is carried out.

- *Changes in leadership and top management role*: The AR study confirmed the importance of keeping top management unchanged in the first few years following implementation, since changes in the leadership can profoundly impact on the vision and strategic direction of the company (Kotter, 2008a, Zairi, 1994). It is advisable to defer the adoption of new technologies such as SPC until the leadership of the company is stable(Maneesh, 2010).

- *SPC awareness phase:* SPC is most effective when top management understands its benefits, supports its application and communicates these across the company(Hubbard, 2003, Wood, 1994, Rungtusanatham, 2001, Noskievičová, 2010, Antony and Taner, 2003, Antony and Balbontin, 2000, Gaafar and Keats, 1992). The role of top management is most critical during the readiness phase, as it is in the best position to persuade employees to embrace the technique(Weiner, 2009). A number of academics have argued the importance of assessing company's readiness to implement SPC prior to its adoption Radnor (2011), Lee et al. (2011), Abdolvand et al., 2008, Self and Schraeder (2009), Cascella and Graesar (2010). This was borne out in the AR, which confirmed that if SPC is implemented in a company that is not ready to commit to the technique, the likelihood of success is significantly reduced. In the AR case company, too little investment was allocated to the project, while resistance from middle managers slowed progress and contributed to its ultimate failure. The researcher would argue that other organisational readiness factors need to be considered apart from recognition of the need for change, and top management's awareness of and commitment to SPC. Given the paucity of literature on this topic, further empirical investigation is required.

- *Team development:* Several preparatory activities are required even before a pilot project can be launched, chief of which are the selection of a multidisciplinary SPC team and appointment of an SPC leader(Rungtusanatham et al., 1999). The composition of the team is important; appointees must have sufficient technical knowledge to make a useful contribution and collectively, they must have expertise and experience in a range of disciplines. It is also crucial to keep them – or the core members at least – in the project team from beginning to end. AsVan de Ven and Poole (1990)explained:

  'systematic and creative data analysis often involves a sequential set of tasks best performed by one or two individuals who can increase their probabilities of learning and generating significant insights by performing all these tasks from beginning to end'.

As explained in Chapter 3, Belbin argues that each team member plays a unique and important role in the implementation of SPC. In the AR case company, the company's Head of Process was appointed SPC leader because he had experience of working with both managers and operators in the production unit. Other roles such as coordinator, implementer, shaper, monitor/evaluator, finisher and plant were also assigned. This is in line with Elg et al. (2008) recommendation that the various tasks that make up the pilot project should be assigned to several different persons (task performers).

6.4 Initiation Phase: Pilot project in Alpha Co.

The first step in this phase is process **prioritisation** in order to select a project. However, the term 'prioritisation' was foreign to the team in the AR case company, and there was no formal mechanism for selecting and prioritising projects. There is little on process prioritisation in the SPC literature, and this step is ignored by most companies. This may be partly attributable to the lack of SPC training in the food industry, which means that managers lack the relevant knowledge (Grigg, 1998), but in addition, there are few tools managers in the manufacturing sector can use to prioritise improvement projects, apart from Six Sigma (Kirkham et al. (2014).

The AR underscored how crucial it is for the SPC team to develop objective criteria for process prioritisation; it highlighted the alarming fact that company-controlled processes, parameters and products are often solely based on customer requirements, and that the critical parameters of the process are often ignored. Costs are saved by avoiding data collection on parameters that are not requested by customers. Underestimating the importance of data collection, companies may also fail to capture critical failure costs such as the costs of reworking and scrapping and the losses resulting from out-of-control processes(Tan-intara-art and Rojanarowan, 2013, Xie et al., 1995).

According toTan-intara-art and Rojanarowan (2013), there are three types of parameter in manufacturing processes:

- Final product parameters are quality characteristics that describe the ability of a product to serve the needs of the customer.
- In-process product parameters are quality characteristics of products or parts during the process or the transformation.
- Process parameters are factors in the process which affect product parameters or final product critical parameters.

As far as prioritisation in the AR case company was concerned, the usual practice was for top management to pick the products that were perceived to cause the most problems; the quality manager was then required to address these problems. The SPC team members were mostly comfortable with the application of Pareto analysis (waste percentages) for process prioritisation, as suggested by Does and Trip (1997). This enabled them to shortlist the critical products and rank them in order of their contribution to wastage. However, even then, there was little sense of urgency from the senior management, possibly because the cost of this wastage was not being calculated and presented to them(Botta, 2007). The SPC team members argued that, given the complexity of food manufacturing processes, several criteria should be considered simultaneously when prioritising improvement projects, such as customer complaints, failure costs and the complexity of the project(Luning and Marcelis, 2009).

The complex system of food quality leads to process prioritisation based on multi-criteria decision analysis, such as Analytical Hierarchy Process (AHP)(Xie et al., 1995, Goh et al., 1998, Luning and Marcelis, 2007, Saaty, 1990). However, some team members lacked the mathematical skills to apply this technique, subsequently impact their confidence to apply AHP(Vaidya and Kumar, 2006, Xie et al., 1995). It is crucial that the SPC facilitator in the company has discussions with team members to decide the set of criteria for prioritisation and to develop a template for AHP application. The company has a number of options for prioritising SPC projects:

- It can apply Quality Function Deployment to determine and prioritise the parameters and processes needing control (Luis Duarte Ribeiro et al., 2001).
- It can apply AHP by considering technical criticality and statistical criticality(Xie et al., 1995, Goh et al., 1998).
- It can apply a combination of QFD and AHP (Ho et al., 2011).
- It can develop a project prioritisation matrix (Pande et al., 2002).

Process prioritisation helps the SPC team in a number of ways:

- It allows the SPC team to develop realistic schedules.
- It enables the team to make the best use of the available resources.
- It allows the SPC team to spend more time and effort reducing the process variation associated with technical problems and critical key performance parameters.

- It reduces the cost of collecting data—food companies collect data without having clear purpose on how to use the data

Process prioritisation enables the team to focus only on one product for SPC implementation. The crucial next step in the initiation phase is to determine the scope of the project, which involves mapping the process — **process description**. The importance of team members doing this on site was highlighted in the AR case company when a line supervisor mapped the process from memory without visiting the actual site, with the result that several sub-processes were initially omitted from the process flowchart. In order to improve the accuracy of the flowchart, the SPC leader then assigned three people to map the process. A standard process flowchart and VSM were employed to systematically record process characteristics (e.g. the type of process, steps, raw materials, quality parameters).Although the objective of process description is to set the boundaries of the project, it also allowed the team to uncover the reasons underlying some of the problems afflicting the manufacturing process(e.g. the problem of the inconsistent waiting time after mixing). The danger here is that a team might conclude it has identified the root of the problem and not bother to investigate other possible factors (Does et. al, 1998).

When implementing SPC, it is crucial to employ other quality tools such as CEA. Teamwork is particularly vital at this stage; it is central to defining the problem, brainstorming and developing an action plan. However, the team in the AR case company sometimes found it difficult to achieve consensus as members came from different departments and therefore understood the problem from different perspectives. The problem was addressed by employing multi-voting analysis, when necessary, to arrive at a consensus answer (the team members were satisfied with this approach). The success of CEA depends to a large extent on the effectiveness of brainstorming sessions (Gijo, 2005), which require extensive input from team members. If these sessions are to be productive, it is important that team members avoid criticising each other's ideas(indeed, discussion of these ideas is best limited to clarification);that no one is allowed to dominate the discussion; and that the leader of the session keep steam members focused (Yimer, 2013).

Measurement system analysis is one major components corresponding to the total error process variability (McNeese and Klein, 1991). Since AlphaCo2. had not attempted MSA (GR&R) before, the SPC facilitator proceeded cautiously, simply interviewing three employees involved in data collection to identify the flaws in the company's measurement practice. These revealed that employees did not appreciate the importance of data accuracy in minimising process variation. It also emerged that there was no standard procedure to carry out measurements for critical-to-quality. These may have been contributory factors in the failure of the SPC project; decision making based on statistical analysis is less effective if the data display excessive variations (Srikaeo et al., 2005).

The literature highlights that the main activities in constructing control chart are the selection of the control chart, data sampling and interpretation of the control chart. Although some of the literature claims that statistical knowledge is not the most important requirement for SPC, choosing a control chart, developing a sampling plan and handling technical difficulties all require a reasonable knowledge of statistics. Any errors when plotting the control chart will jeopardise subsequent decision making. Some of the common errors are:

- Measurement errors
  - using the wrong instrument for the measurement
  - choosing the wrong discrimination
  - using an uncalibrated instrument
  - taking incorrect measurements
  - using an untrained observer or one who is physically disabled (e.g. poor eyesight)
  - recording imprecise data
- Miscalculations (can be reduced by using SPC software)
- miscalculating means, ranges, moving ranges, standard deviations
- Data entry errors
  - Poor set up of the chart file
  - Typing errors
  - Failure to detect bias in the data
- Misplotting
  - using one chart for two different processes
  - entering biased data
  - plotting points in the wrong place

The control chart is only effective as a control technique when operators are in an OOC situation. AlphaCo2. does not prepared a guidelines in the Out-of-Control-Action-Plan (OCAP) as they regarded these as inapplicable to its processes, machinery and people. It is vital for the SPC team to develop an OCAP that will be effective in its own company. Managers may ignore the OOC or mistrust the results from the control chart, but it is important to trust these results and to react promptly.

6.5 Learning in SPC implementation

The importance of learning in the context of SPC is explained in Chapter 2. This section lists the improvement of the type of learning in an organisation through practising SPC activities.

The SPC pilot project investigated in this action research highlighted that the learning process involves setting up goals and targets for process improvement, developing criteria and methods for decision making, allocating resources for developmental activities, developing new follow-up and reporting procedures, training, and setting up a new control system. Drawing on the reflections in the previous section, a number of changes were made to the conceptual framework (see Table 7.1).

Table 6.1 Summary of changes made to the conceptual framework

Step	Additions and modifications to the conceptual SPCIF
Awareness phase	Most of the steps in the awareness phase were found to be appropriate for the readiness phase. Top managers should attend SPC awareness meetings so that they understand their role and can set the strategic goals for the SPC implementation.* SPC readiness is crucial if implementation is to be successful. Top managers should confirm there are no planned changes in the leadership of the company. Top management should nominate an SPC leader who has the authority to manage the process and who has an understanding of SPC and the process.
Training	The SPC facilitator should continually educate team members onsite as well as providing formal training sessions. * Timing of training is important (avoid too early or too late).
Process prioritisation	Prioritisation process can be carried out using three approaches: * Pareto analysis (single criterion/requirement)

	QFD and AHP (multi-criteria) Prioritisation matrix (multi-criteria) The core SPC team should develop an AHP template (e.g. Microsoft Excel) to respond to rapid movement in production site and employees' lack of statistical skills. The team needs to set up a set of criteria and rank these according to importance.* In AHP, when constructing hierarchies, sufficient information must be provided to: • thoroughly represent the problem; • represent the environment surrounding the problem; • identify the attributes that contribute to the solutions; • identify which team members are associated with the problem.
Process description	As the steps in process description are closely related to that in process synthesis, these may be combined as process definition. More than one team member should be assigned to map the process to increase the accuracy and reliability of the result. Teamwork is the underlying principle of SPC. The risk when mapping the process is that the team might jump to conclusions if they have detected several possible causes of the problem.
Process synthesis	Other quality tools can be applied here such as Nominal Group Technique, multi-voting, VSM, why-why analysis and multi-vari charts.**
Measurement system analysis	The GRR should involve those responsible for collecting data in order to make sure it reflects the actual practice of the company.** The result of GRR should be taken seriously, and reactive action should be carried out
Control chart	Simple tools such as trend graphs, histograms, Pareto charts and scatter diagrams are typically used for analysis. More complicated analysis may require input from SPC experts.

	As many food processes involve more than one critical process parameter, multivariate control charts are the best approach. Operators interpreting the control chart should focus on: • process mean • process variability.
OCAP	OCAP is not a static document; it should be updated as the team learns more about the process. ** The team should develop its own OCAP tailored to the resources it has to carry out corrective action.*

**Practices involving organisational learning theory in general*

** *Practices involving organisational learning theory- zero learning to single-loop learning*

****Practices involving organisational learning theory- double-loop learning.*

In the AR case company, corrective action was taken whenever faults emerged that were attributable to identifiable causes, suggesting single-loop learning. Typically, in the food industry, OOC criteria other than the breaching of control limits are ignored. This may help maintain system stability, but it does little to achieve any systemic improvement. The required responses are often codified as part of the quality system so that operators can carry out standard corrective activities/OCAP to minimise process variation, without having to query the underpinning process values and statistical principles. It has been argued that the control chart may indicate the presence of a problem and trigger improvement activities, but it is debatable whether this may be characterised as double-loop learning (Wang and Ahmed, 2002, Savolainen and Haikonen, 2007), unless the control chart information is used to redesign or reengineer the process in some way (Elliott, 1996). Single-loop learning may be sufficient to address process variation if it results from a special cause of variation, but such variation occasionally requires the fundamental improvement of the process, including the re-evaluation of its governing variables (Prajogo and Sohal, 2001).

6.6 Conclusion

This chapter reflects upon the findings from the action research. The main aim of the study is to contribute to the existing literature on SPC implementation in the food industry. To this end, the conceptual framework developed in Chapter 3 is validated in this chapter and refined in chapter 9, subsequently addressing RQ3. A number of improvements to the framework are suggested, especially in the readiness phase and the appointment of SPC leader. The SPC project investigated in the action research initially faced major challenges because managers and employees in the company were resistant to change, which is expected based on the literature. However, the acceptability of the employees is incremental and clear understandings of the activities in SPC implementation were based on the systematic approach of its implementation. Based on the experience in action research, the practitioners in the food industry highlight the importance of companies assessing their readiness to implement SPC before embarking on such projects. Accordingly, this is the focus of the next part of this study.

CHAPTER 7 — SPC READINESS SELF-ASSESSMENT TOOL: A DELPHI STUDY

7.1 Introduction

The readiness phase is similar to the 'unfreezing' phase conceptualised by Lewin (1947), in which members of the organisation are encouraged to relinquish, both physically and psychologically, existing practices for process control and improvement. There are relatively few studies that focus on readiness factors for adopting CI and none on SPC readiness in the food industry. This chapter presents the findings from a three-round Delphi study that was conducted to address this research gap (RQ3).

Twenty SPC experts participated in the first and second round of the Delphi study and eighteens experts took part in the second and third round. In the first round, the panellists were asked a series of open-ended questions with the aim of identifying a broad range of readiness factors that could be used to assess organisational preparedness for SPC. In the second round, the SPC experts were asked to re-assess these factors and the set of SPC readiness factors identified in the CI literature. In the final round, they were asked to break down the organisational readiness factors into sub-factors. The resulting list of readiness factors was used to develop a self-assessment tool for companies in the food industry to evaluate their organisational readiness to adopt SPC.

7.2 Determining organisational readiness factors for SPC adoption

Organisational readiness is an under-researched area in the CI literature. Organisational change theory posits that greater readiness increases the chance that new techniques will be implemented successfully (Antony, 2014, Armenakis et al., 1993), while social cognitive theory suggests that when organisational readiness for change is high, employees are more likely to initiate change (e.g. institute new practices such as SPC), exert greater effort in support of change, and exhibit greater persistence in the face of obstacles or setbacks during implementation (Weiner (2009), Bandura (1993). Herscovitch and Meyer (2002) cite motivation theory to argue that when organisational readiness is high, employees will act to support change in ways that exceed their job requirements or expected role. Kotter (2008b) suggests that failure to establish sufficient organisational readiness is the reason half of all efforts towards organisational change fail.

Despite its apparent importance, however, few studies in the CI literature have focused on how to identify organisational readiness. Several papers in the SPC literature discussed the importance of CSFs, as popularised by Rockart (1979), but little attention has been paid to the equally important question of how an organisation can assess whether it is ready to adopt CI initiatives such as SPC (Antony, 2014, Lagrosen et al., 2011, Smith, 2005a). By ensuring it is ready, an organisation can largely avoid employee resistance to change and improve adoption behaviours (Kotter and Schlesinger, 2008, Armenakis et al., 1993).

7.3 Delphi Round 1: SPC readiness factors

The first round of the Delphi survey was intended to explore the factors that should be considered when assessing the readiness of a food company to implement SPC. The results are presented in Table 7.1.

Table 7.1 SPC readiness factors from the first round of the Delphi survey

Readiness factors	Reasons given by the experts	Number of experts
Top management's uncompromising support Management commitment Top management's active involvement Top management on board	▪ *Top management commitment is the prominent readiness factor in the CI literature, and should be considered fundamental throughout the SPC journey.* ▪ *Type of support the top management should provide depends on the stage of the SPC implementation (e.g. pre-implementation, implementation, sustainability).* ▪ *If SPC adoption is to go smoothly, top management should be convinced that SPC is a valuable instrument for improving process stability and capability.*	20
Urgency to change Understand the need	▪ *Unless there is a need to implement SPC in the business, there is no point in investing in SPC.*	15

to change Acknowledge the need to adopt SPC Appreciate the importance of SPC	▪ *Understanding the 'Why' will provide the drive to commit to the implementation and reduce the risk of an aborted rollout.* ▪ *Information about the process (e.g. key process, critical parameters and process performance) is useful when deciding how important it is to adopt SPC.*	
Organisational culture CI culture Process performance is based on data (e.g. waste percentages, number of defects)	▪ *Experts recognised this factor as the foundation for any business excellence model and quality effort, including SPC.* ▪ *The company culture influences any quality improvement initiative in the industry. Culture and leadership can be correlated; thus, one should explore both, rather than treating them separately.*	7
Employees' knowledge and skills Train employees in how to use process capability indicators Train employees in how to use control charts Training for employees at all levels in the organisation	▪ *Training in basic mathematics skills for employees, or at least to reduce mathematics phobia among employees.* ▪ *The use of appropriate process capability metrics allows accurate measurement of process performance and improves employees' awareness of the importance of data in the decision making.* ▪ *While management commitment is critical, technical expertise is required to guide and oversee the effort.* ▪ *Sufficient understanding of the technical and managerial aspects of SPC is crucial in ensuring successful implementation. Lack of knowledge during the application of SPC and its underlying philosophy can lead to errors in implementation.*	7
Leadership	▪ *Top management should appoint someone to be responsible for leading the SPC programme, and this person should have a technical understanding of the technique as well as good training skills.* ▪ *If top managers support the SPC programme in the company, sufficient resources will be allocated to the SPC implementation effort.*	2

	▪ *Transformational leadership makes the technique more sustainable.*	
Reliable and valid measurement system	▪ *Measurement System Analysis (MSA) is one of the principal activities within the implementation process. At this point, it is important to identify the existence of data.* ▪ *SPC cannot be introduced unless there is a stable and capable measurement system in place, so this is a readiness factor for any organisation.*	2
Process selection and prioritisation	▪ *Initiation of SPC should start with a pilot project in which the technique can be deployed successfully. A successful pilot project will make employees appreciate the value of SPC.* ▪ *There should be a systematic approach to choosing the pilot project for SPC implementation.*	1
The deployment plan	▪ *To achieve success, there must be a viable plan for rolling out the initiative. The plan should include a training plan, but also more importantly, a plan for selecting projects, tracking the progress of these projects, reviewing strategy for process management and measuring business performance.*	1
Linking SPC to customer and business strategies	▪ *To highlight the importance of SPC to the business, SPC has to be included in the business's strategic plan.*	1

Thus, the thematic analysis identified nine SPC readiness factors from the survey. *Top management commitment* was unanimously suggested by the experts as having an impact on SPC readiness; if conventional methods are to change, this must be initiated by top management and filter down to employees (Oakland, 2008, Hubbard, 2003). *A sense of urgency* was the second most frequently suggested SPC readiness factor. This factor has not previously been mentioned in CSF for SPC implementation studies (Lim et al., 2014, Grigg, 1998).The industry-based experts claimed that this factor is most relevant to the top management. A sense of urgency does not just motivate food companies to implement SPC in the first place, it ensures that they apply it continuously (Johnson, 2004). The experts echoed the literature in suggesting that food companies generally lack this sense of urgency and are therefore willing to tolerate their process performance, rather than taking steps to improve it through SPC (Lim et al., 2014).

7.4 Assessing the organisational readiness factors

A review of the literature relating to organisational readiness for CI methods such as Six Sigma and TQM revealed several potential SPC readiness factors (see Chapter 3). In Round 2, the SPC experts reviewed these factors and those identified in Round 1 and decided whether they should be retained (i.e. left unchanged in the Delphi questionnaire), modified (factors that were regarded as important but as needing correction) or deleted. A factor was deleted if more than 50% of the experts opposed it (Okoli and Pawlowski, 2004).

Table 7.2. Round 2: Final SPC readiness factors

Proposed readiness factors	**Retain (++)**	**Modify (+)**	**Delete (-)**	**Explanation by the experts**
Sense of urgency	20 (100%)	0	0	Retain: The need for change must be clear to everyone, especially top management. If there is no sense of urgency, the importance of adopting SPC will not be communicated to the employees. The senior management must be convinced that current practice is no longer viable and requires improvement. Urgency is not a response to critical danger or loss in process performance but to a perceived opportunity to make great improvement.
Capable	14 (70%)	2 (10%)	4 (20%)	Retain: A good and reliable measurement system

measurement System				is a principal requirement to initiate SPC. The majority of the SPC experts highlighted that reliable, valid and meaningful data are vital for adopting SPC.
Top management commitment and involvement	7 (35%)	13 (65%)	0	Modify: It was suggested that *top management commitment and involvement* be renamed *top management support* as commitment is more important in the implementation phase. Top management must be supportive of problem-solving and quality improvement activities in the company. Top management must assess current process performance and acknowledge the need to improve process management practices.
Organisational culture	12 (60%)	8 (40%)	0	Modify: The experts agreed that this factor affects employees' willingness to embrace the technique.
Project management	4 (20%)	3 (15%)	13 (65%)	Delete: It was argued that it is more important to establish a structured plan during the implementation phase than the readiness phase.
Process selection and prioritisation	2 (10%)	2 (10%)	16 (80%)	Delete: Although selection of the right process is crucial for the pilot project, this factor is more important in the implementation phase than the readiness phase.
SPC	2	2	16	Delete:

deployment plan	(10%)	(10%)	(80%)	Although most of the experts saw this factor as critical to implementation, they did not see it as indicating an organisation's readiness to adopt SPC. Planning does not usually take place until the management has agreed to implement SPC, so it is irrelevant at this stage.
Employee management	2 (10%)	14 (70%)	4 (20%)	Modify: The term was seen as too broad to be used as an SPC readiness indicator. In the readiness phase, employee management may refer to senior managers' attempts to engage and involve employees in CI, or to assess employees' efforts at quality improvement to increase the morale of the employees. Most of the experts suggested this should be changed to *employee involvement.*
SPC Training	5 (25%)	2 (20%)	13 (65%)	Delete: *SPC training* is deleted as it was considered appropriate as part of the SPC implementation phase. Employees should be trained in basic statistical knowledge.
Customer focus	2 (10%)	3 (15%)	15 (75%)	Delete: Experts explained it is important to define the critical quality parameters prior to the initiation of the SPC project; otherwise, the organisation will end up focusing on the wrong area. The experts explained that control charts should not be guided by customer

				specifications, but by the 'voice of the process'.
Leadership	1 (5%)	5 (25%)	14 (70%)	Delete: Leadership and management commitment are both important. Leadership involves inspiring people through shared vision, ideas and direction, whereas management involves making sure people do things. At the readiness stage, leadership was not seen as critical, except for decision making. The leadership must be committed to the overall programme, of which SPC is part. Most of the experts argued that top management support is more critical at this point than leadership, so recommended that the factor be dropped from the SPC readiness factors.

Table 7.2 shows that the experts unanimously agreed to maintain *sense of urgency* as a factor, with the majority commenting that this is the most critical factor for assessing SPC readiness. 70% of the experts agreed to accept *capable measurement system* as measurement and data is the source information for the use of SPC. Like Ahire and Ravichandran (2001), the experts felt that no attempt for changes in practice (such as adopting SPC) will succeed without a capable measurement system. *Top management commitment and involvement* was voted one of the most important factors though the experts wanted this renamed *top management support*.

The second round resulted in *sense of urgency, top management support, organisational culture, capable measurement system* and *employee involvement* being retained as the five key readiness factors for SPC implementation in the food industry. Interestingly, as findings from Ahire and Ravichandran (2001), *customer focus* and *leadership*, which feature prominently in CI readiness studies, were deleted here (Antony, 2014, Bayazit and Karpak, 2007, Lameei, 2005, Lee et al., 2011). The companies may implement SPC in response to customer expectations, but this is a motivation factor for adopting SPC rather than viewed as an indicator of readiness (Grigg, 1998). Ahire and Ravichandran (2001) explain that customer focus may lead employees to make a concerted effort to improve the quality of processes and products, but it does not necessarily impact the adoption of new technology. Leadership, meanwhile, plays a pivotal role in cultural transformation and the adoption of new technology (Antony, 2014, Lee et al., 2011). Supporting the views expressed by the experts, Lameei (2005) claims that top management is pivotal in organisational readiness, and leadership appeared under the top management support.

The final Delphi round identified the attributes associated with each of the five readiness factors. The potential attributes for each of the SPC readiness factors determined in the previous round were listed based on a collective data from the exhaustive literature review and the previous round of Delphi study. Following Okoli and Pawlowski (2004), the attributes that attracted support from more than 50% of the experts were shortlisted. Since two of the experts dropped out from the survey at this stage, this left eighteen experts in Round 3.The results are shown in Table 7.3.

Table 7.3. SPC readiness factors

	Top management support	% of experts who selected
T1	The management is ready to commit to SPC implementation (e.g. shut down a highly unstable process for corrective action, and provide resources to investigate and overcome the root cause of the problem)	100 %
T2	Top management understands its role and commits to start implementing SPC	83%
T3	Top management demands regular (e.g. daily, monthly) process performance reviews and holds monthly review sessions focusing on quality	83%

T4	Top management support CI activities	100%
T5	Top management visibly committed to SPC implementation	78%
	Capable measurement system	
M1	The measurement system is available	67%
M2	Employees aware of the key processes	61%
M3	Employees trained to collect data	89%
M4	Appropriate measurement tools exist	94%
M5	Guidelines are available for calibrating measuring equipment	83%
	Organisational culture	
O1	Decision making is based on data	100%
O2	Problems are addressed using teamwork approach	89%
O3	Process performance is measured using appropriate metrics (e.g. C*pk*, P*pk*)	89%
O4	Regular meetings (e.g. monthly) are held to discuss quality problems using data	89%
O5	Employees' accountability is respected and blame culture discouraged	61%
	Urgency to change	
U1	Top management communicates legitimate reasons for adopting SPC	77%
U2	Confidence that company will benefit from SPC implementation; it will not just be introduced in response to customer demand	94%
U3	Understand that SPC able to continually improve process performance	83%
	Employee involvement	
E1	Employees trained in basic statistics	100%
E2	Employees' ideas and opinions are appreciated	94%
E3	SPC facilitator hired (external/internal) to aid SPC adoption	94%
E4	Employees understand the benefits of process improvement to the business and themselves	89%
E5	Employees involved in CI activities	77%

7.5 SPC readiness self-assessment tool: Scoring the criteria

In this exploratory study, each of the readiness factors was given equal importance when calculating organisational readiness scores. (It is strongly suggested that further empiric studies be conducted to determine a rank order of importance for the factors.) Each sub-factor was marked on a five-point Likert scale where 0 = never implemented, 1 = rarely implemented, 2 = occasionally implemented, 3 = often implemented and 4 = always implemented. This study drew on previous quality management studies to determine the threshold values for the level of organisational readiness(e.g. (Abdolvand et al., 2008, Maneesh, 2010). Thresholds to determine the level of readiness were equivalent to the characteristics of Kaye and Dyason's (1995) quality control model (era 2), Dale and Smith's (1997) quality management implementation grid (level 5-Improver) and Dale and Lascelles (1997)(level 3-Tool pushers). Table 7.4 depicts that a score of 3 or above suggests that the food organisation is ready to embrace SPC; a score below 2 indicates the need for remedial action.

Table 7.4. Score level for the SPC readiness self-assessment

Level of readiness	Mean	Reaction
(green)	>3	Ready In the right state to initiate implementation
(amber)	2-3	Moderately ready Company should continue in its plan to adopt SPC but needs to reassess the readiness factors that gave a low score
(red)	<2	Not ready Most of the factors score very low, indicating that the company may not be fully prepared to commit to the adoption and implementation of SPC

Two non-SPC companies and one SPC food company were recruited to test the validity of the SPC readiness self-assessment tool developed based on factors identified earlier in the study. Theoretically, a company whose process performance has benefited from implementing SPC (Cp> 1.33) should score higher than 3 for most readiness criteria in the index. Any company that has started Six Sigma expected to score closer to 4, as the company is applying SPC as part of the Six Sigma methodology. It should be noted here that this tool is still in its beta or testing phase and may be revised following future research (including the feedback from the participating firms and SPC experts in this study).

The demographic details of the participating firms are provided in Table 7.5 (see Chapter 5 for further details of the company demographics). Company H is struggling to maintain its Lean sustainability initiative following changes in management structure and company focus, but it volunteered to participate in the readiness exercise and to identify weaknesses or gaps in its CI efforts because they are interested in adopting SPC to their key processes.

Table 7.5 Demographic details for the case companies

Company	**Size of company (by number of employees)**	**Type of process involved**	**Quality management initiative**	**Quality tools applied**
A	Large	Automated	Lean Six Sigma	Advanced technique
F	Medium	Semi-auto	Lean	Basic tools
H	Large	Semi-auto	Lean	Basic tools

Participants in this phase of the study, who included quality managers, CI managers and quality assurance managers from the case companies, completed the assessment form in the readiness questionnaire (each criterion was scored on a five-point Likert scale). The scores for the five factors are shown in Table 7.6. Company A scored highest, followed by Company H, while Company F scored poorly on all five factors.

Table 7.6 SPC Readiness Self-Assessment scores for Companies A, F and H

SPC readiness factors	Scores		
	A	F	H
Top management support	3.8	1.8	2.4
T1	3	2	3
T2	4	2	2
T3	3	1	3
T4	4	2	2
T5	3	2	2
Capable measurement system	3.8	0.6	2.6
M1	4	1	2
M2	3	0	3
M3	4	0	1
M4	4	1	3
M5	4	1	4
Organisational culture readiness	3.0	1.2	2.0
O1	3	1	2
O2	3	1	2
O3	3	1	1
O4	3	2	3
O5	3	1	2
Sense of urgency	3.3	2	3.3
U1	4	2	3
U2	4	1	3
U3	2	3	4
Employee involvement	3.2	0.4	1.6
E1	3	0	2
E2	3	1	1
E3	4	0	1
E4	3	0	2
E5	3	1	2
Total mean score	3.48	1.48	2.73

7.6 Interpretation of the SCPRAT scores

7.6.1 Top management support

Company A scored above average in the *top management readiness* dimension, Company F scored lowest, while Company H achieved mediocre scores. The quality manager from Company H explained that management changes over the past two years have caused a shift in focus towards Lean initiatives with the result that more attention is now being paid to process efficiency. The company claims it wants to incorporate an SPC pilot project into the production process, but its top management was seen by respondents as still lacking understanding of CI initiatives, and instead as tending to push for short-term improvement. Both the literature and this study's findings indicate that top management is the most important factor in ensuring the success of CI initiatives. This was borne out by the quality manager from Company F, who identified lack of top management support as the principal factor hindering its pursuit of CI (see Figure 7.1).

The company initiated Lean in 2013 to manage waste and process efficiency, but the respondents felt that top management is still reluctant to embrace the culture of CI, observing that quality improvement rarely discussed in the management meetings (T3). In contrast, there was clear support in Company A, which has taken a number of positive steps on its CI journey. At each step, the manufacture director has granted sufficient resources, encouraged employee training by making it a key performance indicator and demonstrated commitment to the initiative (e.g. by demanding monthly reviews of quality improvement projects and regular process performance reports).

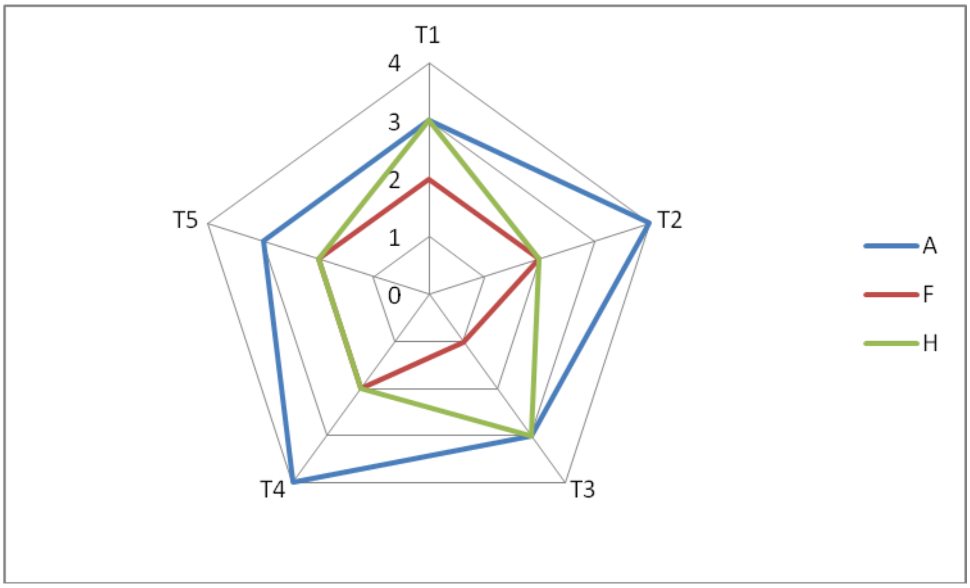


Figure 7.1. SPC readiness scores in *top management support* dimension

Company A integrated SPC into its strategic planning in order to compete more effectively in a fierce global market. Its senior managers see process improvement techniques as a key part of the Lean Six Sigma (LSS) programme, as they enable the company to minimise waste, improve process efficiency and compete with other multinational companies.

7.6.2 Measurement system

The results for measurement system factor are depicted in Figure 7.2. Core business processes in the three companies are documented and key activities mapped using flowcharts, or process maps, as required in the HACCP. All three firms adhere to the British Retail Consortium (BRC)'s principles, in addition to which Company H implements Lean and Company A implements LSS. As Company A is already implementing LSS, its decision making is based on facts and data and the measurement system capabilities have been assessed. The benefits generated by the application of SPC are measured using process performance metrics (e.g. C*p*, C*pk*, waste percentage) and the results communicated across the company via bulletin boards and senior management debriefing sessions. The senior management of Company A ensures employees receive the training to carry out measurement and equipped them capable machinery and tools.

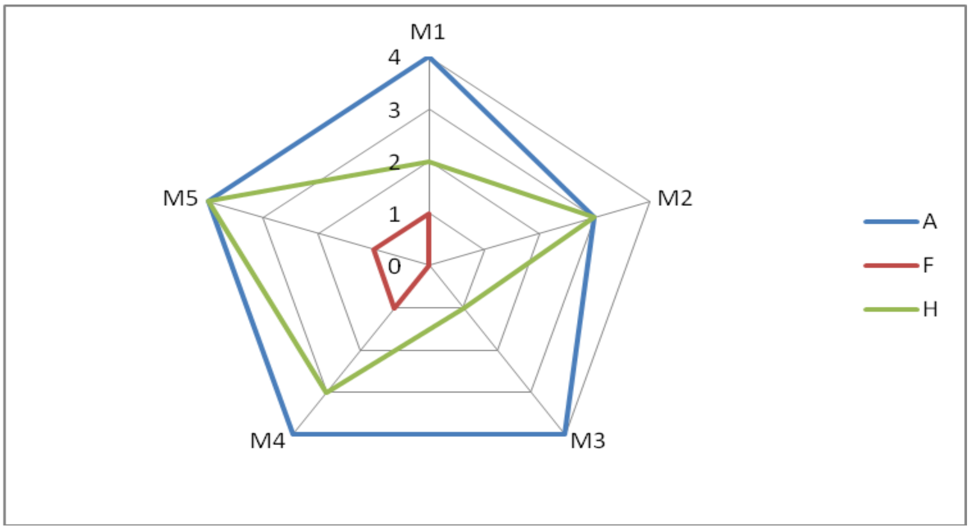


Figure 7.2 SPC readiness scores in *measurement system* dimension

Company F scored poorly in the *measurement system* dimension owing to its employees' lack of CI training and limited statistical skills (Hersleth and Bjerke, 2001, Lim et al., 2014). There has been no assessment of the measurement system at the company's processing plant, key processes and its critical metrics are not explained to employees and decisions are not made based on data. Most of the decisions in Company F are based on past experience and gut feeling. Following HACCP principles, employees are trained for their assigned job, food safety and food handling, but they receive no introduction to quality improvement tools and techniques. In Company H, basic Lean tools like 5S and VSM have been implemented to minimise waste from shop floor operations. Although there are guidelines for calibrating machines at each station, employees are not trained to take measurements or collect data.

7.6.3 Employee involvement

Company A scored above average on employee involvement (see Figure 7.3), while Companies H and F scored relatively low in this dimension. Senior managers in Company A believe that any new process improvement programme or technique will only be successful if there is sufficient employee involvement; that is, if it offers employees opportunities for training and career development. All employees are given one day's training in CI and quality tools/techniques to improve their awareness of CI initiatives and how they can help the company to achieve its strategic business objectives. Shop floor employees are encouraged to take ownership of their processes and report any discrepancies in product quality to senior management.

In contrast, Company H only provides training for middle management which only if employees themselves request it. , although managers occasionally involve employees in problem solving, their suggestions are rarely acted upon. However, things may be changing in the company; for example, the 5S exercise has given shop floor employees a sense of responsibility and motivated them to improve their own processes. The company's new management team is transforming process management practices, but they faced difficulties to get everybody on board.

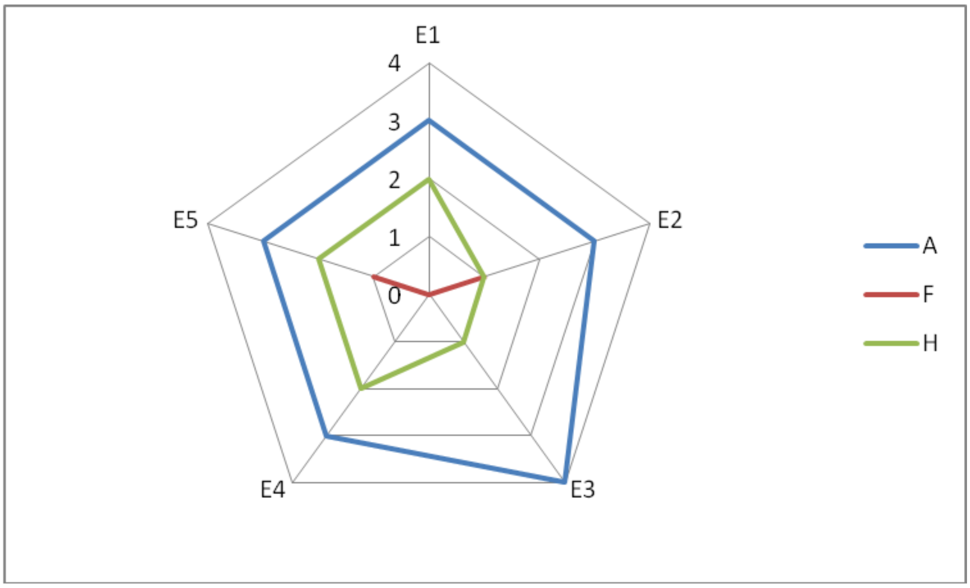


Figure 7.3 SPC readiness scores in *employee involvement* dimension

In Company F, senior managers offer no training in CI tools/techniques at all, demonstrating their poor awareness of CI initiatives. Unlike Company A, where involvement is company-wide, Company F's quality control is the sole responsibility of the quality manager and his department; shop floor employees are not empowered to improve their processes or given opportunities to become involved in quality improvement activities. Since they are not involve in problem-solving discussions, they do not understand how improving process performance benefits both the business (by enabling it to achieve its strategic goals) and themselves.

7.6.4 Organisational culture

Table 7.6 and Figure 7.4 indicate that Company A has well-established systems and control of its processes. This is attributable to the company's performance in the first three readiness factors: in other words, support from the top management, careful analysis of the measurement system, and a high level of employee involvement has created an efficient, proactive organisational culture. Recognising that a team made up of representatives from different departments can bring a range of perspectives to bear on production problems, the company has set up a multi-disciplinary team to execute SPC projects (e.g. quality manager, technical manager, production manager, supervisor, operators).

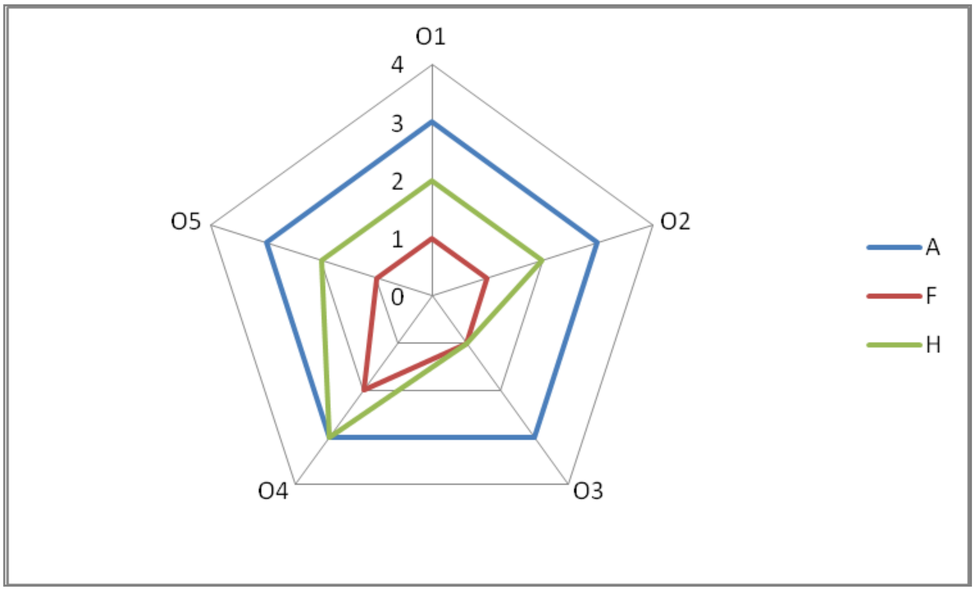


Figure 7.4 SPC readiness scores in *organisational culture* dimension

Companies F and H adhere strictly to BRC principles, establishing standardised processes and regularly reviewing improvement opportunities. As it becomes more aware of the importance of reliable data for decision making, Company H has taken steps to establish a robust measurement system and now requires critical performance measurements to be presented to top management on a weekly basis. The management in Company F rarely assesses current process performance — only productivity and waste percentages are recorded – though it is occasionally discussed in the weekly meeting with the production and quality managers.

7.6.5 Sense of urgency

Company A exhibits a sense of urgency: participants from this company identified employee performance as the prime reason for adopting SPC. Employees are expected to be visibly aware of process performance (daily production figures are posted on the bulletin board) and production line supervisors are expected to single out the poorest-performing employees to discuss the problem. Senior managers in Company H demand a monthly review of process performance and quality, but participants from this company acknowledged that its current process is not achieving expected targets, and that it is in fact generating an alarmingly high waste rate. Hence, the company scored high on this factor, indicating its readiness to adopt SPC. Company F scored in the average range on this factor because the quality manager not only refused to believe that SPC could be applied in the company but was skeptical about its potential to improve process management.

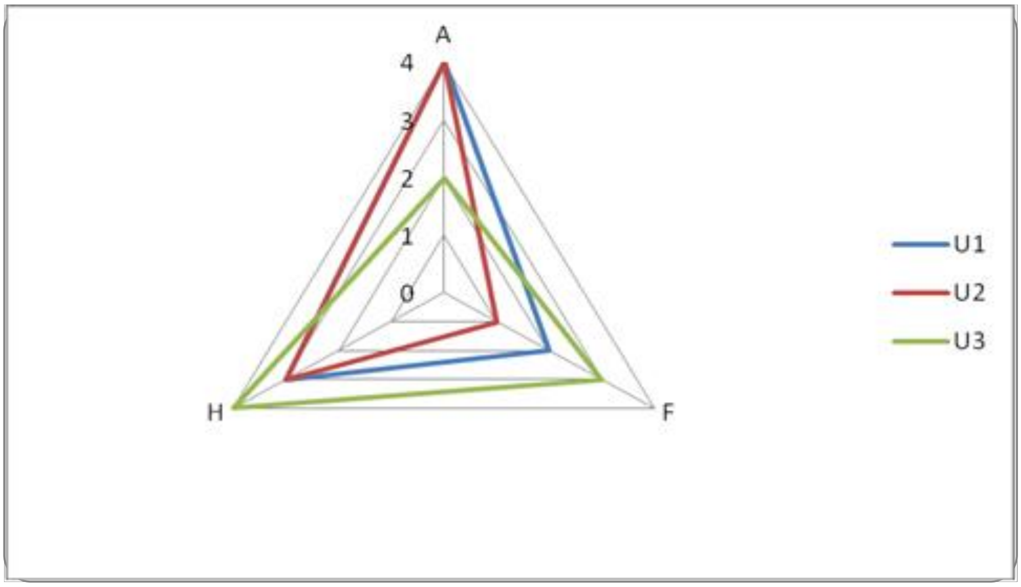


Figure 7.5 SPC readiness scores in *sense of urgency* dimension

Whether an organisation is ready for SPC depends on how able it is to minimise resistance to adoption of the technique and how prepared it is to apply SPC tools effectively.The high score achieved by Company A in this dimension indicates a high level of commitment from senior management and shows that resistance to change in the company has been minimal; employees have found it easy to accept the new process management practices. This is perhaps not surprising given that the company employs Six Sigma and Lean Six Sigma, of which SPC is a principal component.

The quality manager from Company H explained that the company wants to implement SPC, to which end it has updated its business processes, established performance metrics for key processes and developed an awareness of CI. However, the company's SPC readiness self-assessment score indicates that it still needs to improve in four of the five dimensions (*top management support, measurement system, employee involvement* and *organisational culture*) before it can initiate SPC. The score reflects a reactive rather than a proactive culture and a lack of support for employees becoming involved in CI. It seems that although the implementation of Lean may facilitate improvement in terms of organisational culture and top management support, it does not guarantee readiness to adopt SPC. Company F scored very low on four of the five factors and only scraped an average score for the *sense of urgency* factor. The company needs to reassess its current manufacturing practices for quality and take action for improvement.

7.7 Discussion

This study employs the Delphi technique as part of an exploratory investigation to identify the key SPC readiness factors in the food industry. The findings from the case study companies provide preliminary validation of the SPC readiness factors suggested by the panel experts.

7.7.1 Employees involvement

The results from the survey (see Chapter 5) and the literature review suggest that top managers in the food industry typically tolerate poor process performance and have little sense of economic urgency to make improvements (Mazu and Conklin, 2012).

The readiness factors determined in this study highlighted employee involvement and sense of urgency are relevant to the food industry as this sector typically unlikely to practice both factors (Lim et al., 2014). Secondly, this sector is short of employees who are skilled in using quality improvement tools and techniques (Grigg and Walls, 2007a, Lim et al., 2014, Paiva, 2013). The failure of food companies to develop a skilled and knowledgeable workforce militates against new technology being adopted successfully in the industry (Davis and Ryan, 2005, Jones and Dent, 1994).

7.7.2 Sense of urgency

One factor emerged as pivotal: a sense of urgency. Underlying this factor is the question: Why do we need SPC? Company A scored high on this dimension, indicating that its top management is highly motivated to improve the status quo — to seize opportunities, avoid hazards and shed low-priority activities in order to operate smoothly (Kotter, 2008b). When deciding whether to adopt SPC, a company must begin by evaluating its competitiveness, market position, financial performance and current technological trends (Appelbaum et al., 2012). This is one of the most challenging steps in Kotter's eight-stage model of change, but it is crucial in empowering managers to explain the need for change and tackle employee complacency (Kotter, 2008b). This complacency is common in the food industry, but companies generally underestimate its power and prevalence. Kotter (2008b) highlights the importance of combating complacency and differentiates between true and false urgency, which he suggests are often confused. False urgency, which is usually the result of pressure from top management or customers, often leads to action, which does not address the root cause of problems. True urgency arises from companies being motivated to look relentlessly for opportunities to improve their status. Food companies must develop a sense of true urgency before they can adopt SPC. Employees in the food industry are generally highly resistant to SPC implementation due to fear and their unfamiliarity with statistical techniques — compared to employees in other sectors, they are rarely required to apply statistical techniques in their daily job (Dora et al., 2013a). Consequently, fire-fighting remains the prominent problem-solving approach in this sector (Hersleth and Bjerke, 2001). How to create a sense that there is an urgent need for change in the sector is the focus of much academics.

7.7.3 Measurement system

The measurement system is imperative at the implementation stage, as SPC relies on the availability of reliable statistical data (Lee et al., 2011, Deming, 1986). The system must be robust enough to allow the accurate calculation of process variation (Srikaeo et al., 2005). The panel experts, therefore chose to retain this factor, expressing concern that food companies often underestimate the effect measurement system issues can have on process performance. Such systems are typically not a priority in the food industry; data are usually stored and rarely used for quality improvement purposes. This is mainly because the industry as a whole has a poor understanding of how to use data and does lack of statistical thinking(Hersleth and Bjerke, 2001).

7.7.4 Top management support

The panel experts described top management commitment and support as a vital factor in CI; indeed, the low uptake of SPC in the food industry is mostly attributable to top managers' resistance to change (Vlachos, 2015, Surak, 1999a). Different kinds of top management support are required at different stages of the implementation process (Pinto and Prescott, 1988). The results of this study support Maskin and Sjöström (2002) finding that top management commitment is particularly important in the implementation phase, but less so in the readiness phase. In this phase, top management support is viewed is much crucial in order for the employees to confidently adopt this technique.

7.7.5Organisational culture

The SPC experts believed that the organisational culture significantly influences how accepting employees are of SPC. Organisational culture is considered pivotal in the CI readiness literature (Mohamad et al., 2013, Lagrosen et al., 2011, Lee et al., 2011, Hensley and Dobie, 2005, McNabb and Sepic, 1995). The term was, however, criticised by the SPC experts as too broad and vague for this study. To address this concern, sub-factors were developed that are specific to SPC implementation. These sub-factors include: *decisions are based on data rather than instinct*; *teams are used to solve problems*; and *process performance is assessed using process data and teamwork*. The sub-factors describe aspects of the internal process, which is one of the four dimensions of organisational culture developed by Quinn and Rohrbaugh (1983). A data-driven culture is viewed as important not only for decision making, but also for performance assessment and operating company reward systems (Grigg, 1998, Luning and Marcelis, 2009). It was also argued that food companies should encourage team-based CI, as quality issues in food production are complex and usually involve more than one department (Paiva, 2013, Pable et al., 2010, Luning and Marcelis, 2006). Quality improvement practices in the food industry are generally left to quality managers and their departments (Lim et al., 2014), but it is the researcher's view that quality should be seen as everyone's responsibility. This will also make the company-wide adoption of quality improvement techniques much easier.

The readiness score for the three firms reflects their existing commitment to quality management practice and their CI journey. This SPC readiness self-assessment tool captured the data it was designed to capture, indicating the validity of the instrument. However, like the maturity models in CI (Nightingale and Mize, 2002, Bessant and Caffyn, 1997, Bessant et al., 2001), and the technological assessment model of (Parasuraman, 2000), the SPC readiness self-assessment tool will take some time to develop. Further input from SPC practitioners and industry executives will help refine the readiness index.

7.8 Summary

The food organisations struggle to adopt SPC due to their staff are highly resistant to changes and lack of guidance to implement the technique. Drawing on organisational readiness theory (that readiness plays a critical role in reducing resistance to new technology adoption), this study explored SPC readiness factors in order to construct a new instrument for measuring organisational readiness to adopt SPC in the food industry. The three-round Delphi study identified five readiness factors: *a sense of urgency, top management support, employee involvement, organisational culture* and *capable measurement system*. These were used as the basis of the SPC readiness self-assessment tool. Three food companies then tested the instrument by using it to assess their organisational readiness for SPC adoption. The results indicated that Company A was the most ready and Company F was the least.

The identification of SPC readiness factors and development of a self-assessment tool critically facilitated the food industry's managers preparing for SPC implementation. The self-assessment tool provides a starting point and serves as a checklist for food practitioners to ensure the preparedness of their company before they begin the SPC journey. It may also help quality managers formulate strategies that will foster SPC's long-term use in the company. The research has a number of limitations, however, the Delphi study did not consider on how food companies can establish a true sense of urgency to adopt SPC.

The inquiry process captured organisational readiness factors only. However, SPC is a teamwork-oriented technique which requires support at both organisational and individual levels (Weiner, 2009). This is recognised in organisational readiness theory, which posits that readiness is a multi-faceted construct which requires the contributions of many individuals.

Data were only collected from quality managers, as most SPC leaders are quality managers or quality directors (Lim et al., 2014). However, other senior managers and shop floor employees can also give insights into a company's SPC readiness. Future researchers should distribute the SPC READINESS SELF-ASSESSMENT form to employees at different levels in the company hierarchy.

Both the expert panel and sample of companies were small, which means that the results should be treated with some caution. It was particularly challenging to find food companies willing to test the self-assessment tool as not many are aware of the existence of SPC and very few are planning to adopt the technique. However, the testing process was the best way of analysing the qualitative data from the Delphi study — and it is common for Delphi studies to use a relatively small sample (Okoli and Pawlowski, 2004).

This research can be extended in several directions. The SPC readiness self-assessment tool has been tested in three companies, but testing it on a larger sample would clarify the extent of its applicability in the food industry. Second, while the assessment tool recognises the significance of each readiness factor, it is not yet clear whether food companies need to score highly for all the factors (or just for certain factors) to implement SPC successfully. Future research should also investigate the connections between and mutual influence of the five readiness factors. Finally, It is as yet unclear whether the same factors that affect organisational readiness also affect the readiness of individual, team and project levels, which call out for further empirical studies. The next section will provide the next step of the SPC implementation after the companies are identified as ready to implement SPC.

CHAPTER 8 — STATISTICAL PROCESS CONTROL IMPLEMENTATION ROADMAP (SPCIR)

8.1 Introduction

This chapter presents the SPC implementation roadmap developed based on the critical review existed on SPC implementation frameworks (Chapter 3) and the empirical studies in previous chapters (Chapter 8). The objective of this framework is providing a practical guideline for the food companies that have the intention to initiate the journey of SPC application. Along the research journey, although organisational readiness was vaguely discussed within the literature review, the researcher identified that 'Readiness phase' is critical for the food industry to assess in order to examine their current state of process management and their preparedness to adopt SPC in their respected companies. As the SPC readiness self-assessment tool was presented in the previous chapter, this next section presents the roadmap of SPC implementation framework for the UK food industry

8.2 SPC Implementation Roadmap (SPCIR)

The journey towards companywide SPC implementation involved five phases — Awareness, Planning, Initiation, Institulisation and Sustainability. The pre-requisite for the effective usage of SPCIR is the company has to be ready for its implementation. Therefore the SPC self-assessment tool was developed for the companies to assess their level of readiness for the SPC implementation —Readiness phase. Readiness is the first step to facilitate food industry to sustain the advantages of SPC implementation. The next section discusses the steps involved within the five stages of the implementation roadmap as depicted in Figure 8.1.

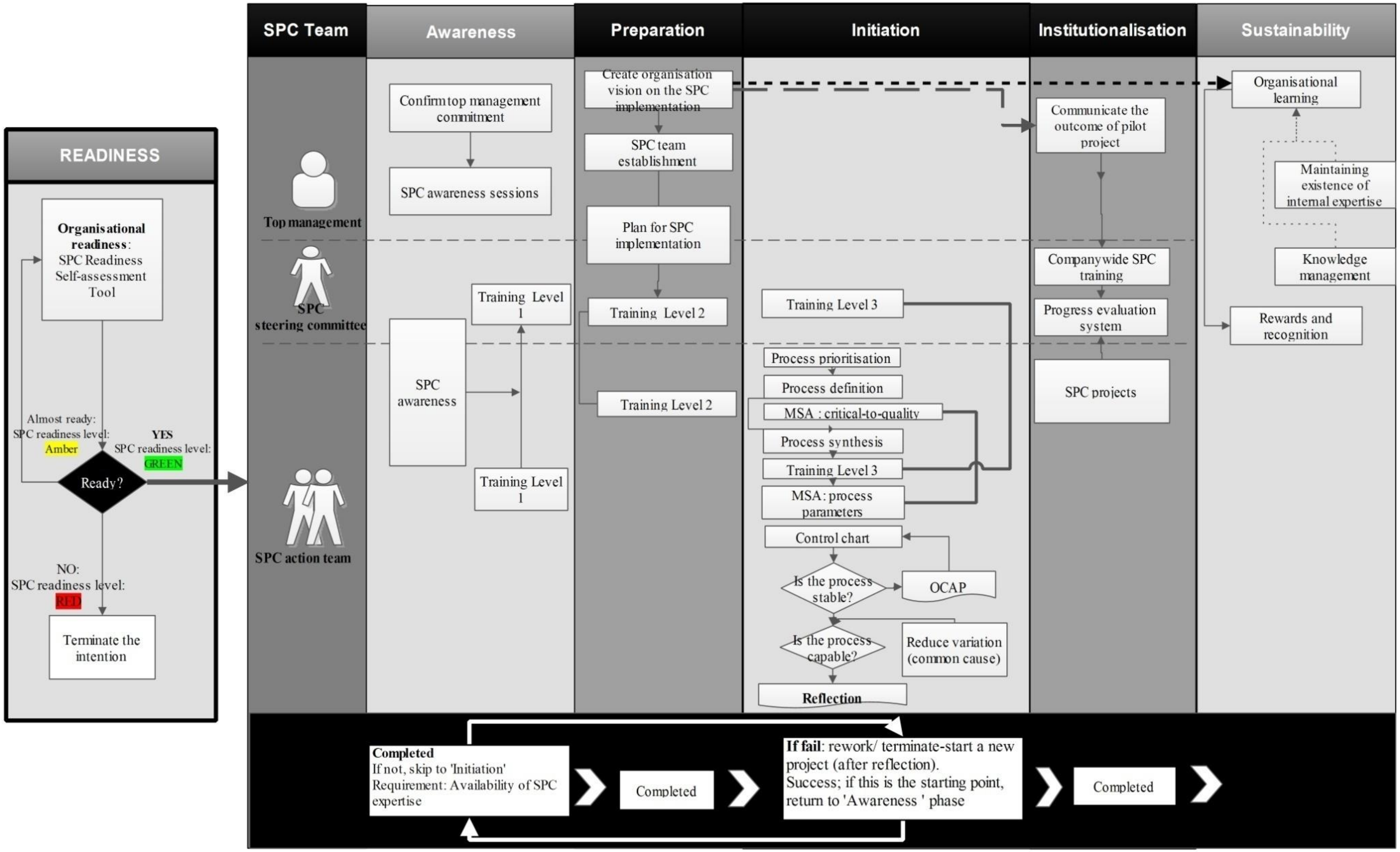


Figure 8.1 SPC Implementation Roadmap (SPCIR)

8.2.1 Phase Awareness

An awareness of SPC is the sign of a formal start and considered as the appetiser of the SPC deployment in the company. This phase principally aims to educate and introduce people in the organisation regarding the reasons the switch of current practice to SPC, challenges and benefits of the implementations. Moreover, it is also developing a sense of urgency and creating values for SPC application in the company to gain support from the top management.

<u>**Step 1:** Confirm top management commitment</u>

Once the food company carried out the SPC readiness assessment, the current state of process management is known and subsequently it also provide an indication that the firm had a committed top management supporting SPC. This commitment from top management and leaders in the company needs to be confirmed at the start of the SPC implementation. This is the principal aspect to start with because many food companies have failed in their attempt to implement SPC either due to the lack of commitment and support from the top management or due to lack of drive from the leadership towards the initiative. The activities required in this step are:-

- Top management shows support by improving their knowledge of SPC (attending the awareness session, attending training on quality tools and techniques).
- Communicate the scope, objectives and requirement of SPC implementation from top to bottom of the companies.
- Top management is supportive instead of being autocratic. Promote employee involvement in quality improvement activities by authorising the process ownership to the employees.
- Top management should ensure and confirm there are no potential changes in the leadership of the company.
- Top management is readily to continuously evaluating the progress of the project and process performance related to SPC.
- Appoint an SPC leader to plan, lead and manage the SPC deployment.

Top management should choose an SPC leader who has great passion for quality improvement with a sense of urgency for the initiation of SPC (Morgan, 2006). Some of the reported SPC leader's roles are:

- Chair the team meeting
- Issue instructions required to complete the project.
- Assign tasks to the team members.
- Maintain a continuous application of SPC
- Develop a strategic plan for a companywide SPC deployment

As the employees competency level influence the SPC implementation success, hence the selection of top talent team members especially the leader is crucial (Hersleth and Bjerke, 2001, Davie and Ryan, 2005). Although there are not many managers in the food industry aware of the existence of SPC (see Chapter 6), the SPC leader should at least have acquired several criteria such as a logical and analytical mind, perseverance, project management skills and zeal in the use of SPC tools. The major reasons that top talent is considered important in this implementation are that better result can be achieved with participation of talented employees, top talents attract more talented people and top talent becomes the next company leader (Snee and Hoerl, 2003).

Meanwhile, communication plans should be developed in order all senior management team are aware of the quality improvement effort and understand the reason of the implementation. SMEs have the advantage of faster communication across the business due to their flat layer structure and less functional hierarchy(Maneesh, 2010). The top management may inform the employees in regards to their intention for SPC adoption through emails, bulletin board, company's web page or meetings. This step is considered achieved after the top management is supportive to commit to SPC and understand their role towards a successful SPC implementation and intention to adopt SPC.

Step 2: <u>SPC awareness sessions</u>

This step is viewed as the formal start of education about SPC in the company, is an awareness meeting for the senior management of the company. The objectives of awareness sessions may similar to training session (except it is much in shorter time and more business advantages and less technical material) and the general objectives are:-

- to familiarised the senior management with the principal philosophy of SPC
- to build positive impression with respect to SPC adoption in the company

- to provide explanation the commitment expected within the SPC implementation

In order to secure senior management commitment for this implementation, it is important to start SPC awareness session at the top of the organisation and this should then be cascaded down (employees training) through the organisation hierarchy. Furthermore, the involvement of top management in the awareness session able to convince the employees top management on the adoption of SPC. The awareness sessions will secure senior management commitment and faith in the initiative.

The topics should be covered in the SPC awareness meeting:-

- The linkage of statistical thinking in the process management practice
- Benefits of shifting from detection to prevention approach.
- SPC is a means to move from fire-fighting culture to process improvement.
- SPC requires changes of management style with respect to the delegation of tasks and employee empowerment.
- SPC is a technique used to establish process capabilities and the importance of such metrics is used as the process performance assessment.
- SPC is a technique to recognise, quantify, reduce and control variation.
- SPC is linked to food quality management strategy.

Step 3 SPC Training

It is crucial that everyone in the company not only aware of SPC but also understands clearly on the importance of SPC and how can it brings advantageous to the employees and for the company. Similar to top management awareness session, at this stage SPC should be introduced with emphasis on definitions, requirements, and benefits. In the food industry, training for quality were highly sought (based on result in case studies) in regards to food safety, which it is encouraged to include the SPC module (for Level 1) within such training session or other training under food quality management. The objectives of training programmes in the SPC implementation are to:

- increase awareness of quality and SPC tools
- to reduce the resistance to SPC adoption
- to maintain in-house expertise towards the SPC implementation.
- to support the sustainability of SPC implementation and establishing a continuous learning culture in the company.

Current training session mainly focus on the technical aspect, neglecting the managerial aspects, which often caused the failure of SPC implementation (Hoerl, 1995). The most ineffective approach is to congest all information in one training session as explained by Gaafar and Keats (1992), however, to provide training in each step along the implementation will cost the company extra time and budget.

Ensuring the module of the training match the level of employees knowledge is essential in the food industry the workforce were reported short in knowledge and statistical skills. A survey of employees in a company will always reveal special skills, knowledge, interests and motivations of employees and it could be used to enrich the role of employees in SPC. In order to increase its effectiveness and efficiently use the resources (time, cost), level of SPC training depicted in Table 8.1 is divided into three levels.

Table 8.1 SPC Training

Characteristics	Level 1	Level 2	Level 3
Objective	• Provide SPC general concepts of SPC without technical details.	• Develop problem-solving skills and teamwork.	• Guide the application of control chart and (Out-of-Control-Action-Plan)OCAP
Participants	• All employees	• SPC steering team	• SPC steering team, SPC action team and related personnel to the selected process.
Contents	• Statistical thinking • Quality tools • Overview of process performance • Measurement system	• Data quality and Quality tools and SPC tools and the relation of these tools to current QC/manufacturing practices.	• Theoretical and hands-on approach on control charts, • Sampling and data collection method • Capability analysis OCAP and emphasised on the data analysis and feedback action.

For smaller food companies, they were suggested to collaborate with other organisations/business, customers or government bodies or academics institution for training and support the initial phase of the adoption as the most prevalent resource constraint is financial (Dora et al., 2013a).

The food companies are also suggested to seek for external advice from the consultation companies or academic institutes. Local universities able to facilitate food companies in several ways to embark on their CI journey such as trainings (e.g. statistics and its applications), principal of SPC, tools and techniques of CI; student internship work on the SPC or Six Sigma project supported by an academic mentor, work with the Knowledge Transfer Programme.

8.2.2 Phase Preparation

It was noted from the first finding in the literature, which was that successful implementation requires careful preparation (Oakland and Tanner, 2007). Under the efforts of preparing for the implementation, there are four key important points emerged from the literature, which are; establishing direction of the implementation, the appointment of an SPC leader, establishing SPC team and planning for the implementation.

Step 4 Create corporate SPC vision

Top management needs to create and clearly communicate the vision and mission statements for SPC implementation. SPC should be linked with the company's FQM system to improve food quality and maintain food safety (Kolesar, 1993, Vanderspiegel et al., 2005, Stuart et al., 1996). It is the top management responsibility to draw the direction for SPC deployment in the company complete with a clear target, people involved and budget allocated for the deployment.

Step 5 SPC team establishments

The SPC leader has the responsibility to establish an SPC team, as teamwork is an important element underlying SPC philosophy(Deming, 1986).The team establishment depends on the size of the company (e.g. small company may consists of top management team and SPC implementation team (integration of SPC steering team and action team) and large companies should able to develop the bigger team. Multi-disciplinary team works well in expanding SPC due to its ability to capitalise on the knowledge diversity of the team members, encourage collaboration for better problem solving, innovative decisions and to greater extent of engagement in implementation of proposed solutions (Procontrol, 1994, Costa Dias et al., 2012, Cuevas, 2004). Table 8.2 depicted type of teams, team members and their respective tasks (it is not compulsory to include all the team members listed in the table) (Watson, 1998, Elg et al., 2008, Donnell and Singhal, 1996, Dale and Shaw, 1991, Study and Carter, 1993, Does and Trip, 1997, Mason et al., 1994, Luning and Marcelis, 2007, Herschdoerfer, 1967).

Table 8.2 Type of SPC team, team members and their tasks

Teams	Team members	Roles and responsibilities
Top management team	• Chief Quality Officer • Chief Sales Officer • Chief Supply Chain Officer • Chief Procurement Officer • Chief Operating Officer • General Manager • Sponsors • Executive boards	• Delegate implementation to the SPC steering committee • Monitor the progress reported by the SPC steering committee • Approve training required for SPC implementation • Understand the rationale of SPC implementation and the needs to reduce variation • Integrated values and expectation through division of Vision and Mission statement • Communicate performance expectations to all levels of the organisation • Assign action plan to the stakeholders and the coordinator in order to ensure timely completion of SPC projects. • Appoint an SPC leader
SPC steering committee	• SPC facilitator • Operation manager • Process manager • Quality manager • Quality improvement manager • Purchasing manager • Production manager	• Formulate goals and form teams • Initiate training and program support • Set priority for quality activities • Stimulate SPC awareness through personal involvement • Initiate promotion activities (e.g.SPC news and bulletin boards) • Stimulate team building • Provide strategy for implementation • Advise on quality strategy • Assess results and certify teams when ready • Make sure that the control plan is developed

	• Maintenance manager • Reliability manager	• Provide appropriate budget to realize improvement • Monitor the progress of SPC action team • Assess problems and progress • Report on progress to top management • Apply cost benefit analysis
SPC action team	• SPC facilitator (could be internal/external) • Supervisors • Engineers • Operators	• Bring the process under control • Implement the SPC project (refer to Initiation phase in Figure1) • Resolve out-of-control situation.

The team members should be selected based on Table 9.3 depending on the association of the team members with the process. Type of employee's position is not the only factor necessary for the implementation, but also individual roles (Senior, 1997, Meredith, 1997). According to Belbin's Roles Theory, regardless of the size of the team, team roles should be assigned to the team members —Table 8.3 (Belbin, 1981).

Table 8.3 SPC Team members' roles

Team roles	Description	• References
Leader	A leader is: • Someone who has a great interest in implementing SPC and able to lead the team with high commitment. • a motivator and continuously guides the team members in problem solving by providing relevant materials and clear objective of the SPC implementation. • an important role in creating creative thinking culture in developing team	• (Krumwiede and Sheu, 1996, Gordon et al., 1994, Watson, 1998, Hewson et al., 1996).

	dynamics.	
Sponsor	• SPC implementation required investment from the organisation; hence, the availability of sponsors of SPC project is vital to ease the implementation process. • The sponsors may require providing a variety of resources such as financial aspect, allocating sufficient time for the employees to run SPC projects, workforce and technology required to carry out the project	• (Krumwiede and Sheu, 1996, Bunney and Dale, 1997, Owen et al., 1989).
SPC expert	This role may be selected internally or externally of the organisations. However, as time goes by, the organisation should increase internal expertise based on organisational learning culture, instead of constantly depending on external expertise, which is costly for continuous implementation. SPC expert plays a crucial role in providing knowledge and guidance related to SPC for the organisation to operate SPC in their processes	• (Does and Trip, 1997, Hewson et al., 1996, Antony and Taner, 2003).
SPC coordinator	SPC coordinator is one of the critical roles where SPC deployment is prepared and planned not only to align the implementation with the leaders' vision, but also to communicate the vision across company by providing	• (Dogdu et al., 1997b, Hewson et al., 1997, Kumar and Gupta, 1993).
Users	This role is vital to be included in an SPC team, as they are the people who will continuously face and implementing SPC in their processes. Furthermore, the inputs from the users are crucial because they are the right people to seek for related process information as they deal with the processes all the time	• (Does and Trip, 1997, Dogdu et al., 1997a, Kumar, 1993, Owen et al., 1989).

SPC action team consists of a small number of people with 6-8 people (depends on the size of the company and the complexity of the project) to facilitate the team achieve consensus decisions more effectively(Hubbard, 2013).

Step 6 Plan for the SPC implementation

The SPC steering team has the responsibility to commence the introduction, development and planning of the implementation process (Does and Trip, 1997). SPC in food industry involved with complex processes and raw materials, which requires people to work together, often under time pressure, efficiently and effectively on product that have a tight margin, required a detail and careful planning for the implementation to be a success (Dora et al., 2013a).

This step formulates SPC strategies in line with the vision and mission set up by the top management team. Such planning should cover several aspects such as people, time, tools, training, activities and resources for the pilot projects (Clute, 2008). This step is to ensure the implementation of SPC activities can be operated well with the company environment and availability of facilities and resources.

8.2.3 Phase Initiation

The pilot project is crucial when it comes to providing clear and objective evidence on the benefits of SPC implementation to the company and subsequently to capture the attention of top management team (Efstratiadis M., 2000). Typically, a pilot project can take from three months to more than a year, depending on the complexity and size of the process (Does and Trip, 1997). If this is the starting point of the implementation, the positive outcome should be communicated to the top management (return to the phase A). The company-wide institution of SPC is not possible without top management support and commitment (Hubbard, 2013).

Step 7 Process prioritisation

Identification of potential project brings potential improvement in a process that will result to a significant breakthrough (Antony and Balbontin, 2000). Sources such as production reports, failure cost, customer complaints can help in identifying the problem areas and selecting one area on which to focus (Gaafar and Keats, 1992, Hung and Sung, 2011b, Knowles et al., 2004).Several approaches to carry out process prioritisation are as below:*

- Pareto analysis (singular criteria/requirement)
- QFD and AHP (multi-criteria)
- Prioritisation matrix (multi-criteria)

Therefore, a set of criteria must be developed and should be based on realistic metrics that are easily or readily measurable. The creation of the criteria should focus on the critical-to-quality, critical-to-cost, critical-to-delivery, and critical-to-responsiveness by the food companies (Kumar et al., 2009, Banuelas et al., 2006). In order to accommodate the rapid movement in production site and the shortage of statistical skills of the employees in the food industry, the core SPC team is suggested to develop an AHP template to secure the easiness and motivation for prioritisation (e.g. Microsoft Excel). When carrying out AHP, one must able to provide the sufficient relevant information to:

- thoroughly represent the problem;
- consider environment surrounding the problem;
- identify the attributes that contribute to the solutions; and
- identify the company's personnel associated with the problem.

The success of the pilot project would act as a model for the rest of the company to follow. It is desirable that the finance department is involved from the commencement of the project to guarantee that the cost-benefit analysis is carried out for each SPC project and savings are actually reflected in the bottom-line.

Step 8 Process description

In this step, the selected project should be examined by the SPC team through mapping the project boundaries. The team members are selected through numbering the process steps coherently following real situation of the process (Rungtusanatham et al., 1997). Similar to HACCP guidelines, this step is can be carried out by using process flowchart, process map or VSM(Hurst and Harris, 2013).

It is advisable to assign more than one team members for mapping the process in the manufacturing plant to avoid biasness. In this step, some improvement opportunity can be detected by comparing different work methods, different operators, different shift and engineering information(Does and Trip, 1997). It is noteworthy to highlight the risk of the team might jump to conclusion after detecting several possible cause of the problem at this stage. The other quality tools could be applied in this step such as group voting, nominal group techniques, VSM, why-why analysis and multi-vari charts.

This step is completed when the selected process is defined in terms of its performance, process description form with process step numbers and names, key sub-processes, and other information relevant to the objective of the project. In this step, the team discovers the key processes that influence the critical quality parameter and measures the defects and waste currently generated relative to those processes.

Step 9 Process synthesis

This step identifies critical process parameters and describes the main problems relate it to their effects (the problems should be process related). FQM faced difficulties with identifying and prioritising critical process parameters, chemical/microbiology hazards, and CPs on the scientific and quantitative basis (Luning and Marcelis, 2006). If there are too many cause-effect factors to be assessed (e.g. more than 100), it was suggested to prioritised and choose the most important critical and frequently effected or the relations need to be prioritised using Pareto analysis or multi-voting approach. The usage of CEA, design of experiment (DOE), multi-vari chart, why-why analysis, multi-voting, and Pareto analysis are valuable in this step. For instance, after the team determined critical process parameters, DOE is applied to identify the significant parameters among the listed (Hung and Sung, 2011b, Dalgiç et al., 2011). Multi-vari charts is the best approach to identify the different sources of process variability (shift-to-shift, lot-to-lot, machine-to-machine) (Woodall and Thomas, 1995).

Step 10 Measurement System Analysis (MSA)

Assess the capability of measurement system by identify the variability of gauges or instrument (Montgomery, 2012, Dogdu et al., 1997b).Based on the results in Chapter 5, the main limitation in FQM practices is poor of relevant monitoring systems, lack of proper equipment and use of wrong measuring equipment. Data is needed in the food companies for many critical reasons including for food safety, product quality, legal requirement, customer service, cost control and actionable cost (Hubbard, 2013, Grigg and Walls, 2007a)

In MSA, the application of GRR viewed variability from the perspective of the machine and variability of people in using the machine itself, respectively (Hung and Sung, 2011b, Srikaeo et al., 2005). Based on the Automotive Industry Action Group (AIAG) manual is the rule of thumb:

1. Less than 10%- Acceptable

2. 10% to 30%- May be acceptable

3. Greater than 30%- Unacceptable

Typically, food companies faced the issue of the samples were altered or destroyed during testing, they cannot be retested. Hence, these companies have to consider using a destructive GR&R experiments. Key inputs for the GR&R should be operators and machines (Kovach and Cho, 2011). The company may require re-calibrating the equipment/machines, preventive maintenance, updating the latest model of manufactured machines and increasing the training of operators as correction actions for incapable measurement system (Srikaeo et al., 2005, Kovach and Cho, 2011).

Step 11 Control chart

This step is the foci of the SPC implementation in order to understand the process variation and process mean, detect or avoid out-of-control situation. Once critical process parameters or Critical Points (for HACCP) identified, the next steps are constructing control charts and interpretation of the control chart (Hayes et al., 1997) (refer to Figure 9.2). Construction of control chart contains underlying steps;

1. selecting the type of control chart
2. method of sampling
3. frequency of sampling and
4. plotting the chart.

In terms of sampling methods, sample size for control chart, twenty-five or more subgroups or more than a hundred individual readings give a sufficient good test for stability (Montgomery, 2012). The Operating Characteristic curves can be helpful in choosing the sample size. For the frequency of sampling, typical available strategies are, either to take small, but frequent samples or take larger samples less frequently. The selection of the right control chart is critical to avoid false alarm signal and the selection process is depicted in Figure 8.2 (Montgomery, 2012). It is also useful to distinguish between Phase I and Phase II methods in the applications of control charting (Woodall and Spitzner, 2004). It was identified that mean and range chart are the most applied control charts in the food industry and as for many food productions that run small-batch processes application of short-run SPC charts is available (Pable et al., 2010, Grigg, 1999). The out-of-control signals can be identified by using decision rules for Shewhart control charts, published in West Electric Handbook (1956). Simple tools such as trend graphs, histogram, Pareto chart, scatter diagram typically able to be analysed by the employees, but occasionally a more complicated technique such as AHP, Taguchi and DOE requires the knowledge of SPC experts.

Step 12 Establish Out-of-Control-Action-Plan (OCAP)

In the procedure of eliminating the assignable cause, it is highly suggested to investigate the root cause of the problem and solving it by a standard guideline (Grigg and Walls, 2007b, Fortune et al., 2013). At this stage of point, it is crucial the top management communicate their official support on the employee's empowerment in taking corrective action towards the OOC process (Montgomery, 2012, Schippers, 2001). The SPC team in the company should develop their own OCAP based on the company's environment to accommodate their resources and employees knowledge and skills to carry out the corrective actions. OCAP is an output-oriented alternative, which takes form in the flowchart manner as a sequence of activities that can prescribe actions to remove special causes (Figure 8.3) (Montgomery, 2012). Constructing OCAP does not only contribute to a better organized decision making process and promoting employee empowerment culture, but also become an important knowledge base for the SPC action team members (Hood and Wilson, 2001). OCAP is not a static document as it should be updated and revised reflecting team learned about new knowledge about the process. Food companies need to be careful and ensure that food safety and food regulation is not compromised with the change or correction action. OCAP is the primary step in driving the food companies to *double-loop learning* through SPC implementation, and Senge (2006) explained such approach of learning is required to achieve organisational learning.

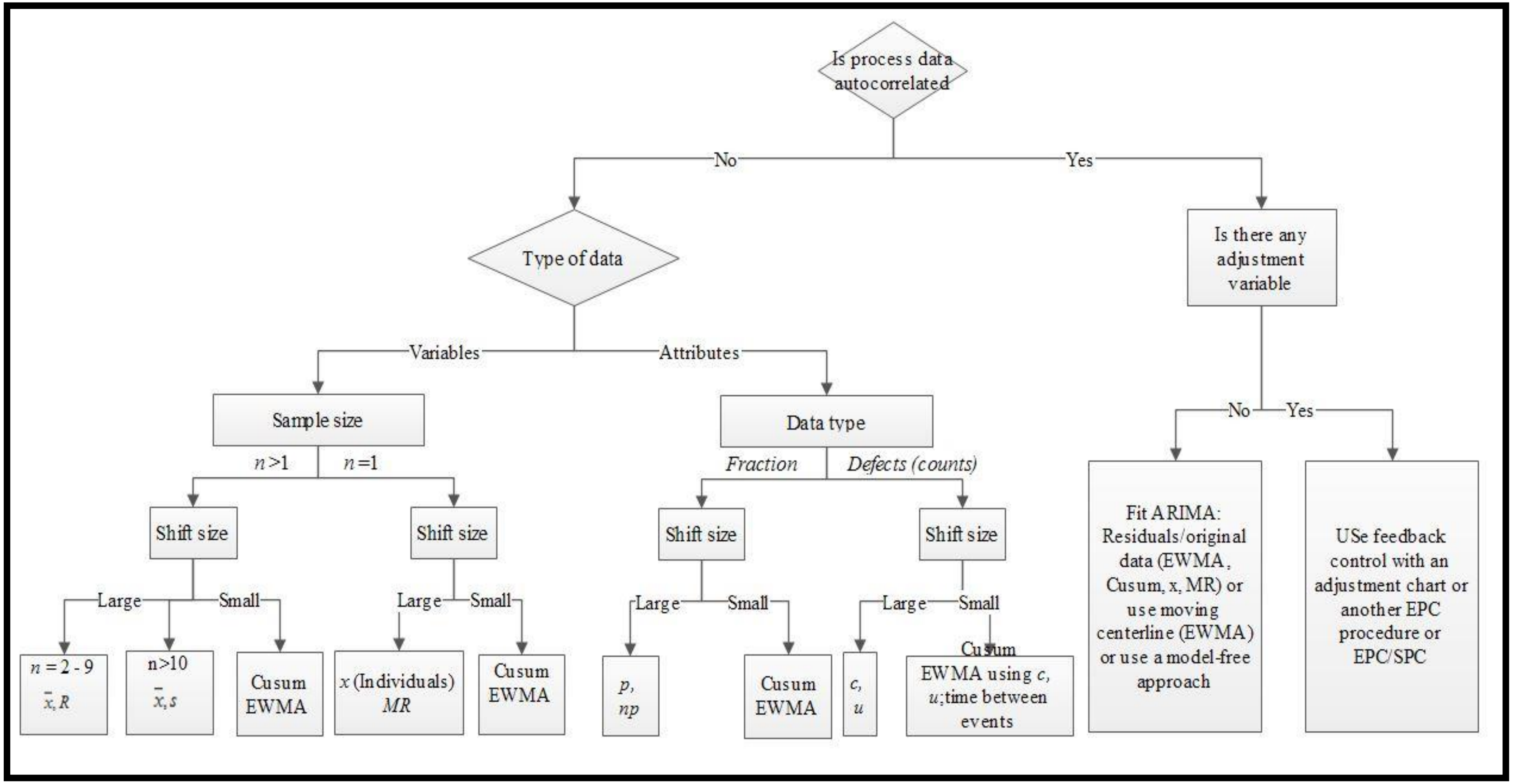


Figure 8.2 Control chart selection flowchart, adopted from (Montgomery, 2012)

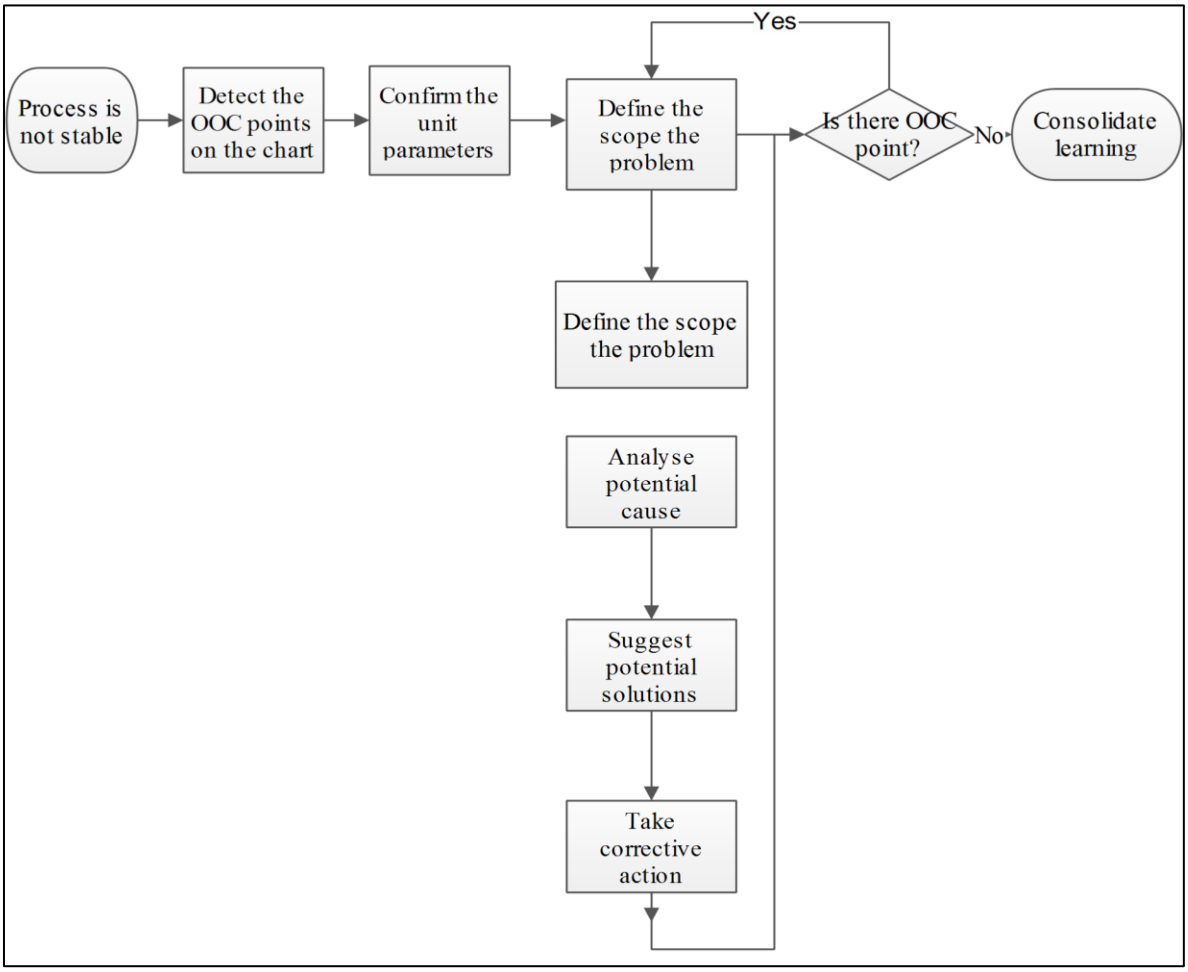


Figure 8.3 Out-of-Control Action-Plan (Montgomery, 2012, Antony and Taner, 2003)

Step 13 Process capability

Many food companies failed to understand the concept of process variation when process capability analysis has not been carried out after the process stability is achieved. The importance of this step (process capability analysis) is to determine whether the process is able to meet customer specifications (Khan and Pervaiz, 2005). Since the process is stable (in statistical control), the number of non-conforming products may be predicted and the usage of histogram may provide the level of statistical control needed (Does and Trip, 1997, Özilgen, 1998). Process capability should be calculated to quantify the ratio between tolerance width and process inherent variation (*Cp* index) and the effect of this ratio due to the variation as well as due to the deviation of the position of the process mean from the target value (*Cpk* index). Process capability analysis measures the variability of a process based on these assumptions; (i) the process in state of statistical control (ii) the data is following normal distribution

(Montgomery, 2012). In the food industry, data is typically not necessarily following normal distribution, mostly non-normal distributed process. There were various approaches to deal with the non-normal data such as data transformation to normal data, extension of the definitions of the standard capability indices to non-normal distribution, modification of the capability indices so that they are appropriate for the common families of distribution (Pearson and Johnson families) (Montgomery, 2012).

Step 14 Reflection

Reflection of the pilot project is crucial in order to assess the initial SPC implementation in the company, which involve evaluation of process performance, financial savings and SPC action team activities (Antony and Taner, 2003, Does and Trip, 1997). Again, the accounting representative is advised to participate in this process in order to measure cost benefits from the project. The pilot project is not considered complete until the target achieved and a team of financial auditors signs off. Cost savings gained from the SPC implementation project should be determined in order to communicate/announce easily the success/failure of the project to the entire company. A meeting with all the SPC steering team and the SPC action team should be held to announce and communicate the result and award the official reward for their results. However, most important activity is to assess the feedback, suggestions, critique on the activities and approaches taken in the project and incorporate such information in the next project plan. Project stakeholders and all the SPC team members should participate in this particular step. The information in this step should be valuable source of information to the next SPC projects, which will be carried out by several other SPC action team.

8.2.4 Phase Institution: Company-wide Implementation

This phase is outlining the activities involved in applying the SPC to other parts of the company. The company should publicise the outcome of the project, widen the participants for training sessions, and promote the opportunities of SPC to implement in the non-production departments so that the culture of statistical thinking and CI is embedded within the organisation.

Step 15 Communicate success of initial project

Financial savings generated and other outcomes by the pilot project should be communicated throughout the companies. Financial advantages are the effective language to convince the top management towards the implementation of SPC. Awareness and recognition towards SPC implementation is achievable through effective communication of successful SPC projects. Several communication strategies are available in most of the food companies such as newsletter, bulletin board, company's webpage, intranet etc. Critical information should be considered in this step are: — widely celebrate and share the success of pilot projects, the appreciation from top management and share the major challenges and pitfalls during implementation of the project. The successful pilot project will reduce resistance of management towards SPC and employees and increase motivation of SPC implementation within the organisation.

Step 16 Company-wide training

Typically, in-house experts will lead this step through the company's SPC implementation plan under the FQM system. The most effective strategy for such training is to start small and build up a bank of experiences and knowledge (Grigg, 1998). SPC training is highly suggested to invite external trainer and later build an in-house training follow up by projects and workshops. Typically, a three-day SPC course is followed within six weeks by a one or two-day workshop (Does and Trip, 1997). The training materials should focus on statistical tools, leadership, change of culture, which wider attendance of employees from different type of department should be encouraged at this point of training sessions (Efstratiadis M., 2000). Based on the previous empirical studies, the training should offer different level of training due to the employees in the food industry acquired big range of knowledge level in CI and statistics in particular.

Step 17 Progress evaluation systems

SPC steering team is responsible to continuously monitor the performance of critical processes. Having a good performance measurement induce target areas with the opportunity of improvement, to be identified and has a key role in communication (Oakland and Tanner, 2007). This step is to ensure SPC implementation does not stop only at the pilot project, but continuously applied in other quality improvement projects. In this step, the SPC team should develop standard procedure for reporting the project, communicate the good and poor results to the employees, the owner of the processes are accountable to report on their own process performance, and a monthly review for the on-going projects should be established.

8.2.5 Phase Sustainability

The sustainability phase accentuates on the efforts to continuously reaping the benefits from the implementation of SPC and learns from the previous implementation phases that could be transferred, managed and reacted across the organisation on a continuous basis. Such efforts including maintaining the in-house SPC expertise and provide a mean of motivation for other employees to implement the technique. The principle idea behind this phase was to ensure the knowledge and other benefits generated through SPC implementation are sustained in a long term basis.

Step 17 Maintenance of in-house expertise

Sustaining SPC implementation is definitely challenging as the food industry has limited employees expertise in statistical knowledge (Grigg and Walls, 2007). In SPC implementation, it is imperative to make sure knowledge transfer within the organisation is actively progressing in order to increase the number of in-house expertise (Davis and Ryan, 2005), 1998). The results from the empirical studies in this study reveal that the high employees' turnover causes difficulties for the food companies to maintain their in-house expertise. Continuous awareness training session and workshops can help the company to achieve such objective (Bidder 1990; Hubbard, 1999). The company, which has not implement SPC and has no SPC expertise in the company, the SPC facilitator should be hired externally to provide training sessions and facilitate the company in the implementation. Knowledge management is arguably critical for such situation, to ensure the company develop in-house expertise (Grigg and Walls, 2007a).

Step 18 Towards learning organisation

The implementation of SPC has a role in nurturing learning culture in the company. Senge (2006) posits that the notion of organisational learning is through systems thinking, team learning, shared vision, individual mastery and the use of highly sophisticated mental models. Learning organisation depicts characteristics such as: open communication without fear or criticism, learning through teamwork, employees empowerment for making decisions, action and result focus and wide learning opportunities (Denton, 1998). A regular review session should be established monthly for on-going projects, while the past performance tendency should be subsequently updated together with updated information (Raper et al., 1997). Benchmarking and learning from best-practice of internal and external competitors will continuously keep company in the momentum for CI(Mann and Adebanjo, 1998). Senge (2006) highlights the need for organisations to become learners (e.g. single-loop learners and double-loop learners) towards achieving organisational learning. SPC implementation characterised double-loop learning by questioning adequacy of data reflected true variation demonstrate by the process, the governing variables to the process, appropriateness of corrective actions through OCAP plan taken in response to the data (Grigg and Walls, 2007). Many researchers believe that benefits of learning organisation towards food companies are that learning became mainstream activity, constant learning leads to continual change and learning facilitates response to change (Grigg and Walls, 2007b, Martino and Polinori, 2011) .

Step 19 Reward system

Reward system should be designed to appreciate and motivate the employees to display their commitment to quality and seek opportunities to involve in the SPC implementation, and attract and maintain people with knowledge and expertise. By this, they will show the skills and abilities needed to achieve the company's strategic goal to create a better process performance and subsequently superior organisation (Scott et al., 2009). One of the causes of failure in deploying and sustaining SPC is that the management has ignored the fact that the deployment of SPC can lead to unintentional improvements in intrinsic reward (Rungtusanatham, 2001).

8.3 Summary

The SPC implementation has not always been simple task for many food organisations. There is a paucity publication in the implementation aspects of SPC, which describes on where, when and how to get started. This chapter highlight the importance SPC Readiness Assessment Tool and synthesis on SPC implementation roadmap framework tailored to the needs of the food industry. Both were developed based on the critical literature review and key findings from an empirical research conducted over a 3 years period.

Following the organisation readiness theory, adoption of new technology such as SPC work best in organisations that are prepared for their implementation (Weiner, 2009). Therefore, the food companies were advised and required to assess their readiness using the SPC Readiness Self-assessment Tool. It was designed to point-out strengths, weaknesses, and improvement opportunities in process management practices under the FQM program, subsequently, provide a signal their readiness to initiate the SPC implementation.

This chapter finalised the five-phased SPCIR after a through qualitative work on exploring, refining and validating the SPC implementation framework through the action research in the previous chapter. The framework highlights the importance to be prepared to commit for the SPC adoption, roadmap to adopt and deploy the SPC to the whole company and sustain the benefits for long-term period. In the SPCIR Phase 5 suggests the approach to sustain the benefits from SPC implementation by focusing on the intrinsic motivation of employees and organisational learning practices across the firm.

The customised developed SPCIR for the food industry enable the managers to strategically plan their SPC implementation in the company. This will provide the managers a holistic picture of the SPC implementation starting with a pilot project until the deployment of the technique companywide.

CHAPTER 9 — CONCLUSIONS AND FUTURE RESEARCH

9.1 Introduction

In this chapter the quality, originality and contributions of this doctoral research are summarised. The research questions were addressed through the achievement of the research objectives: RQ1 and RQ2wereaddressed in Chapters 2 and 5; RQ3 in Chapters 3 and 6 and RQ4 in Chapters 3 and 7. RQ1 called for the systematic review of previously published studies on the SPC implementation in the food industry and determination of future research agenda (see Chapter 2). Assumptions (factors affected the adoption of SPC) derived from the literature review were then tested in the survey, and the data were later discussed further in the case study (triangulation of methods) (Chapter 5). The literature highlights the lack of guidance to implement SPC as a research gap in the study of SPC within the food industry, RQ3, where an action research was carried out to address the practicality of developing a roadmap by learning from action. Finally, RQ4 was addressed using an exploratory study involving the collection of consensus answers from a panel of SPC experts, comprising academics, food industrial practitioners and consultants. This chapter will explain the validity and reliability of the findings and discuss the contributions of the study to theory and practice. It concludes by describing the limitations of the research and offering the personal reflections of the researcher towards this doctoral research.

9.2 Critical reflections on the research questions

The main objective of the thesis is to contribute, theoretically and practically, to SPC implementation literature. The research began with a broad question: How to successfully implement SPC in the food industry? Four research questions were formulated following the research gaps identified in the systematic review:

9.2.1 RQ1: What is the status of SPC implementation in the UK food industry?

In addressing the gap in the body of knowledge of SPC, this research identified the widespread of SPC application in the UK food industry is still slow, with 45% of 59 participating food companies applied SPC. The result depicts a static state for its widespread in this sector since seventeen years ago, based on the comparison with a similar survey by Grigg (1998). Furthermore, majority of the SPC users aware and applied basic control chart such as $\bar{x}$-chart and S-chart, although food productions is known for its complexity, which mostly appropriate for multivariate SPC (Cinar and Schlesser, 2005, Montgomery, 2012). It was identified contextual factors such as size of the organisation and commodities of the main product affected the adoption of SPC in this sector. However, certifications such as ISO 9001, ISO 22000, HACCP, and BRC have no significant impact on the adoption of SPC. It was identified although such certifications required processes to be systematically managed, but there is a lack of recommendation to apply SPC and SPC implementation guidelines are not provided.

9.2.2 RQ2: What are the organisational factors that critically inhibit and facilitate the SPC implementation in the context of UK's FMI?

The literature identifies the CSFs of SPC implementation as being top management commitment, reliable measurement systems, understanding of statistical thinking among employees, training of employees, communication, employee empowerment and the availability of SPC expertise. The empirical findings in this study indicated a new CSF for SPC implementation: the appointment of a dedicated SPC leader.

This study identified the lack of training for CI initiatives and the lack of awareness on SPC as common inhibiting factors (Lim et al., 2014). The interviewees explained that food companies are highly pressured to ensure safe food product, and therefore, their employee training on food safety systems is the focus of their training programme rather than CI practices (Lozier et al., 2012). The empirical research in this study identified that internal resistance to change has been stated as a significant barrier that validated the result in the literature. Case studies (Chapter 5) revealed that although employees may not express open resistance, it may be evident in their actions during the implementation process. Other barriers to the implementation of SPC in food companies were identified to be poor measurement systems, lack of data collection systems and lack of statistical knowledge and experience in CI implementation (especially SPC).The type of learning involved in the SPC implementation is *single-loop learning*, although *second-loop learning* is possible only if the control charts' result pointed lead to the change of current system in the company. The slow widespread of SPC and the high resistance lead to the investigation of the reasons for food companies do not adopt SPC. It was revealed that the lack of awareness of the existence of SPC and the lack of knowledge of the underlying philosophy of SPC and its advantages. Again this is contributed to the lack of training to educate and update quality improvement techniques to the employees (Dora et al., 2013a).

9.2.3 RQ3: How to successfully implement SPC in a food company?

The implementation of SPC was found to be a complex and challenging process for the food industry. Some SPC implementation frameworks, many of which were originally developed for the automotive and electronics industries have been developed. Therefore, SPCIR specifically developed to provide the food companies with a structured approach to the implementation of SPC and help the industry reach its full process improvement potential. As it is equally important to sustain implementation over the long-term, this framework focuses on fostering employee motivation and organisational learning.

9.2.4 RQ4: How to enable food companies to assess their organisational readiness to adopt SPC?

A self-assessment SPC readiness tool was developed by the researcher following a careful review of the readiness models described in the CI literature (Abdolvand et al., 2008, Aksu, 2003, Elgamal, 1998, Hensley and Dobie, 2005, Lagrosen et al., 2011, Lameei, 2005, Lee et al., 2011, McNabb and Sepic, 1995, Snyder-Halpern, 2001) and complemented by the findings of the empirical Delphi survey of SPC experts. The tool assesses a company's preparedness for SPC adoption based on its score against five critical readiness criteria. It investigates the current state of readiness of participating company to assess its capability in initiating SPC implementation.

The literature on organisational readiness to change theory suggests that organisational readiness reduces resistance to change and facilitates the adoption of SPC without major disruption. When the self-assessment SPC readiness status was tested in three food companies, their readiness scores reflected their existing quality management practices, indicating the validity of the designed index. The readiness index represents a novel contribution and eventually be of practical use to food companies wanting to assess their preparedness for SPC implementation, though it requires further testing in a bigger number of companies and across different size of companies.

9.3 Quality of the research output

Before accentuating the contributions of this study, it is essential to explain the quality of the study for the findings to be regarded as valid. The research quality criteria (see Chapter 4) were derived from the literature; in this chapter, these criteria are used to evaluate the research approach employed. Concern has been expressed that the difficulties involved in implementing multiple research procedures may make it harder to draw accurate inferences from the results. Teddlie and Tashakkori (2009) therefore argue that mixed-method researchers should use the sets of standards below to assess the quality of the inferences generated:

- They should evaluate inferences derived from the analysis of quantitative data using quantitative standards
- They should assess the degree to which the meta-inferences made by these two sets of inferences are credible (this is difficult when the two sets of inferences are inconsistent)

The following section discusses the steps taken to assess the quality of the each research method employed in this study.

9.3.1 Survey

This study has adopted two surveys: — descriptive survey (Chapter 5) and Delphi survey (Chapter 8). The survey quality was assessed regarding the criterion validity and reliability of the measurement scale as depicted in Table 9.1.

Table 9.1 Quality of survey research (Dillman, 2000; Forza, 2002)

Quality criteria	Activities to achieve them
Criterion validity −The ability of the scale to investigate the relationship between predictor variables and the external variable (objective outcome or criterion).	*Comparison/contrast of the performances of SPC and non-SPC companies against fifteen process performance metrics drawn from the literature.
Content validity−The ability to measure the extent to which the content of the items in a summated scale truly measures the concept it intends to measure.	*An extensive review of the literature was undertaken to design and develop the questionnaire. *Input also sought from two academics and two industrial practitioners.
Reliability−Consistency of a measure of a concept.	*Cronbach-αvalue is 0.87, higher than 0.70, indicating the consistency and reliability of the

		questionnaire. Existing Validated instruments were adopted (from the literature) for most of the study variables.

*= YES this research quality criterion is achieved in this research

Construct validity does not need to be tested when the survey instrument does not use multiple-item measurement scales (Rungtusanatham et al., 2003). In this case, there were a limited number of multi-item questions in the survey instrument, rendering the construct validity test unnecessary.

9.3.2 Case study research

Steps were taken during the design, data collection and analysis stages to ensure the case studies met the research quality criteria described in Chapter 4 (refer Table 9.2). Some of the results of the qualitative research were verified with the data from the survey research to ensure the credibility of the sequential research design.

Table 9.2 Quality of case study research

Quality criteria	**Suggested tactics from literature**	**How quality was achieved in this research**
Construct validity– **Appropriate operational measures for the concepts being studied.**	• Use multiple sources of evidence • Generate chain of evidence • Review draft case report	**Multiple sources of data, (methodological) triangulation, systematic case reporting, literature. *The case study themes were developed from an extensive review of CI implementation literature. **The draft case reports were reviewed, and changes made where necessary in light of case companies' comments.
Reliability– **Similar observations are**	• Case study protocol • Case study database • Verify the results	*Case study protocol (seven themes) **Case study reports

reached by other observers. Data analysis and findings follow a clear process to avoid complication and idiosyncrasy.		*Cross-case analysis
Internal validity– **Standard of research refers to setting up a causal relationship.**	• Pattern matching • Explanation building • Logic models • Matrix of categories • Data display (flowcharts) • Tabulating frequency of different events	**Use of pattern matching, narrative and matrix of categories.

*= YES this research quality criterion is achieved in this research

**=TO SOME EXTENT this research quality criterion is obtained in this research

9.3.3 Action research

As validity is the term from traditional positivist science and has connotations of proof and replication of a study, a quality of AR studies can be justified within its terms, which in this study the criteria to assess the research using Shani and Pasmore (1985)'s recommendations (Chapter 4). The quality of AR studies is evaluated regarding two principal dimensions, as shown in Table 9.3.

Table 9.3 Quality of action research

Quality dimension	**Quality criteria**	**How was quality achieved in this research**
Inquiry process	• Use multiple sources of evidence • Repeatable process of learning and	**Multiple sources of data: documentation of the production line, meeting minutes and reflective notes. * Each AR cycle involved diagnosis, planning, implementation, followed by

	knowledge creation .	observation and evaluation of the results to plan further action.
	• Joint-meaning construction	*The SPC team gathered (with researcher) to document and made sense of the project data. *Reflect upon the documents of the assignments and review feedback from the companies. **Stage-by-stage plan developed for the AR to ensure the quality of the research data, companies' motivation and process performance. **Issues that arose were discussed and resolved.
Implementation process	• Research responds to a genuine problem identified in the company	*The AR project was selected based on the prioritisation process in Chapter 7.
	• Solutions are workable	**The conceptual SPC implementation roadmap framework was validated through AR for process improvement project.

*= YES this research quality criterion is achieved in this research

**=TO SOME EXTENT this research quality criterion is met in this research

By carrying out the activities to guarantee the quality of the data above, the action researcher was able to understand the generated data, test the assumptions (based on literature) and reflect upon the issues of the AR project (Middel et al., 2006). According to Eden and Huxham (1996b), in action research:

"The researcher becomes involved in and contributes to the practitioner's world, and contributes directly to the form of the research output".

The SPC implementation roadmap was designed and articulated based on the real experience and the reflections on the conceptual SPCIR explained in Chapter 3. The team members have formulated workable solutions towards challenges for the SPC implementation especially the activities that are observed lacking in the food industry including training, measurement system and team development that aligned with the company's environment.

The objective throughout the research process was then to present the most reliable and quality results to answer the research questions in Chapter 1. The researcher has ensured that appropriate research methodology was defined, and research output quality was justified from the quality assessment described above. Both research approach and its quality were further established from the discussions with leading academics at doctoral symposiums in research methods, academic conferences and methodology courses added to this.

9.4 Theoretical contributions

Every doctoral research study is expected to contribute to theory/knowledge by presenting something new or adding value to what is already in the literature. For example, it may validate existing theory, extend an existing theory into emerging new research areas; advanced methodology by developing the application of research techniques; or develop and test hypotheses, grounded theories or insights (Wacker, 1998).

The study contributes to theory in the areas of operation management and extending the theories of OL and organisational change readiness by advancing research in SPC implementation. This study builds on earlier theorising CI activities promotes OL, and OL facilitates the sustainability of its implementation (Locke and Jain, 1995).

Theoretically, this study categorised OL as a process of creating, retaining and transferring knowledge in the organisation under the implementation of SPC. This study is filling the gaps of many previous publications in OL — interlinks both OL theories and SPC under CI philosophy. OL studies have expanded since the 1990s. However, the literature is short of explaining the activities endeavouring OL under SPC implementation. Among many other types of research in OL, this study focuses on the identifying type of learning within the SPC implementation through OL model (e.g. double-loop learning, single loop learning) (Argyris and Schön, 1978). Double-loop learning is claimed to be a critical factor for sustainability of business excellence, although it is found activities in SPC depicted single-loop learning.

SPC application is used to indicate the existence of a problem in the process (may due to common variations or special variation), which triggered an act for improvement. This study identified that if an ad hoc correctable cause is identified, then single-loop learning is adequate to maintain the process in control. However, double-loop learning may exist in the corrective action under the SPC implementation as there are changes in objectives, norm and policies, of the company (e.g. the MSA caused the case company to review the procedures for measuring critical quality parameters) (Argote and Miron-Spektor, 2011). It was a common cause of variations is excessive, improvement activities are required, and, therefore, the control chart will lead to re-assessment of the existing governing variables, which characterised double-loop learning. The results identified the integration of SPC with other processes improvement techniques such as DOE and Taguchi method able to increase the opportunity for double-loop learning in the organisation. For instance, in applying DOE, the cause-and-effect analysis will be taking place where all the possible causes will be assessed and usually will be tested by a series of experiments (Hung, 2011). DOE effectively pointed the factors which causing the problem and reveal the key factors and significant interactions between the factors. DOE application for the improvement of the quality of cake regarding its size and texture (in the action research's case company) indicates the possible need to change and re-assess the supplier, ways of training, the recipe and the way of mixing.

This study also identified that *double-loop learning* in SPC application is through statistical thinking. Statistical thinking is questioning the quality of data in reflecting true process variation, reflecting *double-loop learning* by assessing the governing variables and questioning the adequacy of the actions taken in response to chart data. Typically, the action plan towards the OOC situation is not systematic, and highly suggested the employees to report such situation to the supervisors and managers. However, the process within OCAP will require the involvement of the employees that indicate the need to change the approach for reaction activities from the typical action plan. Within the OCAP, investigations for the root of the cause will be carried out, in which the usage of experimentations, CEA and brainstorming were involved. Actions taken based on the investigations may require the change of production line, the recipe and system, which indicate the application of *second-loop learning*.

Integration of OL theories into the operations management context, the result of this study is relevant to multidisciplinary studies (Murray and Chapman, 2003, Grigg and Walls, 2007b). Furthermore, the development of the implementation roadmap was developed in light of statistical thinking, which was found poorly understood by the food practitioners (Grigg and Walls, 2007a, Bjerke, 2002).

Another critical component considered is the inherent conundrum of SPC adapted from theories of organisational change readiness explained by Armenakis and Harris (2002), Holt et al. (2007a): ─ the state of organisational readiness plays a crucial role in creating preparedness for the SPC adoption and can be a significant reduction in the need for management of resistance to change. Following organisational changes theory by Armenakis and Harris (2002) and Lewin (1946), three distinct phases (readiness, adoption and institutionalisation) unfolded in any changes or new technology uptake in an organisation. Current literature is unable to provide information on the readiness aspect within the SPC implementation. Therefore, this study contributed to the first phase (readiness or unfreezing phase) towards organisational change through SPC implementation.

This research extended the organisational readiness theory within the implementation of SPC by the determination of five SPC readiness factors: − top management support, capable measurement system, sense of urgency, employee's involvement and organisational culture readiness. The study provided differences on types of SPC readiness where it may be clarified as a "state" and "process". The SPC readiness "state" is determined after the organisation preparedness is assessed against the SPC readiness factors. Meanwhile, readiness is a "process" that involves the efforts of the organisations to improve the preparedness of an organisation on the SPC readiness factors.

Although the organisational change readiness is viewed as pivotal in reducing the resistance to change (Self and Schraeder, 2009), the results of this study aligned with the theory of organisational readiness ─ readiness and resistance are not polar opposites on a linear continuum (Self and Schraeder, 2009). Based on the results of this study, it was identified that reducing the resistance of the implementation does not secure the organisational readiness towards its implementation. For instance, the empirical study in the action research (Appendix J) shows although the company portrayed acceptance towards the technique, the poor measurement system (e.g. the inappropriate tools applied to measure the cake) caused the challenges in acquiring a quality data.

This study depicted distinct phases on the uptake of SPC in the food companies (e.g. readiness and implementation), which its empirical studies validated the organisational readiness theory ─ the target of readiness phase is different from implementation phase (Weiner, 2009). Based on the literature, the proximal results for the SPC implementation is likely to be an effective implementation (consistency of the employees' use on the new practice or technology) (Klein and Sorra, 1996). This research highlights that organisational readiness for change does not guarantee that the implementation of SPC will succeed in terms of improving quality, safety or some other expected outcome. It was observed that the implementation effectiveness is necessary, however, it is not a sufficient condition in achieving a positive result of the implementation (Klein and Sorra, 1996). For instance, a case study company that previously achieved the readiness state to pursue SPC, has reported that there are SPC projects have not achieve the target cost saving. The main reason for this is identified due to the poor implementation plan (e.g. (small impact project) fail to perform project prioritisation and cost-benefit analysis, fail to identify critical process parameters)). This study also suggests that the organisation has the risk misjudge organisational readiness by overestimating/underestimate their capabilities in adopting the change (SPC implementation).

Phases in the SPC journey not only involved the initiation, and implementation, but the sustainable phase is also considered significant. One of the principal aims of improvement initiatives is to ensure that the changes that have been undertaken are sustained over the long period and support continuous improvement. The study identified that sustainability is highly contingent upon employee's acceptance of change as an opportunity for participation as depicted from the readiness factors determined in this study (Kuntz and Gomez, 2012).

9.5 Practical contributions

Companies deploy quality techniques such as SPC with the purpose this technique improve the process performance and increase the competitive advantage of the business. The main challenges in managing the SPC adoption is highly consolidated by the poor understanding of the technique, lack of statistical knowledge, high resistance to change, and the lack of systematic guidance limiting a successful implementation (Lim et al., 2014). The present research takes a practical approach to contribute to the strategic and organisational thinking on SPC programme based on the information determined by CSFs and barriers. This study showed a distinct idea of the foundational structures that are needed to initiate and implement a successful SPC programme in the food manufacturing sector through the development of SPC implementation roadmap framework and SPC self-assessment readiness tool.

The study is of value to the food manufacturing industry since the study encapsulated the challenges, motivations, benefits and CSFs for SPC application in the food industry into the SPC implementation framework, and considered the critique of present frameworks through reflection activities within the action research study.

The implementation framework offers comprehensive five-stages guidelines for management not only at the organisational level but also at the project level. This dual focus is important because the performance at project level has a major influence on the success of the companywide deployment effort (Lim et al., 2014, Antony and Balbontin, 2000, Hersleth and Bjerke, 2001). The framework has provided a twelve-step practical roadmap for a successful pilot project in the initiation phase, which has rarely presented by the previous literature. Prior research has shown the significance of the pilot project to towards the institutionalisation of the technique (Antony and Balbontin, 2000). This study has pointed out seven critical factors as the key ingredients to complement the SPC implementation roadmap framework, namely: --top management commitment, training programme, statistical knowledge, engineering skills, teamwork skills, engineering skills, organisational culture and SPC leader. In improving its practicality, appropriate practices and decision-making tools (e.g. CEA, nominal group technique, multi-voting) are provided to operationalise each phase.

SPC implementation is strategic in nature as it involves investments and efforts, which hence, the managers were cautious planning a strategic approach to the implementation of the technique companywide. Considering such situation, this study attempted to provide a tool to enable the managers to perform readiness assessment. Food manufacturing industry constitutes of multiple contexts and unique features of processes, hence, the study of readiness factors deserve further attention (Luning and Marcelis, 2007). This study is relevant, practical, and useful to both practitioners and academics to provide a summarised itinerary of organisational constraint that will enable them to assess the readiness for the adoption of SPC. This study is then striving to endeavour the development of the self-assessment SPC readiness tool. Reflecting on the readiness factors derived from a consensus opinion from the SPC experts, a decision can be made as to whether the current state of the organisation is favourable toward piloting SPC initiatives.

This study contributed to the current literature in validating that size of the company impacted the adoption of SPC. Based on the literature, small food companies were observed to face limitations regarding resources, workforce and knowledge. The readiness self-assessment tool developed in this study has the potential to increase a successful adoption of SPC and subsequently to bridge the gap between small and big companies towards the adoption of SPC. The readiness study of SPC allowed the smaller food companies to assess the required preparedness to initiate their SPC journey, which later ensure a successful adoption of the technique.

In the early stage of this study, it was observed that food practitioners are sceptical about the applicability of SPC and the capability of such technique to contribute to the company's operational excellence (Lim et al., 2014, Hersleth and Bjerke, 2001). The findings of this study have pointed that although food industry possessed unique characteristics of production processes, SPC is effective towards the improvement in process performance. This study identified SPC is advantageous in the food manufacturing industry through a comparison between SPC and non-SPC companies' process performance − SPC companies outperformed non-SPC companies. As the process performance metrics used in SPC food companies differ from those used in non-SPC companies as a few of critical metric such as process capability is highlighted by the SPC companies.

9.6 Limitations of the research

Limitations of research may be due to the design of the study, sampling methods, and/or execution of the research. Hence, all of these are considered in drawing of valid research conclusions and the related methodological observations.

Firstly, this study considers its limitation regarding the scope of the study, where the research focuses on only one side of the food industry: food manufacturing. In the SPC implementation, production and manufacturing are the conventional contexts for the technique, however, in these recent years, service context is viewed able to depict the advantageous of such technique implementation (Hensley and Dobie, 2005, Lim et al., 2014, Pena-Rodriguez, 2013). It does not consider SPC implementation in another context of food industry such as food service (e.g. distribution and fast food retail), where SPC might be used to improve both product and service quality (e.g. reliability, the speed of delivery, contamination of food) in this industry (Beardsell and Dale, 1999).

This research seeks to assess the level of SPC implementation in the UK food industry. However, the response rate from the survey study was low (16.8%) ─ it was reported such issue is common in the food industry (Dora et al., 2014). The usage of exploratory study was guided to has no minimum required some samples (Easterby-Smith et al., 2011). Extending the research to a bigger sample size study may provide more generalisable research result.

In this study, eight case studies were conducted, but this might be criticised as being too few for generalisation. However, the primary purpose of the case study was to gain greater insight into a range of SPC implementation themes such as team development, approaches to problem solving and organisational learning practices, through within and cross-analysis. Researcher bias is an inherent limitation of the case study method, but in each phase of the case study, data was analysed as objectively as possible through the usage of the case study protocol. In improving the reliability of this research, the findings were verified with respondents. This section explained that for every degree possible, the researcher considered all the measures required during data collection and analysis to overcome all such limitations.

As this is one among very few studies on SPC implementation in the food industry and the first in developing the implementation framework, the author decided to conduct exploratory research – the research theme and findings evolved from the study. The focus of the study was not, in general, to establish causal relationships between variables nor was any attempt made to compare the findings from this research with those from other industries.

The main weakness of action research is the subjectivity of the process and risk of biases; in this case, the researcher was also SPC facilitator for the pilot project. The researcher reduced the likelihood of research bias by: (1) using the conceptual SPCIR as a guide for the pilot project, (2) To increase the accuracy of the data and to reduce the limitations (bias of the researcher), the results of action research were presented to the participants.

9.7 Research conclusions

It was emphasised that SPC has been a powerful process improvement technique that its implementation accrued beyond financial benefits with wide applications in manufacturing industry. However, it was observed the lack of SPC application in the food industry instead, although quality control is a vital activity in the food production. By tracking the growth of three decades of literature, it was evidence that SPC applies to the food manufacturing, but its usage is not as widespread in other manufacturing industries (e.g. electronic and semiconductor, automotive), with 45% of the survey sample.

Exploration of SPC implementation in food companies showed the importance of training in SPC, top management commitment and reliable measurement system along with some other CSFs. The use of SPC tools showed that food companies, most using basic Shewhart charts such as $\bar{x}$-chart and *s*-chart compared to multivariate control charts, although the critical quality parameters of food products have always been more than one. Lack of training, poor understanding of SPC and statistical thinking and staff turnover during projects or after training are the prominent challenges. The assessment of the reason for not implementing SPC depicted that lack of awareness on SPC and its advantageous, high complacency or lack of urgency, poor measurement system are the main factors. Such information prompts us to further understand the unique nature of food industry and develop a customised implementation framework in implementing SPC.

The framework developed using empirical research based on theory-in-use, is an attempt to understand the phenomena of SPC implementation in food manufacturing organisations. The study contributes to SPC knowledge through the development of theory and practical framework to advise both managers and academics attempting to implement or study SPC in the context of the food industry. The framework considered CSFs and challenges, and tools and techniques, which will act as a guide towards SPC implementation in the food industry. The significance of the framework lies with the use of guidelines in a cookbook fashion as well as addressing some of the practical difficulties in the implementation of SPC.

It was observed that organisational readiness plays a significant role to reduce employee's resistance and improve the chances of SPC implementation sustainability. Therefore, the second objective of this study is to give insight into SPC through operational management aspect of assessing SPC readiness factors in the food industry. The researcher has established a set of SPC readiness factors and developed an SPC readiness self-assessment tool and SPC implementation roadmap framework through theoretical conceptualisation and empirical validation.

This study has provided a refinement of the current body of knowledge in SPC implementation approach. Through answering the research questions, RQ1 and RQ2, this thesis refines the current body of knowledge in operational management and updates the status of SPC in the UK food industry. It identifies the main organisational readiness factors for adopting SPC (top management readiness, measurement system readiness, organisational culture readiness, the urgency to change and employee readiness) and explains how they affect the implementation phase. It also shows that facilitating factors differ depending on the phase of the process (SPC readiness factors are not necessarily the same as CSFs in the implementation phase).

9.8 Agenda for future research

Further research is needed to address some of the procedural problems identified in the limitations section and further extend the investigation of SPC in the food industry.

Transferability – transition from one pilot SPC project for a wider implementation

Although this study covers the implementation of SPC and its deployment across the whole organisation, it does not consider how a pilot project in the production department can be transferred to other business units. Many companies find this is challenging, especially when it comes to service-based business units such as the human resource department and administration (Tsung et al., 2008). Wood (1994) highlighted that the managers of service processes in need of monitoring systems and quality improvement just as much as the managers of manufacturing processes do. However, the problem relates to adapting methods that have developed in a manufacturing context to service context. Future studies might investigate the facilitating factors in the transfer process and highlight these for the benefit of quality managers in planning for companywide SPC implementation. Moreover, currently, many organisations have taken the initiatives to implement quality programmes such as Lean, TQM and Six Sigma. However, the scope of this study has not covered the usage of the results of this study under the powerful quality programme such as Six Sigma and Lean Six Sigma. SPC is a critical component in the Six Sigma implementation where under the DMAIC process, it is useful in measure phase to assess the current performance of process and measurement system, and in the control phase to ensure the variable identified in the improvement phase can be maintained over time (Woodall and Montgomery, 2014). Therefore, further research in co-ordinating SPC under such quality programme would be exceptionally useful.

Maturity model

The research covers to SPC implementation roadmap (SPCIR) and SPC self-assessment readiness tool, but the proposed framework does not help the quality managers to assess the maturity of SPC in their company or identify the next step to take for its development. The researcher argues to assess the collection of organisation-specific behaviour routines, which indicates "the way things were done in the company" (Bessant et al., 2001, Grigg and Walls, 2007a). Based on the empirical studies carried out in this research, the participated companies portrayed the different level of SPC usage, and such factors contribute towards the process performance and sustainability of the technique (Paulzen et al., 2002). Understanding of the evolution of SPC programme in a company does not only facilitate to improve SPC practices but also enable sustainability of its application in the company is achieved (Bateman and David, 2002). In order to develop a maturity model, the activities involved are collecting and analysing a gradual accumulation of routines which constitute particular abilities within the companies that depict behaviour change towards SPC implementation (Bessant et al., 2001). The existing maturity models are in evolutionary of CI by Bessant et al. (2001) and Crosby's Quality Management Maturity Grid by Crosby (1980). However, the criteria applied in the models above may be inappropriate to assess the evolutionary of SPC application, which calling for further research.

SPC readiness feedback action and scoring system

The self-assessment tool assesses companies' preparedness to initiate SPC using three different levels: red= not ready, amber=maybe, green=ready. However, it would be more useful if the self-assessment tool also able to offer feedback or suggestions for corrective action, especially for companies who are not ready to adopt SPC, to help them raise their performance. There is thus a need for empirical studies in developing a practical feedback action system.

The majority of previous studies on SPC implementation have been theoretical and have assumed that the relative importance of individual CSFs remains the same throughout SPC deployment. However, the results of the present study suggest that the critical factors in the readiness phase do not necessarily remain the most important in the implementation phase. Further empirical studies are necessary to determine which

CSFs are the most important in each phase of SPC implementation. This would allow quality managers to focus on the relevant CSFs in each phase.

The usage of SPCIR in other industries

Recently, quality management researchers and practitioners have been paying their attention to the application of quality programmes within the service industries especially public sectors, such as healthcare and higher education, however very few have been carried out in the food industry (Thor et al., 2007). As explained in section 9.6, this study focuses on the food manufacturing industry; however, food service industry was not covered. Food services constitute another food outlet for consumers and it is one of the major components in the food industry (Wijnands et al., 2007). The implementation of SPC in the food services is an important area within the food industry for future research, especially as the performance and quality indicators in the food services sector are significantly different from those in the food manufacturing (Lin, 1991). The waste and productivity in the food supply chain are common issues discussed by the practitioners, which its monitoring and reduction demand a systematic approach (e.g. SPC), where SPCIR is highly recommended to be tested in such area of the food chain (Vlachos, 2015). In light of the efforts to generalise the usage of SPCIR, it is worth to validate its applicability in other sectors, where its usage has the potential to be widened to other sectors. The validation can involve from the strictly regulated industry and highly comparable to the food industry ― pharmaceutical industry to the completely different industry (e.g. insurance industry).

9.9 Personal reflections

This section contains my personal reflections on the research, which has occupied my life for the last four years. About 35 years have passed since the emergence of SPC in western manufacturing industries, and the most frequently asked question now is: ‘Does SPC still work?’ I believe that SPC will be continually being a powerful process variation reduction technique, as it becomes an important component of TQM and Six Sigma. The underlying statistical theory of SPC proposed by Dr. Walter Shewhart is so strong that it has not been changed theoretically; indeed, it has been the foundation of numerous control charts for the adaptation of process behaviours and trends (e.g. non-normal, autocorrelation, short-production, multivariate, etc.).

9.9.1 SPC awareness in the food industry

Though SPC is a well-developed quality improvement technique, responsible for reducing process variations and improving bottom-line savings, it is not widely applied in UK food manufacturing companies. In fact, throughout my four years of study, it has become clear that the food industry as a whole, lacks awareness of advanced statistical techniques such as SPC; only five of the eight case companies I visited had heard of the technique. Several food practitioners I met confused SPC with Six Sigma, but while Six Sigma can provide dramatic improvements to bottom-line savings, this happens more slowly with SPC (because improvements in the process are incremental). More importantly, the two are essentially different; SPC is a statistical technique, while Six Sigma is a philosophy that employs several techniques, including SPC.

My experience of running and attending workshops and conferences on SPC and quality management during the past four years has shown that SPC research mainly concentrates on its technical aspects or statistical theory, while the management aspects of SPC have been largely neglected. The lack of focus on SPC within the food industry is quite intimidating, given the calls from academics and food magazines for the industry to invest in the adoption of real-time monitoring techniques such as SPC. I have heard food companies repeatedly make the excuse that SPC is more suited to engineering-based industries such as the automotive, electronics and semiconductor industries and that their own company's processes are uniquely mixed, making it inapplicable to them. However, my review of the literature and field studies in the early stage of this doctoral research has ignited me to question this argument, as other food companies (Nestle, Kraft,etc.) successfully adopt and sustain SPC. Furthermore, although processes in the food industry involve numerous variables (the interaction of raw materials, process factors and environmental factors), this should not affect SPC applicability. From my observations, the main reason for the low level of SPC implementation in the food industry is that it involves statistical techniques that many managers and directors are not comfortable, and they portrait high resistance to change. The lack of statistical thinking in the company and lack of knowledge causing the food practitioners to lost their confidence in adopting advanced problem-solving techniques such as SPC and DOE.

I believe that government bodies and academic institutions have a crucial role to play in raising awareness of SPC and in helping food companies implement and sustain this initiative. Government agencies such as (Manufacturing Advisory Service) MAS has been formed to assist UK food companies in improving process efficiency, but there is no one, not even from the Food and Drink Federation UK, providing help specifically with SPC. Furthermore, tertiary students, who represent potential food industry practitioners, are not being taught problem-solving tools or statistical techniques for CI, though academic institutions have recently begun to support the food industry, through the Knowledge Transfer Partnership (KTP) programme, to resolve operational issues. I believe that government policy needs to be re-assessed, and the roles of bodies like the Food and Drinks Agency and the Food Standards Agency (FSA) need to be re-assessed. Academics also need to be more actively involved (e.g. by organising seminars, workshops and conferences on CI initiatives) in raising awareness in the food industry and supporting it to achieve process excellence.

9.9.2 SPC as a real-time process control technique in the UK food manufacturing industry

The findings from the literature review suggest that the UK food industry is behind from other industries regarding gathering and leveraging real-time data across its manufacturing operations and suppliers. The case studies I conducted indicated that SPC is applied mainly using historical and off-line data. However, this defeats one of the objectives of SPC implementation, which is to prevent out-of-control situations from occurring. Typically, historical data is used in these companies to identify a baseline for process performance and to determine the control limits in the early stage of SPC implementation (Chakraborti et al., 2008). However, from my encounters with the food practitioners reveal that real-time monitoring is a critically in need, as food products are defined by food standards, where SPC is a powerful approach to avoid breaches of the regulations.

Although comparing the cultures of different companies is beyond the scope of this study delegates at several conferences have asked me whether I have noticed differences between the UK and US food industries regarding process improvement. A survey by *Food Engineering* Magazine in 1980 concluded that US food companies were highly conscious of the process improvement issue (Higgins, 2003), with all 186 respondents confirming that they had quality management programmes in place, and all are indicating an aware the significance to improve process performance. Although there are no empirical research was carried out to address the research gap, (the closest research were done is in comparing US and UK by comparing manufacturing technology innovation(Swamidass and Winch, 2002)), the findings from my empirical studies suggest that the UK food industry is lagging behind its US counterpart in terms of process management activities as very few were found to understand the importance of process performance. This may be due to the lack of awareness the importance of controlling the process quality instead of the end-product quality. Most of the UK food companies in this study do not have a formal quality management programme and are even claimed to struggle to fulfil the requirements for food safety.

9.9.3 Research method chosen for this research

Having enrolled in an engineering faculty at the University of Strathclyde at the early stage of my doctoral study, I am more familiar taking positivist paradigm. The choice of research paradigm may be swayed by the researcher's previous experience and educational background, but it should above all be based on the nature of the research questions. My background (a bachelor's degree in mathematics)inclined me towards a positivist stance, but base on the Research Methodology classes and Doctorial Symposium in Operation Management Research Methodology that I have attended, I was aware that it was not appropriate for me to follow only one research paradigm in this case as my research questions also indicated the need for exploratory studies. I therefore adopted a pragmatic stance and employed the mixed-method approach. As explained in Chapter 4, this minimised the limitations inherent in a singular approach and yielded richer data. Although there are very few Ph.D. researchers agreeing with pragmatism, it is hoped that this research will increase awareness of the potential benefits of using mixed methods in operation management studies.

9.10 Personal remarks

The journey of this study was interesting, although it has not always been smooth sailing. Having started this research as a mathematician, which without any industrial experience, making the transition from positivist to a pragmatist researcher (e.g. engaged in fieldwork and projects) was greatly challenging. Given the opportunity to experience the application of SPC in the industry, I have learnt about the nuance of being a practitioner and some of the fundamental skills of the consultation process while working in the industry. The involvement with the industry has changed my view on the impact and direction of current academic research on this topic.

I have come to the realisation that there is a huge knowledge gap between industry and academia in this topic, even though the technique has been introduced for more than three decades. One highlight of my studies was being given the opportunity to become one of the workshop leaders "Process Excellence for Food Manufacturing Industry" at the International Conference of Lean Six Sigma, as this allowed me to discuss the current issues and the future of SPC with fellow scholars. Finally, the highlight of my doctoral study was the opportunity to meet with numerous scholars renowned in the field of operation management in both Europe and the US. These meetings afforded opportunities to exchange ideas and discuss my research, which were sometimes instrumental in shaping my research approach.

REFERENCES

Abdolvand, N., Albadvi, A. & Ferdowsi, Z. 2008. Assessing readiness for business process reengineering. *Business Process Management Journal,* 14**,** 497-511.

Ackoff, R. L. 1979. The future of operational research is past. *Journal of the operational research society***,** 93-104.

Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D. & Overy, P. 2015. Sustainability-oriented Innovation: A Systematic Review. *International Journal of Management Reviews*.

Ahire, S. L., Landeros, R. & Golhar, D. Y. 1995. Total quality management: a literature review and an agenda for future research. *Production and Operations Management,* 4**,** 277-306.

Ahire, S. L. & O'shaughnessy, K. 1998. The role of top management commitment in quality management: an empirical analysis of the auto parts industry. *International Journal of Quality Science,* 3**,** 5-37.

Ahire, S. L. & Ravichandran, T. 2001. An innovation diffusion model of TQM implementation. *Engineering Management, IEEE Transactions on,* 48**,** 445-464.

Aksu, M. B. 2003. TQM readiness level perceived by the administrators working for the central organization of the Ministry of National Education in Turkey. *Total Quality Management and Business Excellence,* 14**,** 595-608.

Al-Mashari, M. & Al-Mudimigh, A. 2003. ERP implementation: lessons from a case study. *Information Technology & People,* 16**,** 21-33.

Al-Turki, U. & Andijani, A. 1997. Quality control practices in Saudi Arabia: survey result. *Production Planning & Control,* 8**,** 726-730.

Alsaleh, N. A. 2007. Application of quality tools by the Saudi food industry. *The TQM Magazine,* 19**,** 150-161.

Amar, K. & Davis, D. A Review of Six Sigma Implementation Frameworks and Related Literature. *In:* Ao, O. C., Douglas, C., Feng, D. D. & Lee, J.-A., eds. International Multi Conference of Engineering and Computer Scientist, 2008 Hong Kong. Newswood Limited – International Association of Engineers., 1559–1564.

Anderson, J. C., Rungtusanatham, M. & Schroeder, R. G. 1994. A theory of quality management underlying the Deming management method. *Academy of Management Review,* 19**,** 472-509.

Antony, J. 2000. Ten key ingredients for making SPC successful in organisations. *Measuring Business Excellence,* 4**,** 7-10.

Antony, J. 2014. Readiness factors for the Lean Six Sigma journey in the higher education sector. *International Journal of Productivity and Performance Management,* 63**,** 257-264.

Antony, J. & Balbontin, A. 2000. Key ingredients for the effective implementation of statistical process control. *Work study,* 49**,** 242-247.

Antony, J. & Taner, T. 2003. A conceptual framework for the effective implementation of statistical process control. *Business Process Management Journal,* 9**,** 473-489.

Appelbaum, S. H., Habashy, S., Malo, J.-L. & Shafiq, H. 2012. Back to the future: revisiting Kotter's 1996 change model. *Journal of Management Development,* 31**,** 764-782.

Appelbaum, S. H., St-Pierre, N. & Glavas, W. 1998. Strategic organizational change: the role of leadership, learning, motivation and productivity. *Management Decision,* 36**,** 289-301.

Argote, L., Beckman, S. L. & Epple, D. 1990. The persistence and transfer of learning in industrial settings. *Management science*, 36**,** 140-154.
Argote, L. & Miron-Spektor, E. 2011. Organizational learning: From experience to knowledge. *Organization Science,* 22**,** 1123-1137.
Argyris, C. 1993. *Knowledge for action: A guide to overcoming barriers to organizational change*,Jossey-BassInc., San Francisco.
Argyris, C. 1995. Action science and organizational learning. *Journal of Managerial Psychology,* 10**,** 20-26.
Argyris, C., Putnam, R. & Smith, D. M. 1985. *Action science*, Jossey-BassInc. San Francisco.
Argyris, C. & Schon, D. A. 1974. *Theory in practice: Increasing professional effectiveness*, Jossey-Bass Inc, San Francisco.
Argyris, C. & Schon, D. A. 1974. *Theory in practice: Increasing professional effectiveness,* Jossey-Bass.
Argyris, C. & Schön, D. A. 1978. *Organizational learning: A theory of action perspective,* Addison-Wesley Reading, MA.
Armenakis, A. A. & Harris, S. G. 2002. Crafting a change message to create transformational readiness. *Journal of Organizational Change Management,* 15**,** 169-183.
Armenakis, A. A., Harris, S. G. & Mossholder, K. W. 1993. Creating readiness for organizational change. *Human relations,* 46**,** 681-703.
Arrow, K. J. 1962. The economic implications of learning by doing. *The review of economic studies***,** 155-173.
Assael, H. & Keon, J. 1982. Nonsampling vs. sampling errors in survey research. *The Journal of Marketing***,** 114-123.
Augustin, J.-C. & Minvielle, B. 2008. Design of control charts to monitor the microbiological contamination of pork meat cuts. *Food Control,* 19**,** 82-97.
Baines, T. & Shi, V. G. 2015. A Delphi study to explore the adoption of servitization in UK companies. *Production Planning & Control***,** 1-17.
Baker, T. L. & Risley, A. J. 1994. *Doing social research,* New York, McGraw-Hill Inc.
Bandura, A. 1993. Perceived self-efficacy in cognitive development and functioning. *Educational psychologist,* 28**,** 117-148.
Banuelas, R., Tennant, C., Tuersley, I. & Tang, S. 2006. Selection of Six Sigma projects in the UK. *The TQM Magazine,* 18**,** 514-527.
Barker, R. 1990. SPC and total quality management. *Total Quality Management,* 1**,** 37-41.
Barratt, M., Choi, T. Y. & Li, M. 2011. Qualitative case studies in operations management: trends, research outcomes, and future research implications. *Journal of Operations Management,* 29**,** 329-342.
Bartholomew, K., Henderson, A. J. & Marcia, J. E. 2000. Coded semistructured interviews in social psychological research. *Handbook of research methods in social and personality psychology***,** 286-312.
Baskerville, R. & Pries-Heje, J. 1999. Grounded action research: a method for understanding IT in practice. *Accounting, Management and Information Technologies,* 9**,** 1-23.
Bateman, N. & David, A. 2002. Process improvement programmes: a model for assessing sustainability. *International Journal of Operations & Production Management,* 22**,** 515-526.
Bates, S. & Coren, E. 2006. Systematic map no.1: the extent and impact of parental mental health problems on families and the acceptability, accessibility and

effectiveness of interventions. London: Social Care Institute of Excellence (SCIE).
Bateson, G. 1972. *Steps to an ecology of mind: Collected essays in anthropology, psychiatry, evolution, and epistemology*, University of Chicago Press.
Bayazit, O. & Karpak, B. 2007. An analytical network process-based framework for successful total quality management (TQM): An assessment of Turkish manufacturing industry readiness. *International Journal of Production Economics,* 105**,** 79-96.
Beardsell, M. L. & Dale, B. G. 1999. The relevance of total quality management in the food supply and distribution industry: a study. *British Food Journal,* 101**,** 190-201.
Belbin, R. 1981. Management Teams: Why They Succeed or Fail? : Butterworth–Heinemann, Oxford.
Bell, E. & Bryman, A. 2007. The ethics of management research: an exploratory content analysis. *British Journal of Management,* 18**,** 63-77.
Bernerth, J. 2004. Expanding our understanding of the change message. *Human Resource Development Review,* 3**,** 36-52.
Bessant, J. & Caffyn, S. 1997. High-involvement innovation through continuous improvement. *International Journal of Technology Management,* 14**,** 7-28.
Bessant, J., Caffyn, S. & Gallagher, M. 2001. An evolutionary model of continuous improvement behaviour. *Technovation,* 21**,** 67-77.
Bessant, J. & Francis, D. 1999. Developing strategic continuous improvement capability. *International Journal of Operations & Production Management,* 19**,** 1106-1119.
Bethlehem, J. & Biffignandi, S. 2011. *Handbook of Web surveys,* Wiley, New Jersey.
Bidder, P. L. 1990. Experiences of introducing SPC in a confectionery factory. *Applied Statistical Process Control, IEE Colloquium on.* London, UK: IEEEXplore.
Bissell, D. 1994. *Statistical Methods for SPC and TQM,* CRC Press, London.
Bjerke, F. Y. 2002. Statistical thinking in practice: handling variability in experimental situations. *Total Quality Management,* 13**,** 1001-1014.
Bogdan, R. C. & Biklen, S. K. 1998. *Qualitative research in education. An introduction to theory and methods*, Pearson Allyn & Bacon.
Boiral, O. 2012. ISO 9000 and Organizational Effectiveness : A Systematic Review. 19.
Booth, A., Papaioannou, D. & Sutton, A. 2012. *Systematic approaches to a successful literature review*, Sage Publications Inc.
Botta, R. 2007. A prioritization process. *Engineering Management Journal,* 19.
Brannstrom-Stenberg, A. M., Deleryd 1999. Implementation of statistical process control and process capability studies: requirements or free will? *Total Quality Management & Business Excellent,* 10.
Briner, R. & Denyer, D. 2010. Systematic Review and Evidence Synthesis as a Practice and Scholarship Tool Rob B Briner, University of London David Denyer, Cranfield University. 328-374.
Bryman, A. 2003. *Quantity and quality in social research,* Routledge.
Bryman, A. & Bell, E. 2015. *Business Research Methods* Oxford, Oxford university press.
Buckler, B. 1996. A learning process model to achieve continuous improvement and innovation. *The learning organization*, 3**,** 31-39.
Buffa, E. S. 1965. *Operations management: Problems and models*.
Buffa, E. S. 1980. Research in operations management. *Journal of Operations Management,* 1**,** 1-7.

Bunney, H. & Dale, B. 1997. The implementation of quality management tools and techniques: a study. *The TQM Magazine,* 9**,** 183-189.

Burrell, G. & Morgan, G. 1979. *Sociological paradigms and organizational analysis. ,* London, Heinemann.

Bushe, G. R. 1988. Cultural Contradictions of Statistical Process Control In American Manufacturing Organizations. *Journal of Management,* 14**,** 19-31.

Carruthers, J. 1990. A rationale for the use of semi-structured interviews. *Journal of Educational Administration,* 28.

Caruth, G. D. 2013. Demystifying Mixed Methods Research Design: A Review of the Literature. *Online Submission,* 3**,** 112-122.

Caswell, J. A., Bredahl, M. E. & Hooker, N. H. 1998. How quality management metasystems are affecting the food industry. *Review of Agricultural Economics,* 20**,** 547.

Chakraborti, S., Human, S. & Graham, M. 2008. Phase I statistical process control charts: an overview and some results. *Quality Engineering,* 21**,** 52-62.

Chakravorty, S. S. 2009. Six Sigma programs: An implementation model. *International Journal of Production Economics,* 119**,** 1-16.

Chase, R. B. 1980. A classification and evaluation of research in operations management. *Journal of Operations Management,* 1**,** 9-14.

Cheng, P. C.-H. & Dawson, S. D. 1998. A study of statistical process control: practice, problems and training needs. *Total Quality Management,* 9**,** 3-20.

Childe, S. J. 2011. Case studies in operations management. *Production Planning & Control,* 22**,** 107-107.

Chileshe, N. 2007. Quality management concepts, principles, tools and philosophies: A valid methodology for deployment within UK construction-related SMEs. *Journal of Engineering, Design and Technology,* 5**,** 49-67.

Chiva, R. & Alegre, J. 2005. Organizational learning and organizational knowledge towards the integration of two approaches. *Management learning,* 36**,** 49-68.

Choo, A. S., Linderman, K. W. & Schroeder, R. G. 2007. Method and context perspectives on learning and knowledge creation in quality management. *Journal of Operations Management,* 25**,** 918-931.

Cinar, A. & Schlesser, J. E. 2005. HACCP with multivariate process monitoring and fault diagnosis techniques: application to a food pasteurization process. *Food Control,* 16**,** 411-422.

Clarke, J. S., Ellett, C. D., Bateman, J. M., & Rugutt, J. K 1996. Faculty receptivity/re- sistance to change, personal and organizational efficacy, decision deprivation and ef- fectiveness in research I universities. *In:* EDUCATION, P. P. A. T. A. M. O. T. A. F. T. S. O. H. (ed.). Paper presented at the Annual meeting of the Association for the Study of Higher Education: Memphis, TN.

Clarke, R. 1999. A primer in diffusion of innovations theory. *Xamax Consultancy Pty Ltd*.

Clibbens, N., Walters, S. & Baird, W. 2012. Delphi research: issues raised by a pilot study. *Nurse researcher,* 19**,** 37-44.

Coch, L. & French Jr, J. R. 1948. Overcoming resistance to change. *Human relations*.

Cohen, L., Manion, L. & Morrison, K. 2000. Research Methods in Education [5 th edn] London: Routledge Falmer. *Teaching in Higher Education,* 41.

Collis, J., Hussey, R., Crowther, D., Lancaster, G., Saunders, M., Lewis, P., Thornhill, A., Bryman, A., Bell, E. & Gill, J. 2003. Business research methods. Palgrave Macmillan, New York.

Cornell, J. A. 2011. *Experiments with mixtures: designs, models, and the analysis of mixture data*, John Wiley & Sons.

Costa Dias, M. A., Sant'ana, A. S., Cruz, A. G., Faria, J. D. a. F., Fernandes De Oliveira, C. A. & Bona, E. 2012. On the implementation of good manufacturing practices in a small processing unity of mozzarella cheese in Brazil. *Food Control,* 24**,** 199-205.

Coughlan, P. & Coghlan, D. 2002. Action research for operations management. *International Journal of Operations & Production Management,* 22**,** 220-240.

Coughlan, P., Harbison, A., Dromgoole, T. & Duff, D. 2001. Continuous improvement through collaborative action learning. *International Journal of Technology Management,* 22**,** 285-302.

Counsell, C. 1998. Formulating questions and locating primary studies for inclusion in systematic reviews. *Systematic reviews: Synthesis of best evidence for health care decisions***,** 67-88.

Cowan, J. 2006. *On Becoming An Innovative University Teacher: Reflection In Action: Reflection in Action,* McGraw-Hill International.

Cravener, T., Roush, W. & Jordan, H. 1993. Pareto Assessment of Quality Control in Poultry Processing Plants. *The Journal of Applied Poultry Research, 2*, 297-302

Creswell, J. W. 2012. *Qualitative inquiry and research design: Choosing among five approaches,* Sage publications, London

Creswell, J. W. & Clark, V. L. P. 2007. *Designing and conducting mixed methods research,* Wiley Online Library.

Crosby, P. B. 1980. *Quality is free: The art of making quality certain,* Signet.

Cuevas, R. 2004. Food engineering, quality and competitiveness in small food industry systems with emphasis on Latin America and the Caribbean. *In:* Nations, F. A. A. O. O. T. U. (ed.). Rome: Agricultural Services Bulletin.

Czitrom, V. 1999. One-factor-at-a-time versus designed experiments. *The American Statistician,* 53**,** 126-131.

Dada, M. & Srikanth, K. 1990. Monopolistic pricing and the learning curve: An algorithmic approach. *Operations Research,* 38**,** 656-666.

Dale, B. & Shaw, P. 1991. Statistical process control: an examination of some common queries. *International Journal of Production Economics,* 22**,** 33-41.

Dale, B. G. & Cooper, C. L. 1994. Introducing TQM: the role of senior management. *Management Decision,* 32**,** 20-26.

Dale, B. G. & Lascelles, D. M. 1997. Total quality management adoption: revisiting the levels. *The TQM Magazine,* 9**,** 418-428.

Dale, B. G. & Shaw, P. 1992. Statistical process control in PCB manufacture: what are the lessons? *IEE Proceedings A Science, Measurement and Technology,* 139**,** 182.

Dale, B. G., Van Der Wiele, T. & Van Iwaarden, J. 2007. *Managing quality,* John Wiley & Sons.

Dalgiç, A. C., Vardin, H. & Belibaäÿli, K. 2011. Improvement of Food Safety and Quality by Statistical Process Control (SPC) in Food Processing Systems: A Case Study of Traditional Sucuk (Sausage). *In:*Shoyama, Y. (ed.) *Processing, quality control of herbal medicines and related areas.* http://dx.doi.org/10.5772/23805: InTech (2011).

Dalkey, N. C., Brown, B. B. & Cochran, S. 1969. *The Delphi method: An experimental study of group opinion,* Rand Corporation, Santa Monica.

Dalton, C. C. & Gottlieb, L. N. 2003. The concept of readiness to change. *Journal of advanced nursing,* 42**,** 108-117.

Daniels, S. E. 2005. A recipe for excellence. *Quality Progress,* 38**,** 54-62.

Das, A., Kumar, V. & Kumar, U. 2011. The role of leadership competencies for implementing TQM: An empirical study in Thai manufacturing industry. *International Journal of Quality & Reliability Management,* 28**,** 195-219.

Davis, J. & Ryan, M. 2005. Training in the SME sector of the food and drink manufacturing industries. *Management Services,* Spring**,** 38-42.

De Vaus, D. 2001. *Research design in social research*, Sage, London.

Deleryd, M., Garvare, R. & Klefsjö, B. 1999. Experiences of implementing statistical methods in small enterprises. *The TQM Magazine,* 11**,** 341-351.

Deming, W. 1986. Out of the crisis. Cambridge, MA, itd: Massachusetts Institute of Technology Press. MIT Press.

Denton, J. 1998. *Organisational learning and effectiveness,* Psychology Press.

Denyer, D. & Tranfield, D. 2009. Producing a systematic review. *In:*Buchanan, D. A. & Bryman, A. (eds.) *The sage handbook of organization research methods.* Cornwall: Sage Publications Ltd.

Denzin, N. K. & Lincoln, Y. S. 2005. *The Sage handbook of qualitative research*, Sage.

Department of Environment Food and Rural Affairs, D. 2015. Food Statistics Pocketbook 2015. *Department of Environment, Food and rural Affairs.*

Desai, D. A., Kotadiya, P., Makwana, N. & Patel, S. 2015. Curbing variations in packaging process through Six Sigma way in a large-scale food-processing industry. *Journal of Industrial Engineering International,* 11**,** 119-129.

Dewey, J. & Boydston, J. A. 1988. The middle works of John Dewey. Carbondale, IL: Southern Illinois University Press.

Dick, B., Stringer, E. & Huxham, C. 2009. Theory in action research. *Action Research,* 7**,** 5-12.

Dillman, D. A. 2000. *Mail and internet surveys: The tailored design method*, Wiley New York.

Dillman, D. A. 2011. *Mail and Internet surveys: The tailored design method--2007 Update with new Internet, visual, and mixed-mode guide*, John Wiley & Sons.

Does, R. & Trip, A. 1997. A framework for implementation of statistical process control. *International Journal of Quality Science,* 2**,** 181-198.

Doganaksoy, N. & Hahn, G. J. 2014. Improving a Manufacturing Process Using Data-Based Methods. *Quality and Reliability Engineering International,* 30**,** 427-435.

Dogdu, S., Santos, D. & Dougherty, T. Guidelines for implementing statistical process control in printed circuit board manufacturing. SPIE proceedings series, 1997a. Society of Photo-Optical Instrumentation Engineers, 628-633.

Dogdu, S., Santos, D. L. & Dougherty, T. Guidelines for implementing statistical process control in printed circuit board manufacturing. 1997 International Symposium on Mocroelectronics, 1997b. 628-633.

Donnell, A. & Singhal, S. 1996. SPC implementation for improving product quality. *Electronics Manufacturing Technology Symposium, 1996., Nineteenth IEEE/CPMT.* IEEE.

Dora, M., Kumar, M. & Gellynck, X. 2015. Determinants and barriers to lean implementation in food-processing SMEs–a multiple case analysis. *Production Planning & Control***,** 1-23.

Dora, M., Kumar, M., Van Goubergen, D., Molnar, A. & Gellynck, X. 2013a. Food Quality Management system: Reviewing assessment strategies and a feasibility study for European Food Small and Medium-sized Enterprises. *Food Control,* 31**,** 607-616.

Dora, M., Kumar, M., Van Goubergen, D., Molnar, A. & Gellynck, X. 2013b. Operational performance and critical success factors of lean manufacturing in

European food processing SMEs. *Trends in food science & technology,* 31**,** 156-164.
Dora, M., Van Goubergen, D., Kumar, M., Molnar, A. & Gellynck, X. 2014. Application of lean practices in small and medium-sized food enterprises. *British Food Journal,* 116**,** 125-141.
Drisko, J. W. 1997. Strengthening qualitative studies and reports: Standards to promote academic integrity. *Journal of Social Work Education,* 33**,** 185-197.
DTI 1979. Code of Guidance for Packers and Importers. *In:* INDUSTRY, D. O. T. A. (ed.). London: HMSO.
Dubé, L. & Paré, G. 2003. Rigor in information systems positivist case research: current practices, trends, and recommendations. *Mis Quarterly***,** 597-636.
Duffuaa, S. O. & Ben-Daya, M. 1995. Improving maintenance quality using SPC tools. *Journal of Quality in Maintenance Engineering,* 1**,** 25-33.
Easterby-Smith, M., Thorpe, R. & Jackson, P. 2011. *Management research,* London, SAGE Publications Limited.
Eckes, G. 2002. *The Six Sigma revolution: How General Electric and others turned process into profits,* John Wiley & Sons.
Eden, C. & Huxham, C. 1996a. Action research for management research. *British Journal of Management,* 7**,** 75-86.
Eden, C. & Huxham, C. 1996b. Action Research for Management Research. *British Journal of Management,* 7**,** 75-86.
Edith, I. N. & Ochubiojo, E. M. 2012. Food Quality Control : History , Present and Future. *In:* VALDEZ, B. (ed.) *Scientific, Health and Social Aspects of the Food Industry.* InTech.
Efstratiadis M., A. C. K., Ioannis S. Arvanitoyannis, Michalis 2000. Implementation of ISO 9000 to the food industry: an overview. *International journal of food sciences and nutrition,* 51**,** 459-473.
Ehigie, B. O. & Mcandrew, E. B. 2005. Innovation, diffusion and adoption of total quality management (TQM). *Management Decision,* 43**,** 925-940.
Eisenhardt, K. M. 1989. Building theories from case study research. *Academy of management review,* 14**,** 532-550.
Eisenhardt, K. M. & Graebner, M. E. 2007. Theory building from cases: opportunities and challenges. *Academy of Management journal,* 50**,** 25-32.
Elg, M., Olsson, J. & Dahlgaard, J. J. 2008. Implementing statistical process control: an organizational perspective. *International Journal of Quality & Reliability Management,* 25**,** 545-560.
Elgamail, M. A. 1998. An examination of organization and suborganization rediness for total quality mangement. *International Journal of Technology Management,* 16**,** 13.
Elgamal, M. A. 1998. An examination of organisation and suborganisation readiness for total quality management. *International Journal of Technology Management,* 16**,** 556-569.
Elliott, R. L. 1996. Double loop learning and the quality of quality improvement. *The Joint Commission journal on quality improvement,* 22**,** 59-66.
Evans, J. R. & Mahanti, R. 2012. Critical success factors for implementing statistical process control in the software industry. *Benchmarking: An International Journal,* 19**,** 374-394.
Feilzer, M. Y. 2010. Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of mixed methods research,* 4**,** 6-16.

Filippini, R. 1997. Operations management research: some reflections on evolution, models and empirical studies in OM. *International Journal of Operations & Production Management,* 17**,** 655-670.

Fine, C. H. 1986. Quality improvement and learning in productive systems. *Management science,* 32**,** 1301-1315.

Fine, C. H. 1988. A quality control model with learning effects. *Operations Research,* 36**,** 437-444.

Flynn, B., Schroederb, R. G. & Sakakibara, S. 1994. A framework for quality management research and an associated measurement instrument. *Journal of Operations Management,* 11**,** 339-366.

Flynn, B. B., Sakakibara, S., Schroeder, R. G., Bates, K. A. & Flynn, E. J. 1990. Empirical research methods in operations management. *Journal of Operations Management,* 9**,** 250-284.

Fortune, A. E., Reid, W. J. & Miller, R. 2013. *Qualitative research in social work,* Columbia University Press.

Fotopoulos, C., Kafetzopoulos, D. & Gotzamani, K. 2011. Critical factors for effective implementation of the HACCP system: a Pareto analysis. *British Food Journal,* 113**,** 578-597.

Fotopoulos, C. & Psomas, E. 2009. The use of quality management tools and techniques in ISO 9001: 2000 certified companies: the Greek case. *International Journal of Productivity and Performance Management,* 58**,** 564-580.

Fowler Jr, F. J. & Mangione, T. W. 1990. *Standardized survey interviewing: Minimizing interviewer-related error,* Sage, Los Angeles

Frechtling, J. A. & Sharp, L. M. 1997. *User-friendly handbook for mixed method evaluations*, Diane Publishing, New York.

Frost, P. 2002. Principles of the action research cycle. *Action research: a guide for teachers—burning issues in primary education. National Primary Trust, Birmingham***,**4, 24-32.

Gaafar, L. K. & Keats, J. B. 1992. Statistical process control: a guide for implementation. *International Journal of Quality & Reliability Management,* 9**,** 9-20.

Garengo, P. & Sharma, M. K. 2014. Performance measurement system contingency factors: a cross analysis of Italian and Indian SMEs. *Production Planning & Control,* 25**,** 220-240.

Gauri, S. K. 2003. Statistical process control procedures for controlling the weight of packets of biscuits. *Total quality management and business excellence,* 14**,** 529-539.

Gijo, E. 2005. Improving process capability of manufacturing process by application of statistical techniques. *Quality Engineering,* 17**,** 309-315.

Gioia, D. A. & Pitre, E. 2012. Multiparadigm Perspectives on Theory Building. *Management,* 15**,** 584-602.

Glaser, B. G. 1978. *Theoretical sensitivity: Advances in the methodology of grounded theory,* Sociology Press Mill Valley, CA.

Goh, T. N., Xie, M. & Xie, W. 1998. Prioritizing processes in initial implementation of statistical process control. *IEEE Transactions on Engineering Management,* 45**,** 66-72.

Goles, T. & Hirschheim, R. 2000. The paradigm is dead, the paradigm is dead… long live the paradigm: the legacy of Burrell and Morgan. *Omega,* 28**,** 249-268.

Gordon, M. E., Philpot, J. W., Bounds, G. M. & Long, W. S. 1994. Factors associated with the success of the implementation of statistical process control. *The Journal of High Technology Management Research,* 5**,** 101-121.

Greene, J. C. & Caracelli, V. J. 2003. Making paradigmatic sense of mixed methods practice. *Handbook of mixed methods in social and behavioral research,*9, 91-110.

Grigg, N. P. 1998. Statistical process control in UK food production: an overview. *International Journal of Quality & Reliability Management,* 15**,** 223-238.

Grigg, N. P. 1999. The use of statistical process control in food packing research agenda. *British Food Journal* 101**,** 763-784.

Grigg, N. P., Daly, J. & Stewart, M. 1998. Case study: the use of statistical process control in fish product packaging. *Food control,* 9**,** 289-297.

Grigg, N. P. & Walls, L. 2007a. Developing statistical thinking for performance improvement in the food industry. *International Journal of Quality & Reliability Management,* 24**,** 347-369.

Grigg, N. P. & Walls, L. 2007b. The role of control charts in promoting organisational learning: New perspectives from a food industry study. *The TQM Magazine,* 19**,** 37-49.

Grigg, N. P. & Williams, J. 2000. Issues relating to the enforcement and deregulation of Part V of the Weights and Measures Act 1985 An exploratory study involving Trading.

Grunert, K. G. 2005. Food quality and safety: consumer perception and demand. *European Review of Agricultural Economics,* 32**,** 369-391.

Guba, E. G. & Lincoln, Y. S. 1994. Competing paradigms in qualitative research. *Handbook of qualitative research,* 2**,** 163-194.

Gummesson, E. 2000. *Qualitative methods in management research*, Sage.

Gupta, U. G. & Clarke, R. E. 1996. Theory and applications of the Delphi technique: A bibliography (1975–1994). *Technological Forecasting and Social Change,* 53**,** 185-211.

Gurumurthy, A., Mazumdar, P. & Muthusubramanian, S. 2013. Graph theoretic approach for analysing the readiness of an organisation for adapting lean thinking: A case study. *International Journal of Organizational Analysis,* 21**,** 396-427.

Haikonen, A., Savolainen, T. & Järvinen, P. 2004. Exploring Six Sigma and CI capability development: preliminary case study findings on management role. *Journal of Manufacturing Technology Management,* 15**,** 369-378.

Hales, D. N., Siha, S. M., Sridharan, V. & Mcknew, J. I. 2006. Prioritizing tactical quality improvement: An action research study. *International Journal of Operations & Production Management,* 26**,** 866-881.

Harcourt, A. & Brace, D. 2011. The American Heritage Dictionary of the English Language. Houghton Mifflin, Boston.

Hasson, F., Keeney, S. & Mckenna, H. 2000. Research guidelines for the Delphi survey technique. *Journal of advanced nursing,* 32**,** 1008-1015.

Hayes, G., Scallan, A. & Wong, J. 1997. Applying statistical process control to monitor and evaluate the hazard analysis critical control point hygiene data. *Food Control,* 8**,** 173-176.

Hensley, R. L. & Dobie, K. 2005. Assessing readiness for six sigma in a service setting. *Managing Service Quality,* 15**,** 82-101.

Heras Saizarbitoria, I. 2006. How quality management models influence company results–conclusions of an empirical study based on the Delphi method. *Total Quality Management & Business Excellence,* 17**,** 775-794.

Herschdoerfer, S. 1967. *Quality control in the food industry,* London, Academic Press.

Herscovitch, L. & Meyer, J. P. 2002. Commitment to organizational change: extension of a three-component model. *Journal of applied psychology,* 87**,** 474.

Hersleth, M. & Bjerke, F. 2001. Introducing statistical thinking to the food industry-facilitating and inhibiting factors. *Quality management journal,* 8**,** 49-60.

Hewson, C., Cox, R. & Stenning, K. 1997. A study of SPC Training Needs in Small and Medium UK Companies . *Starke***,** 1-58.

Hewson, C., O'sullivan, P. & Stenning, K. 1996. Training needs associated with statistical process control. *Training for Quality,* 4**,** 32-36.

Higgins, K. T. 2003. Technology Update: Food Processing & SPC. *Food Engineering Megazine.*

Hinkin, T. R. 1995. A review of scale development practices in the study of organizations. *Journal of management,* 21**,** 967-988.

Ho, W., Dey, P. K. & Lockström, M. 2011. Strategic sourcing: a combined QFD and AHP approach in manufacturing. *Supply Chain Management: An International Journal,* 16**,** 446-461.

Hoerl, R. 1995. Enhancing the bottom-line impact of statistical methods. *Quality Management Journal,* 15, 11-28.

Holt, D. T., Armenakis, A. A., Feild, H. S. & Harris, S. G. 2007a. Readiness for Organizational Change The Systematic Development of a Scale. *The Journal of applied behavioral science,* 43**,** 232-255.

Holt, D. T., Armenakis, A. A., Harris, S. G. & Feild, H. S. 2007b. Toward a comprehensive definition of readiness for change: A review of research and instrumentation. *Research in Organizational Change and Development,* 14**,** 289-336.

Hood, W. W. & Wilson, C. S. 2001. The literature of bibliometrics, scientometrics, and informetrics. *Scientometrics,* 52**,** 291-314.

Houy, C., Fettke, P. & Loos, P. 2010. Empirical research in business process management–analysis of an emerging field of research. *Business Process Management Journal,* 16**,** 619-661.

Hsu, C.-C. & Sandford, B. A. 2007. The Delphi technique: making sense of consensus. *Practical Assessment, Research & Evaluation,* 12**,** 1-8.

Hubbard, M. R. 2003. *Statistical Quality Control for Food Industry,*Kluwer Academic/Plenum Publishers, New York.

Hubbard, M. R. 2013. *Statistical Quality Control for Food Industry,* Aspen Publishers, Gaithersburg.

Hughes, J. A. & Sharrock, W. W. 1980. *The philosophy of social research*, Longman London.

Hung, H.-C. & Sung, M.-H. 2011a. Applying six sigma to manufacturing processes in the food industry to reduce quality cost. *Practice,* 6**,** 580-591.

Hung, H. C. & Sung, M. H. 2011b. Applying six sigma to manufacturing processes in the food industry to reduce quality cost. *Scientific Research and Essays,* 6**,** 580-591.

Huq, Z. & Stolen, J. D. 1998. Total quality management contrasts in manufacturing and service industries. *International Journal of Quality & Reliability Management,* 15**,** 138-161.

Hurst, W. & Harris, L. 2013. Integrating Hazard Analysis Critical Control Point (HACCP) and Statistical Process Control (SPC) for safer nut processing. *Improving the safety and quality of nuts,* 15, 119-147.

Huxham, C. & Vangen, S. 2003. Researching Organizational Practice through Action Research: Case Studies and Design Choices. *Organizational Research Methods,* 6**,** 383-403.

Ittner, C. D. & Larcker, D. F. 1997. The performance effects of process management techniques. *Management Science,* 43**,** 522-534.

Ittzes, A. 2001. Statistical process control with several variance components in the dairy industry. *Food Control,* 12**,** 119-125.

Jaber, M. Y. & Bonney, M. 2003. Lot sizing with learning and forgetting in set-ups and in product quality. *International Journal of Production Economics,* 83**,** 95-111.

Jacobson, E. H. 1957. The effect of changing industrial methods and automation on personnel. *Symposium on Preventive and Social Psychology.* Washington, DC.

Jacxsens, L., Luning, P., Marcelis, W., Van Boekel, T., Rovira, J., Oses, S., Kousta, M., Drosinos, E., Jasson, V. & Uyttendaele, M. 2011. Tools for the performance assessment and improvement of food safety management systems. *Trends in Food Science & Technology,* 22**,** S80-S89.

Jaikumar, R. & Bohn, R. E. 1992. A dynamic approach to operations management: An alternative to static optimization. *International Journal of Production Economics,* 27**,** 265-282.

Jeliazkova, M. & Westerheijden, D. F. 2002. Systemic adaptation to a changing environment: Towards a next generation of quality assurance models. *Higher Education,* 44**,** 433-448.

Jeyaraman, K. & Teo, L. K. 2010. A conceptual framework for critical success factors of lean Six Sigma: Implementation on the performance of electronic manufacturing service industry. *International Journal of Lean Six Sigma,* 1**,** 191-215.

Jia, C. & Jukes, D. 2012. The National Food Safety Control System of China–A Systematic Review. *Food Control*.

Johnson, D. M. 2004. Adaptation of organizational change models to the implementation of quality standard requirements. *International Journal of Quality & Reliability Management,* 21**,** 154-174.

Johnson, R. B. & Onwuegbuzie, A. J. 2004. Mixed methods research: A research paradigm whose time has come. *Educational researcher,* 33**,** 14-26.

Johnson, R. B., Onwuegbuzie, A. J. & Turner, L. A. 2007. Toward a definition of mixed methods research. *Journal of mixed methods research,* 1**,** 112-133.

Jones, P. & Dent, M. 1994. Lessons in Consistency : Statistical Process Control in Forte plc. *The Quality Management Journal,* 6**,** 18-23.

Jovanovic, B. & Nyarko, Y. 1995. A Bayesian learning model fitted to a variety of empirical learning curves. *Brookings Papers on Economic Activity. Microeconomics***,** 247-305.

Karlsson, C. 2010. *Researching operations management*, Routledge.

Kaspi, M., Rabinowitz, G., Rubinovitz, J., Shtub, A. & Sinriech, D. 1997. Mapping the organization a methodological approach to organizational change initiation. *Production Planning & Control,* 8**,** 633-644.

Kemmis, S. & Mctaggart, R. 1982. T he action research planner. *Victoria, Australia: Deakin University Press*.

Kerlinger, F. N. 1986. Foundations of behavioral research . Fort Worth, TX: Holt, Rinehart and Winston. Inc.

Khan, S. Z. & Pervaiz, M. K. 2005. Statistical Process Control : A Case-Study on Haleeb Foods Ltd ., Lahore. *Statistics,* 1**,** 11-16.

Khan, Z., Bali, R. K. & Wickramasinghe, N. 2007. Developing a BPI framework and PAM for SMEs. *Industrial Management & Data Systems,* 107**,** 345-360.

Kirkham, L., Garza-Reyes, J. A., Kumar, V. & Antony, J. 2014. Prioritisation of operations improvement projects in the European manufacturing industry. *International Journal of Production Research,* 52**,** 5323-5345.

Kitapci, H. & Sezen, B. 2007. The effects of participation in decision making, individual improvement efforts and training on the quality of the product design process. *Production Planning and Control,* 18**,** 3-8.

Klassen, R. D. & Whybark, D. C. 1994. Barriers to the management of international operations. *Journal of Operations Management,* 11**,** 385-396.

Knowles, G., Johnson, M. & Warwood, S. 2004. Medicated sweet variability: a six sigma application at a UK food manufacturer. *The TQM Magazine,* 16**,** 284-292.

Kolesar, P. 1993. The relevance of research on statistical process control to the total quality movement. *Journal of Engineering and Technology Management,* 10**,** 317-338.

Kotter, J. P. 2008a. *Force for change: How leadership differs from management,* Simon&Schuster Inc. New York.

Kotter, J. P. 2008b. *A sense of urgency*, Harvard Business Press, London

Kotter, J. P. & Schlesinger, L. A. 2008. Choosing strategies for change. *Harvard business review,* 86**,** 130.

Kotz, S., Johnson, N. L., Hubele, N. F., Spiring, F., Cheng, S., Yeung, A., Leung, B., Rodriguez, R. N., Bothe, D. R. & Lu, M.-W. 2002. Process capability indices: A review, 1992-2000. Discussions. *Journal of Quality Technology,* 34**,** 2-53.

Kovach, T. & Cho, R. 2011. Better processes make good eats The food industry can benefit from lean Six Sigma principles. *Industrial Engineer,* 43**,** 36-49.

Krippendorff, K. 2012. *Content Analysis: An Introduction to Its Methodology,* Thousand Oaks, SAGE Publications.

Krüger, V. 1999. Towards a European definition of TQM–a historical review. *The TQM Magazine,* 11**,** 257-263.

Krumwiede, D. & Sheu, C. 1996. Implementing SPC in a small organization: a TQM approach. *Integrated Manufacturing Systems,* 7**,** 45-51.

Kuit, J. A., Reay, G. & Freeman, R. 2001. Experiences of reflective teaching. *Active learning in higher education,* 2**,** 128-142.

Kumar, A. & Motwani, J. 1996. Doing it right the second time. *Industrial Management & Data Systems,* 96**,** 14-19.

Kumar, M., Antony, J. & Cho, B. R. 2009. Project selection and its impact on the successful deployment of Six Sigma. *Business Process Management Journal,* 15**,** 669-686.

Kumar, M., Antony, J., Madu, C. N., Montgomery, D. C. & Park, S. H. 2008. Common myths of Six Sigma demystified. *International Journal of Quality & Reliability Management,* 25**,** 878-895.

Kumar, M., Antony, J. & Tiwari, M. 2011. Six Sigma implementation framework for SMEs–a roadmap to manage and sustain the change. *International Journal of Production Research,* 49**,** 5449-5467.

Kumar, S. 1993. Statistical process control at Motorola's Austin assembly plant. *Interfaces,* 23**,** 84-92.

Kumar, S. & Gupta, Y. 1993. Statistical process control at Motorola's Austin assembly plant. *Interfaces,* 23**,** 84-92.

Kvale, S. & Brinkmann, S. 2009. *Interviews: Learning the craft of qualitative research interviewing,* Sage, London.

Lagrosen, Y., Chebl, R. & Tuesta, M. R. 2011. Organisational learning and Six Sigma deployment readiness evaluation: a case study. *International Journal of Lean Six Sigma,* 2**,** 23-40.

Lagrosen, Y. & Lagrosen, S. 2005. The effects of quality management–a survey of Swedish quality professionals. *International Journal of Operations & Production Management,* 25**,** 940-952.

Lameei, A. 2005. Assessment of organization readiness for TQM implementation. *Iranian Journal of Public Health,* 34,.78-92.

Lamikanra, O. 2002. *Fresh-cut fruits and vegetables: science, technology, and market*, Florida, CRC Press, Londo.

Lecompte, M. D. & Schensul, J. J. 1999. *Analyzing and interpreting ethnographic data*, Rowman Altamira.

Lee, G., Bennett, D. & Oakes, I. 2000. Technological and organisational change in small-to medium-sized manufacturing companies: a learning organisation perspective. *International Journal of Operations & Production Management,* 20**,** 549-572.

Lee, H. H. & Lee, C.Y. 2014. The effects of total quality management and organisational learning on business performance: evidence from Taiwanese insurance industries. *Total Quality Management & Business Excellence,* 25**,** 1072-1087.

Lee, T., Wong, W. & Yeung, K. 2011. Developing a readiness self-assessment model (RSM) for Six Sigma for China enterprises. *International Journal of Quality & Reliability Management,* 28**,** 169-194.

Leedy, P. D. & Ormrod, J. E. 2005. Practical research. *Planning and design,* 8.

Levin, M. 2003. Action Research and the Research Community. *Concepts and Transformation,* 8**,** 6.

Lewin, K. 1946. Action research and minority problems. *Journal of social issues,* 2**,** 34-46.

Lewin, K. 1951. Field theory in social science: selected theoretical papers (Edited by Dorwin Cartwright.).

Lieberman, M. B. 1984. The learning curve and pricing in the chemical processing industries. *The RAND Journal of Economics,* 15**,** 213-228.

Lim, S. A. H., Antony, J. & Albliwi, S. 2014. Statistical Process Control (SPC) in the food industry–A systematic review and future research agenda. *Trends in food science & technology,* 37**,** 137-151.

Lin, B. 1991. Building quality control systems for hospital food-service operations. *International Journal of Quality & Reliability,* 8**,** 35-44.

Linderman, K., Schroeder, R. G. & Sanders, J. 2010. A knowledge framework underlying process management*. *Decision Sciences,* 41**,** 689-719.

Locke, E. A. & Jain, V. K. 1995. Organizational learning and continuous improvement. *The International Journal of Organizational Analysis,* 3**,** 45-68.

Lockyer, K. G., Oakland, J. S., Duprey, C. H. & Followell, R. F. 1984. The barriers to acceptance of statistical methods of quality control in UK manufacturing industry. *The International Journal of Production Research,* 22**,** 647-660.

Louise, B. K. & While, A. 1994. Collecting Data using a semi-structured interview: a discussion paper. *Journal of advanced nursing,* 19**,** 328-335.

Lozier, T., Dawson, K. & Rogers, R. 2012. Striking the right balance between safety and quality. *Food Engineering.*

Luis Duarte Ribeiro, J., Schwengber Ten Caten, C. & Fritsch, C. 2001. Integrated process control. *International Journal of Quality & Reliability Management,* 18**,** 444-464.

Luning, P. A. & Marcelis, W. J. 2006. A techno-managerial approach in food quality management research. *Trends in Food Science & Technology,* 17**,** 378-385.

Luning, P. A. & Marcelis, W. J. 2007. A conceptual model of food quality management functions based on a techno-managerial approach. *Trends in Food Science & Technology,* 18**,** 159-166.

Luning, P. A. & Marcelis, W. J. 2009. A food quality management research methodology integrating technological and managerial theories. *Trends in food science & technology*, 20**,** 35-44.

Rungtusanatham, M., Anderson, J. C. & Kevin, J. D. 1999. Towards measuring the "SPC implementation / practice " construct. *International Journal of Quality & Reliability,* 16**,** 301-329.

Maccarthy, B. & Wasusri, T. 2001. Statistical process control for monitoring scheduling performance-addressing the problem of correlated data. *Journal of the Operational Research Society*, 52**,** 810-820.

Maccarthy, B. L. & Atthirawong, W. 2003. Factors affecting location decisions in international operations–a Delphi study. *International Journal of Operations & Production Management,* 23**,** 794-818.

Mahalik, N. P. & Nambiar, A. N. 2010. Trends in food packaging and manufacturing systems and technology. *Trends in food science & technology,* 21**,** 117-128.

Malhotra, M. K. & Grover, V. 1998. An assessment of survey research in POM: from constructs to theory. *Journal of Operations Management,* 16**,** 407-425.

Malik, A. & Blumenfeld, S. 2012. Six Sigma, quality management systems and the development of organisational learning capability: evidence from four business process outsourcing organisations in India. *International Journal of Quality & Reliability Management,* 29**,** 71-91.

Malik, A., Sinha, A. & Blumenfeld, S. 2012. Role of quality management capabilities in developing market-based organisational learning capabilities: Case study evidence from four Indian business process outsourcing firms. *Industrial Marketing Management,* 41**,** 639-648.

Maneesh, K. 2010. *Six Sigma Implementation in UK Manufacturing SMEs: An Exploratory Research.* Doctoral of Philosophy, University of Strathclyde.

Mann, R. & Adebanjo, O. 1998. Best practices in the food and drinks industry. *Benchmarking for Quality Management & Technology,* 5**,** 184-199.

Mann, R., Adebanjo, O. & Kehoe, D. 1999. An assessment of management systems and business performance in the UK food and drinks industry. *British Food Journal,* 101**,** 5-21.

Manning, L. & Baines, R. 2004. Effective management of food safety and quality. *British Food Journal,* 106**,** 598-606.

Marquardt, M. J. 1996. *Building the learning organization*, McGraw-Hill Companies, London.

Marsden, P. V. & Wright, J. D. 2010. *Handbook of survey research*, Emerald Group Publishing.

Marshall, C. & Rossman, G. B. 2010. *Designing qualitative research*, Sage.

Martino, G. & Polinori, P. 2011. Networks and organisational learning: evidence from broiler production. *British Food Journal,* 113**,** 871-885.

Martino, J. P. 1993. *Technological forecasting for decision making,* New York, McGraw-Hill, Inc.

Maskin, E. & Sjöström, T. 2002. Implementation theory. *Handbook of social Choice and Welfare,* 1**,** 237-288.

Mason, B. & Antony, J. 2000. Statistical process control: an essential ingredient for improving service and manufacuring quality. *Managing Service Quality,* 10**,** 233-238.

Mason, G., Van Ark, B. & Wagner, K. 1994. Productivity, Product Quality and Workforce Skills: Food Processing in Four European Countries. *National Institute Economic Review,* 147**,** 62-83.

Mataragas, M., Drosinos, E. H., Tsola, E. & Zoiopoulos, P. E. 2012. Integrating statistical process control to monitor and improve carcasses quality in a poultry slaughterhouse implementing a HACCP system. *Food Control,* 28**,** 205-211.

Mazu, M. J. & Conklin, J. D. 2012. Baker ' s Loaf: Learning from process management successes of all sizes. *Quality progress*.

Mazzola, J. B. & Mccardle, K. F. 1996. A Bayesian approach to managing learning-curve uncertainty. *Management science,* 42**,** 680-692.

Mazzola, J. B. & Mccardle, K. F. 1997. The stochastic learning curve: Optimal production in the presence of learning-curve uncertainty. *Operations Research,* 45**,** 440-450.

Mccutcheon, D. M. & Meredith, J. R. 1993. Conducting case study research in operations management. *Journal of Operations Management,* 11**,** 239-256.

Mcdermott, M. C. 1997. Pan-European branding: CPC International and Knorr. *British Food Journal,* 99**,** 297-307.

Mckernan, J. 2013. *Curriculum action research: A handbook of methods and resources for the reflective practitioner*, Routledge.

Mclellan, E., Macqueen, K. M. & Neidig, J. L. 2003. Beyond the qualitative interview: Data preparation and transcription. *Field methods,* 15**,** 63-84.

Mcnabb, D. E. & Sepic, F. T. 1995. Culture, climate, and total quality management: Measuring readiness for change. *Public Productivity & Management Review***,** 369-385.

Mcneese, W. H. & Klein, R. A. 1991. Measurement systems, sampling, and process capability. *Quality Engineering,* 4**,** 21-39.

Mctaggart, R. 2006. Participatory Action Research : issues in theory and practice Participatory Action Research : issues in theory and practice [1]. 37-41.

Medeiros, C. O., Cavalli, S. B., Salay, E. & Proença, R. P. C. 2011. Assessment of the methodological strategies adopted by food safety training programmes for food service workers: A systematic review. *Food Control,* 22**,** 1136-1144.

Mensah, L. D. & Julien, D. 2011. Implementation of food safety management systems in the UK. *Food Control,* 22**,** 1216-1225.

Meredith, B. 1997. *Management teams: why they succeed or fail*, Butterworth-Heinemann.

Meredith, J. 1993. Theory building through conceptual methods. *International Journal of Operations & Production Management,* 13**,** 3-11.

Meredith, J. 1998. Building operations management theory through case and field research. *Journal of Operations Management,* 16**,** 441-454.

Meredith, J. R., Raturi, A., Amoako-Gyampah, K. & Kaplan, B. 1989. Alternative research paradigms in operations. *Journal of Operations Management,* 8**,** 297-326.

Mertens, K., Löffel, J., Kemps, B., Kamers, B., Zoons, J., Darius, P., Decuypere, E., De Baerdemaeker, J. & De Ketelaere, B. 2009. An intelligent control chart for monitoring of autocorrelated egg production process data based on a synergistic control strategy. *Computers and Electronics in Agriculture,* 69**,** 100-111.

Middel, R., Coghlan, D., Coughlan, P. & Brennan, L. 2006. Action research in collaborative improvement. *International Journal of Technology Management,* 33**,** 67-91.

Miles, M. B. & Huberman, A. M. 1994. *Qualitative data analysis: An expanded sourcebook*, Sage.

Miles, M. B., Huberman, A. M. & Saldaña, J. 2013. *Qualitative data analysis: A methods sourcebook,* SAGE Publications, Incorporated.

Miller, T. & Balch, B. 1991. Statistical process control in food processing. *ISA Transactions,* 30**,** 35-37.

Minkman, M., Ahaus, K., Fabbricotti, I., Nabitz, U. & Huijsman, R. 2008. A quality management model for integrated care: results of a Delphi and Concept Mapping study. *International Journal for Quality in Health Care*.

Minkman, M., Ahaus, K., Fabbricotti, I., Nabitz, U. & Huijsman, R. 2009. A quality management model for integrated care: results of a Delphi and Concept Mapping study. *International Journal for Quality in Health Care,* 21**,** 66-75.

Mohamad, A. N., Dhakal, H., Labib, A. & Bennett, N. 2013. Lean readiness level within Kuwaiti manufacturing industries. *International Journal of Lean Six Sigma,* 4**,** 280-320.

Mohamad, M. N. 2009. *Global sourcing practices: a framework to improve sourcing strategy implementation.* Doctor of Philosophy, Cranfield University.

Mohd Rohani, J., Mohd Yusof, S. & Mohamad, I. 2009. The relationship between statistical process control critical success factors and performance: A structural equation modeling approach. *2009 IEEE International Conference on Industrial Engineering and Engineering Management***,** 1352-1356.

Montgomery, D. C. 2008. *Design and analysis of experiments,* New York, John Wiley & Sons.

Montgomery, D. C. 2012. *Introduction to statistical quality control,* New York, John Wiley & Sons.

Montgomery, D. C., Keats, J. B., Perry, L. A., Thompson, J. R. & Messina, W. S. 2000. Using statistically designed experiments for process development and improvement : an application in electronics manufacturing. *Surface Mount Technology,* 16**,** 55-63.

Morgan, G. 2006. *Sociological paradigms and organizational analysis,* New York, Ashgate Publishing.

Motorcu, A. R. & Gullu, A. 2006. Statistical process control in machining, a case study for machine tool capability and process capability. *Materials & Design,* 27**,** 364-372.

Moy, G., Käferstein, F. & Motarjemi, Y. 1994. Application of HACCP to food manufacturing: some considerations on harmonization through training. *Food Control,* 5**,** 131-139.

Motwani, J., Kumar, A. & Youssef, M. 1997. Forecasting quality of Indian manufacturing organizations: An exploratory analysis. *Total quality management and business excellence,* 8**,** 361-374.

Murray, P. & Chapman, R. 2003. From continuous improvement to organisational learning: developmental theory. *The learning organization,* 10**,** 272-282.

Namey, E., Guest, G., Thairu, L. & Johnson, L. 2007. Data reduction techniques for large qualitative data sets. *Handbook for team-based qualitative research***,** 137-162.

Neely, A., Gregory, M. & Platts, K. 2005. Performance measurement system design: a literature review and research agenda. *International Journal of Operations & Production Management,* 25**,** 1228-1263.

Negiz, A., Ramanauskas, P., Schlesser, J. E., Armstrong, D. J. & Others 1998. Modeling, monitoring and control strategies for high temperature short time pasteurization systems–3. Statistical monitoring of product lethality and process sensor reliability. *Food control,* 9**,** 29-47.

Nembhard, H. & Valverde-Ventura, R. 2003. Integrating experimental design and statistical control for quality improvement. *Journal of quality technology,* 35**,** 406-423.

Nightingale, D. J. & Mize, J. H. 2002. Development of a lean enterprise transformation maturity model. *Information, Knowledge, Systems Management,* 3**,** 15-30.
Nonthaleerak, P. & Hendry, L. 2008. Exploring the Six Sigma phenomenon using multiple case study evidence. *International Journal of Operations & Production Management,* 28**,** 279-303.
Noor, K. B. 2008. Case study: a strategic research methodology. *American Journal of Applied Sciences,* 5**,** 1602.
Noskievičová, D. 2010. Effective implementation of SPC. *In:*Dudas, L. (ed.) *cdn.intechopen.com.* 1 ed. Rijeka: Sclyo.
Nowack, M., Endrikat, J. & Guenther, E. 2011. Review of Delphi-based scenario studies: quality and design considerations. *Technological Forecasting and Social Change,* 78**,** 1603-1615.
Noyes, J. & Lewin, S. 2011. Chapter 5: Extracting qualitative evidence. *In:*Booth, A., Hannes, K., Harden, A., Harris, J. & Lockwood, C. (eds.). Cochrane Collaboration Qualitative Methods Group.
O., H. 1997. Statistical process control with the help of international statistical standards. *human system management,* 16**,** 201.
Oakland, J. & Tanner, S. 2007. A new framework for managing change. *The TQM Magazine,* 19**,** 572-589.
Oakland, J. S. 2008. *Statistical process control*, Routledge.
Oakland, J. S. & Tanner, S. J. 2006. Quality management in the 21st century–implementing successful change. *International Journal of Productivity and Quality Management,* 1**,** 69-87.
Ogden, J. A., Petersen, K. J., Carter, J. R. & Monczka, R. M. 2005. Supply management strategies for the future: a Delphi study. *Journal of Supply Chain Management,* 41**,** 29-48.
Ogland, P. 2014. *Mechanism design for total quality management: Using the bootstrap algorithm for changing the control game*, Raleigh, Lulu. com.
Okoli, C. & Pawlowski, S. D. 2004. The Delphi method as a research tool: an example, design considerations and applications. *Information & Management,* 42**,** 15-29.
Onwuegbuzie, A. J., Johnson, R. B. & Collins, K. M. 2009. Call for mixed analysis: A philosophical framework for combining qualitative and quantitative approaches. *International journal of multiple research approaches,* 3**,** 114-139.
Ooi, G. & Mcfarlane, D. 1998. Non-standard application of SPC in sugar quality monitoring. *Control'98. UKACC International Conference on (Conf. Publ. No. 455).* IET.
Ottosson, S. 2003. Participation action research: A key to improved knowledge of management. *Technovation,* 23**,** 87-94.
Owen, M., Dale, B. & Shaw, P. 1989. Implementing SPC: Keys to success. *The TQM Magazine,* November**,** 279-283.
Özdemir, M. & Özilgen, M. 1997. Comparison of the quality of hazelnuts unshelled with different sizing and cracking systems. *Journal of agricultural engineering research,* 67**,** 219-227.
Özilgen, M. 1998. Construction of quality control charts with sub-optimal size samples. *Food control,* 9**,** 57-60.
Pable, A., Lu, S. & Auerbach, J. 2010. Integrated Qualitative/Quantitative Techniques for Food Product Quality Planning. *Journal of Food Quality,* 33**,** 112-129.
Padhy, R., Sahu, S. & Das, R. 2011. Implementation of Six Sigma in Indian industries–a Delphi study. *International Journal of Computer Aided Engineering and Technology,* 3**,** 19-33.

Paiva, C. L. 2013. Quality Management: Important Aspects for the Food Industry. *In:* Muzzalupo, I. (ed.) *Food Industry.* Rijeka: InTech.

Palmberg, K. 2010. Experiences of implementing process management: a multiple-case study. *Business Process Management Journal,* 16**,** 93-113.

Pande, P. S., Neuman, R. P., Cavanagh, R. R. & George, M. L. 2002. *The Six Sigma way: team fieldbook: an implementation guide for process improvement teams*, McGraw-Hill Columbus.

Parasuraman, A. 2000. Technology Readiness Index (TRI) a multiple-item scale to measure readiness to embrace new technologies. *Journal of Service Research,* 2**,** 307-320.

Parkhideh, S. & Parkhideh, B. 1998. Design of a flexible zone individuals control chart. *International Journal of Production Research,* 36**,** 2259-2267.

Patton, M. Q. 1990. *Qualitative evaluation and research methods*, SAGE Publications, inc.

Pena-Rodriguez, M. E. 2013. *Statistical Process Control for the FDA-Regulated Industry*, ASQ Quality Press.

Penland, T. 1997. A Model to Create "Organizational Readiness" for the Successful Implementation of Quality Management Systems. *International Journal for Quality in Health Care,* 9**,** 69-72.

Pereira, Z. L. & Aspinwall, E. 1991. Total Quality Control in the food industry. *Total Quality Management,* 2**,** 123-129.

Pereira, Z. L. & Aspinwall, E. 1993. Off-line quality control applied to food products. *Total Quality Management,* 4**,** 37-41.

Perry, C. & Zuber-Skerritt, O. 1994. Doctorates by action research for senior practising managers. *Management Learning,* 25**,** 341-364.

Pfeffermann, D. & Rao, C. 2009. *Handbook of Statistics: Sample Surveys: Theory, Methods and Infernece,* Access Online via Elsevier.

Pinto, J. K. & Prescott, J. E. 1988. Variations in critical success factors over the stages in the project life cycle. *Journal of management,* 14**,** 5-18.

Pisano, G. P. 1994. Knowledge, integration, and the locus of learning: An empirical analysis of process development. *Strategic Management Journal,* 15**,** 85-100.

Platts, K., Mills, J., Bourne, M., Neely, A., Richards, A. & Gregory, M. 1998. Testing manufacturing strategy formulation processes. *International Journal of Production Economics,* 56**,** 517-523.

Pluta, P. L. 2014. Statistical Tools for Development and Control of Pharmaceutical Processes: Statistics in the FDA Process Validation Guidance. *Journal of Validation Technology,* 20.

Prajogo, D. I. & Sohal, A. S. 2001. TQM and innovation: a literature review and research framework. *Technovation,* 21**,** 539-558.

Procontrol, S. 1994. Statistical process control for deep-frozen bakery products. 15-16.

Prosser, L. 2009. UK Standard Industrial Classification of Economic Activities 2007 (SIC 2007). *In:* (ONS), O. O. N. S. (ed.).: Macmillan Publishers Limited,Hampshire.

Prybutok, V. R. & Ramasesh, R. 2005. An action-research based instrument for monitoring continuous quality improvement. *European Journal of Operational Research,* 166**,** 293-309.

Psomas, E. L. & Fotopoulos, C. V. 2010. Total quality management practices and results in food companies. *International Journal of Productivity and Performance Management,* 59**,** 668-687.

Quinn, R. E. & Rohrbaugh, J. 1983. A spatial model of effectiveness criteria: towards a competing values approach to organizational analysis. *Management science,* 29**,** 363-377.

Rábago-Remy, D., Padilla-Gasca, E. & Rangel-Peraza, J. 2014. Statistical Quality Control and Process Capability Analysis for Variability Reduction of the Tomato Paste Filling Process. *Ind Eng Manage,* 3**,** 1-7.

Radnor, Z. 2011. Implementing Lean in Health Care: Making the link between the approach, readiness and sustainability. *International Journal of Industrial Engineering and Management,* 2**,** 1-12.

Rai, B. K. 2008. Implementation of statistical process control in an Indian tea packaging company. *International Journal of Business Excellence,* 1**,** 160-174.

Raju, K. V. R. 2005. Quality Control For Processed Food. *In:* Raju, K. V. R. (ed.) *APO Seminar on Quality Control for Processed Food.* China: Asian Productivity Organization.

Raper, P., Ashton, D., Felstead, A. & Storey, J. 1997. Towards the Learning Organisation? Explaining Current Trends in Training Practice in the UK. *International Journal of Training and Development,* 1**,** 9-21.

Reason, P. & Bradbury, H. 2001. *Handbook of action research: Participative inquiry and practice*, Sage.

Roberts, G. B., Watson, K. & Oliver, J. E. 1989. Technological Innovation and Organisational Culture: An Exploratory Comparison of Larger and Smaller Firms. *Journal of Organizational Change Management,* 2**,** 65-74.

Robson, C. 2011. *Real world research: a resource for users of social research methods in applied settings,* Wiley Chichester.

Rockart, J. 1979. Chief executives define their own data needs. *Harvard business review,* 57.

Rogers, E. 1995. *Diffusion of innovations,* New york, Simon & Schuster, Inc.

Rohani, J. M. & Teng, Chan. K.T. 2007. Improving quality with basic statistical process control (spc) tools: a case study. *Jurnal Teknologi,*35**,** 21-33.

Rosenweig, G. 1991. Instrument reliability : the key to statistical process control. *ISA Transactions,* 20.

Rousseau, D. M. 2012. *The Oxford handbook of evidence-based management,* New York, Oxford University Press.

Rungasamy, S., Antony, J. & Ghosh, S. 2002. Critical success factors for SPC implementation in UK small and medium enterprises: some key findings from a survey. *The TQM Magazine,* 14**,** 217-224.

Rungtusanatham, A., Anderson, J. C. & Dooley, K. J. 1999. Towards measuring the "SPC implementation / practice " construct. *International Journal of Quality & Reliability,* 16**,** 301-329.

Rungtusanatham, M. 2000. The Quality and Motivational Effects of Statistical Process Control. *Journal of Quality Management,* 4**,** 243-264.

Rungtusanatham, M. 2001. Beyond improved quality: the motivational effects of statistical process control. *Journal of Operations Management,* 19**,** 653-673.

Rungtusanatham, M., Anderson, J. C. & Dooley, K. J. 1997. Conceptualizing organizational implementation and practice of statistical process control. *Journal of Quality Management,* 2**,** 113-137.

Rungtusanatham, M. J., Choi, T. Y., Hollingworth, D. G., Wu, Z. & Forza, C. 2003. Survey research in operations management: historical analyses. *Journal of Operations Management,* 21**,** 475-488.

Rusly, F. H., Corner, J. L. & Sun, P. 2012. Positioning change readiness in knowledge management research. *Journal of Knowledge Management,* 16**,** 329-355.

Saaty, T. L. 1990. How to make a decision: The analytic hierarchy process. *European Journal of Operational Research,* 48**,** 9-26.

Saini, P. K., Marks, H. M., Dreyfuss, M. S., Evans, P., Cook, L. V. & Dessai, U. 2011. Indicator organisms in meat and poultry slaughter operations: their potential use in process control and the role of emerging technologies. *Journal of food protection,* 74**,** 1387-94.

Saldaña, J. 2012. *The coding manual for qualitative researchers*, Sage, London.

Sargeant, J. M., Amezcua, M. D. R., Rajic, A. & Waddell, L. 2005. *A guide to conducting systematic reviews in agri-food public health*, Public Health Agency of Canada.

Saunders, M. N., Saunders, M., Lewis, P. & Thornhill, A. 2011. *Research methods for business students, 5/e*, Pearson Education, India.

Savolainen, T. & Haikonen, A. 2007. Dynamics of organizational learning and continuous improvement in six sigma implementation. *The TQM Magazine,* 19**,** 6-17.

Scandura, T. A. & Williams, E. A. 2000. Research methodology in management: Current practices, trends, and implications for future research. *Academy of Management journal,* 43**,** 1248-1264.

Schein, E. H. 1999. *Process consultation revisited: Building the helping relationship*, Addison-Wesley Reading, Massachusets.

Schippers, W. a. J. 1998. Applicability of statistical process control techniques. *International journal of production economics,* 56**,** 525-535.

Schippers, W. a. J. 2001. An integrated approach to process control. *International journal of production economics,* 69**,** 93-105.

Schmidt, R. C. 1997. Managing Delphi Surveys Using Nonparametric Statistical Techniques*. *Decision Sciences,* 28**,** 763-774.

Scott, B. S., Wilcock, A. E. & Kanetkar, V. 2009. A survey of structured continuous improvement programs in the Canadian food sector. *Food Control,* 20**,** 209-217.

Sedghi, A. 2015. UK tops chart of EU food waste. *The Guardian.* UK: Guardian News and Media.

Self, D. R. & Schraeder, M. 2009. Enhancing the success of organizational change: Matching readiness strategies with sources of resistance. *Leadership and Organization Development Journal,* 30**,** 167-182.

Senge, P. M. 1990. The leader's new work: building learning organizations. *Sloan Management Review,* 32**,** 7-23.

Senge, P. M. 2006. *The fifth discipline: The art & practice of the learning organization*, Crown Business.

Senior, B. 1997. Team roles and team performance: is there 'really'a link? *Journal of Occupational and Organizational Psychology,* 70**,** 241-258.

Shani, A. B. & Pasmore, W. A. 1985. Organization inquiry: Towards a new model of the action research process. *Contemporary organization development: Current thinking and applications,* 1**,** 438-48.

Sharma, R. & Kharub, M. 2014. Attaining competitive positioning through SPC–an experimental investigation from SME. *Measuring Business Excellence,* 18**,** 86-103.

Shewhart, W. 1939. *Statistical Method: From the Viewpoint of Quality Control,* New York, Dover Publications.

Skulmoski, G., Hartman, F. & Krahn, J. 2007. The Delphi method for graduate research. *Journal of Information Technology Education: Research,* 6**,** 1-21.

Smith, H. W. 1975. *Strategies of social research: The methodological imagination*, Prentice-Hall Englewood Cliffs, NJ.

Smith, I. 2005a. Achieving readiness for organisational change. *Library Management,* 26**,** 408-412.

Smith, I. 2005b. Managing the 'people' side of organisational change. *Library Management,* 26**,** 152-155.

Snee, R. D. 1990. Statistical thinking and its contribution to total quality. *The American Statistician,* 44**,** 116-121.

Snee, R. D. & Hoerl, R. W. 2003. *Leading six sigma: A step by step guide based on experience with GE and other six sigma companies,* Ft Press.

Snyder-Halpern, R. 2001. Indicators of organizational readiness for clinical information technology/systems innovation: a Delphi study. *International journal of medical informatics,* 63**,** 179-204.

Srikaeo, K., Furst, J. E. & Ashton, J. 2005. Characterization of wheat-based biscuit cooking process by statistical process control techniques. *Food Control,* 16**,** 8.

Srikaeo, K. & Hourigan, J. A. 2002. The use of statistical process control (SPC) to enhance the validation of critical control points (CCPs) in shell egg washing. *Food Control,* 13**,** 263-273.

Staples, M. & Niazi, M. 2007. Experiences using systematic review guidelines. *Journal of Systems and Software,* 80**,** 1425-1437.

Stoumbos, Z. G., Reynolds, M. R., Ryan, T. P. & Woodall, W. H. 2000. The State of Statistical Process Control as We Proceed into the 21st Century. *Journal of the American Statistical Association,* 95**,** 992.

Stuart, M., Mullins, E. & Drew, E. 1996. Statistical quality control and improvement. *European journal of operational research,* 88**,** 203-214.

Stuckey, H. 2013. Three types of interviews: Qualitative research methods in social health. *Journal of Social Health and Diabetes,* 1**,** 56.

Study, A. C. & Carter, D. W. 1993. Effective Implementation of SPC in Wide Area Manufacturing Systems. *CompEuro '93. 'Computers in Design, Manufacturing, and Production', Proceedings.***,** 132-138.

Surak, J. G. 1999a. Quality in commercial food process. *Quality progress,* February**,** 25-29

Surak, J. G., Cawley, J. L. & Hussain, S. A. 1998. Integrating haccp and spc. *Food Quality,* 5**,** 41-43.

Susman, G. I. & Evered, R. D. 1978. An assessment of the scientific merits of action research. *Administrative science quarterly***,** 582-603.

Swamidass, P. M. 1991. Empirical science: new frontier in operations management research. *Academy of management review,* 16**,** 793-814.

Swamidass, P. M. & Winch, G. W. 2002. Exploratory study of the adoption of manufacturing technology innovations in the USA and the UK. *International Journal of Production Research,* 40**,** 2677-2703.

Tan-Intara-Art, S. & Rojanarowan, N. 2013. Prioritization and selection of parameters for control chart implementation based on technical criticality and cost criticality. *Decision Science Letters,* 2**,** 203-210.

Tashakkori, A. & Teddlie, C. 1998. *Mixed methodology: Combining qualitative and quantitative approaches,* Sage, London.

Tashakkori, A. & Teddlie, C. 2010. *Sage handbook of mixed methods in social & behavioral research,* Sage, London.

Teddlie, C. & Tashakkori, A. 2009. *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences,* Sage Publications Inc,London.

Teddlie, C. & Yu, F. 2007. Mixed methods sampling a typology with examples. *Journal of mixed methods research,* 1**,** 77-100.

Teram, E., Schachter, C. L. & Stalker, C. A. 2005. The case for integrating grounded theory and participatory action research: empowering clients to inform professional practice. *Qualitative health research,* 15**,** 1129-40.

Thomas, D. R. 2006. A general inductive approach for analyzing qualitative evaluation data. *American journal of evaluation,* 27**,** 237-246.

Thomas, J. & Harden, A. 2008. Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC medical research methodology,* 8**,** 45.

Thor, J., Lundberg, J., Ask, J., Olsson, J., Carli, C., Härenstam, K. P. & Brommels, M. 2007. Application of statistical process control in healthcare improvement: systematic review. *Quality & safety in health care,* 16**,** 387-99.

Thorpe, R., Holt, R., Macpherson, A. & Pittaway, L. 2005. Using knowledge within small and medium-sized firms: A systematic review of the evidence. *International Journal of Management Reviews,* 7**,** 257-281.

Tranfield, D., Denyer, D. & Smart, P. 2003. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management,* 14**,** 207-222.

Trienekens, J. & Zuurbier, P. 2008. Quality and safety standards in the food industry, developments and challenges. *International Journal of Production Economics,* 113**,** 107-122.

Tsakanikos, E. 2006. Associative learning and perceptual style: Are associated events perceived analytically or as a whole? *Personality and Individual Differences,* 40**,** 579-586.

Tsung, F., Li, Y. & Jin, M. 2008. Statistical process control for multistage manufacturing and service operations: a review and some extensions. *International Journal of Services Operations and Informatics,* 3**,** 191-204.

Tucker, A. L., Edmondson, A. C. & Spear, S. 2002. When problem solving prevents organizational learning. *Journal of Organizational Change Management,* 15**,** 122-137.

Upton, D. M. & Kim, B. 1998. Alternative methods of learning and process improvement in manufacturing. *Journal of Operations Management,* 16**,** 1-20.

Vaidya, O. S. & Kumar, S. 2006. Analytic hierarchy process: An overview of applications. *European Journal of Operational Research*, 169**,** 1-29.

Van De Ven, A. H. & Poole, M. S. 1990. Methods for studying innovation development in the Minnesota Innovation Research Program. *Organization Science,* 1**,** 313-335.

Van Der Spiegel, M., Luning, P. A., Ziggers, G. W. & Jongen, W. M. F. 2003. Towards a conceptual model to measure effectiveness of food quality systems. *Trends in Food Science & Technology,* 14**,** 424-431.

Vanderspiegel, M., Luning1, P. A., Boer, W. J. D., Ziggers, G. W. & Jongen, W. M. F. 2005. How to improve food quality management in the bakery sector. *NJAS - Wageningen Journal of Life Sciences*, 53**,** 131-150.

Varzakas, T. H. & Arvanitoyannis, I. S. 2007. Application of Failure Mode and Effect Analysis (FMEA), cause and effect analysis, and Pareto diagram in conjunction with HACCP to a corn curl manufacturing plant. *Critical reviews in food science and nutrition,* 47**,** 363-87.

Vasconcellos, J. A. 2003. *Quality assurance for the food industry: a practical approach*, CRC Press.

Vlachos, I. 2015. Applying Lean thinking in the Food Supply Chains: A Case Study. *Production, Planning and Control*.

Voss, C., Tsikriktsis, N. & Frohlich, M. 2002. Case research in operations management. *International journal of operations & production management*, 22**,** 195-219.

Wacker, J. G. 1998. A definition of theory: research guidelines for different theory-building research methods in operations management. *Journal of Operations Management*, 16**,** 361-385.

Wallace, C. A., Holyoak, L., Powell, S. C. & Dykes, F. C. 2012. Re-thinking the HACCP team: An investigation into HACCP team knowledge and decision-making for successful HACCP development. *Food Research International,* 47**,** 236-245.

Wang, C. L. & Ahmed, P. K. 2002. *A review of the concept of organisational learning*, University of Wolverhampton Wolverhampton.

Watson, R. M. 1998. Implementing self-managed process improvement teams in a continuous improvement environment. *The TQM Magazine,* 10**,** 246-257.

Weeks, B., Helms, M. M. & Ettkin, L. P. 1995. Is your organization ready for TQM? An assessment methodology. *The TQM Magazine,* 7**,** 43-49.

Weiner, B. J. 2009. A theory of organizational readiness for change. *Implement Sci,* 4**,** 67.

Weitzman, E. & Miles, M. B. 1995. *Computer programs for qualitative data analysis: A software sourcebook*, Sage Publications.

Westbrook, R. 1995. Action research : a new paradigm for research in production and operations management. *International Journal of Operations & Production Management,* 15**,** 6-20.

White, S. 2013. Business Population Estimates For the UK and Regions 2013. *In:* (BIS), D. F. B. I. S. (ed.). Sheffield: National Statistics.

Wijnands, J., Van Der Meulen, B., Poppe, K. & Industria, C. E. D. G. D. E. E. 2007. Competitiveness of the European Food Industry: an economic and legal assessment.

Wilcox, M. 2004. Prediction and pragmatism in Shewhart's theory of statistical control. *Management Decision,* 42**,** 152-165.

Wood, M. 1994. Statistical methods for monitoring service processes. *International Journal of Service Industry Management,* 5**,** 53-68.

Woodall, W. & Spitzner, D. 2004. Using control charts to monitor process and product quality profiles. *Journal of Quality,* 36, 309-320.

Woodall, W. H. 2000. Controversies and contradictions in statistical process control. *Journal of Quality Technology,* 32**,** 341-350.

Woodall, W. H. & Montgomery, D. C. 2014. Some Current Directions in the Theory and Application of Statistical Process Monitoring. *Journal of Quality Technology,* 46, 78-94.

Woodall, W. H. & Thomas, E. V. 1995. Statistical process control with several components of common cause variability. *IIE transactions,* 27**,** 757-764.

Xie, M. & Goh, T. 1999. Statistical techniques for quality. *The TQM magazine,* 11**,** 238-242.

Xie, M., Goh, T. N. & Xie, W. 1995. Prioritizing processes for better implementation of statistical process control techniques. *Engineering Management Conference, 1995.'Global Engineering Management: Emerging Trends in the Asia Pacific'., Proceedings of 1995 IEEE Annual International.* IEEE.

Yimer, W. 2013. Quality improvement using statistical process control tools in glass bottles manufacturing company.*International Journal for Quality Research* 7, 107–126

Yin, R. K. 2008. *Case study research: Design and methods*, Thousands Oak, SAGE Publications, Incorporated, Los Angeles.

Yusof, S. M. & Aspinwall, E. 2000a. A conceptual framework for TQM implementation for SMEs. *The TQM magazine,* 12**,** 31-37.

Yusof, S. R. M. & Aspinwall, E. 2000b. Total quality management implementation frameworks: Comparison and review. *Total Quality Management,* 11**,** 281-294.
Zairi, M. 1994. Leadership in TQM Implementation. *The TQM Magazine,* 6**,** 9-16.
Ziglio, E. 1996. The Delphi method and its contribution to decision-making. *Gazing into the oracle: The Delphi method and its application to social policy and public health,* 5, 3-33.
Zuber-Skerritt, O. & Perry, C. 2002. Action research within organisations and university thesis writing. *Learning Organization,* 9**,** 171-179.

APPENDIX

Appendix A

Survey Invitation Letter

QUALITY IMPROVEMENT INITATIVES IN THE FOOD INDUSTRY
DESIGN MANUFACTURING AND ENGINEERING MANAGEMENT,
UNIVERSITY OF STRATHCLYDE
Doctoral Research Survey Invitation

SPC AND FOOD INDUSTRY- DOCTORAL RESEARCH SURVEY INVITE

Dear Sir/Madam

I am writing to invite you to participate in a survey for a study on the quality improvement initiatives deployment in the food industry as a part of a Doctoral research to **determine the status of the food industry in implementing quality improvement initiatives to enhance their product quality and bottom-line impact**. The results of this survey will be the foundation of the development of a **systematic and practical step-by-step roadmap for the food industry that would provide a practical guideline on how and when to get started with SPC journey.** Such objective will be practical to the utility of the food industry to have a successful adoption of a powerful quality improvement technique such as SPC.

The other aim of this Doctoral research is to develop an '**SPC Readiness Index' that can identify key areas a company is excelling in or indeed if underperforming** and subsequently determine if they are ready or not for the SPC journey. We plan to develop a **practical framework** for the food industry as a guide to getting started with quality improvement initiatives likes SPC not only in achieving but to sustain results as well. The results from the survey will be used for the research purpose only and there will be no attempt will be made to identify any individual in the organisation. If you are interested to receive the result of this study, please fill in your contact details at the end of the survey. All responses will be treated with the utmost **confidential** and no single set of responses will be readily identifiable. Your assistance and time taken to complete this questionnaire is greatly appreciated.

Appendix B

Survey Questionnaire

Q1 PART I COMPANY BACKGROUND

Q2: Please states the full name of your company.

____

Q3: Please specifies the state and country which this company operates.

Country :______________________

County/State :_________________

Q4: What is the type of your company?

☐Local firm

☐Joint venture

☐Subsidiaries of Multi-national

☐Others (Please specify) :________________________

Q5: What is the main product category of your company based on the Standard Industrial Classification (SIC)?

☐Meat

☐Fish, crustaceans and mollusks

☐Fruit and vegetables

☐Vegetable/animal oils and fats

☐Grain mill products, starches and starch products

☐Dairy

☐Bakery

☐Sugar

☐Cocoa, chocolate and sugar confectionery

☐Macaroni, noodles, couscous and similar farinaceous products

☐Prepared meals and dishes

☐Prepared animal feeds

Q6: What is your current position in the company?

☐CEO/Director/General Manager

☐Departmental head (2)

☐Managers (quality/process/production)

☐Black belt

☐Others (Please specify):________________________

Q7: How many employees work in your company?

☐1-10

☐11-50

☐51-250

☐251-100

☐More than 1000

Q8: Please ticks any of the following third party-accredited quality assurance system, which is/are used in your company.

	Application	Duration
	Tick in the box	Number of year(s)e.g.: 2 years
ISO 9001:2008	☐	________________________
European Food Safety Inspection Service (EFSIS)	☐	________________________
Hazard Analysis and Critical Control Point (HACCP)	☐	________________________
Customer-specific QA system	☐	________________________

Q9: Please tick quality award(s) (if any) your company has won.

☐EFQM

☐MBNQA

☐Deming Prize

☐Australian Quality Award (AQA)

☐Others (Please specify):______________________

Q10: **Which quality improvement program(s) have been implemented in your company?**

Partial = Reduced scale deployment (could be a division, business unit, or even a single plant)

Full **=** Company wide deployment

	Implementation			**Duration**
	None	Partial	Full	Year(s)
Six Sigma	☐	☐	☐	________________
Lean	☐	☐	☐	________________
Lean Six Sigma	☐	☐	☐	________________
Total Quality Management (TQM)	☐	☐	☐	________________
Others (If any, please specify, if none please state as 'none') ________________	☐	☐	☐	________________
Others (If any, please specify, if none please state as 'none') ________________	☐	☐	☐	________________

Q11: Knowledge and usage of quality improvement basic tools in your company.

	How frequent these tools used in your company? (1= Never been implemented to 5=Frequently implemented)					How do you assess the usefulness of these tools in your company? (1=Not useful to 5=Extremely useful)				
	1	2	3	4	5	1	2	3	4	5
Basic statistics calculation (mean, median, mode, standard deviation, range, defect counts)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Boxplots	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cause and effect/Ishikawa/ fishbone diagram	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brainstorming	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Check sheets	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Customer complains analysis	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Run chart	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Histograms	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pareto analysis	☐	☐	☐	☐	☐		☐	☐	☐	☐
Scatter diagrams	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Affinity diagram	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Arrow diagram/ critical path analysis	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Matrix data methods	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Matrix diagrams	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Stem and leaf plots	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Relation diagram	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Systematic diagram/ tree diagrams	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Time series plot	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pie/Bar chart	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Single minute exchange of dies (SMED)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Value stream mapping (VSM)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Force field analysis	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Others (If any, please specify, if none please state as 'none'): ________________	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Q12: Knowledge and usage of quality improvement advance methods, techniques and tools in your company.

	How frequent these tools used in your company? (1= Never been implemented to 5=Frequently implemented)					How do you assess the usefulness of these tools in your company? (1=Not useful to 5=Extremely useful)				
	1	2	3	4	5	1	2	3	4	5
Benchmarking	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Design of experiments (DOE)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Taguchi method	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Failure Mode and Effect Analysis (FMEA)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Poke-yoke	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Quality cost	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Quality function deployment (QFD)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Q13: Does your company implement SPC?

☐Yes

☐No

If **No** Is Selected, Then Skip To **PART VI Performance Measurement Q22,** if **Yes** is selected please proceed to **Q17.**

Q14: How many year(s) has your company have been using SPC?

(____)

Q15: Who leads SPC implementation in your company? (Job title e.g. quality manager, process manager)

(____)

Q16: PART III KNOWLEDGE AND USAGE OF CONTROL CHARTS AND OTHER SPC TOOLS IN THE FOOD INDUSTRY.

	How frequent these tools used in your company? (1= Never implemented to 5=Frequently implemented)					How do you assess the usefulness of these tools in your company? (1=Not useful to 5=Extremely useful)				
	1	2	3	4	5	1	2	3	4	5
Mean ($\bar{x}$) chart	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Range (R) chart	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Standard deviation (s) chart	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Proportion defective (p) chart	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Number of non-conforming (np) chart	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Count of nonconformance (c) chart	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Count of nonconformance(u)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
CUSUM charts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Multivariate control charts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Exponentially weighted moving average (EWMA)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Individual/ Moving range (X-MR) chart	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Acceptance sampling plans	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Operating characteristics curves	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Q17: PART V CRITICAL SUCCESS FACTORS OF SPC IMPLEMENTATION

Please rate the critical factors for a successful SPC implementation in your company in terms of its importance and implementation.

Importance = The factor has significant impact on the success of SPC implementation.

Implementation = The factor that has been executed or is available in current practice in your company.

	Importance (1=Least important to 5=Most important)					Implementation (1=Never implemented to 5=Fully implemented)				
	1	2	3	4	5	1	2	3	4	5
Leadership	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Top management commitment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Continuous training sessions	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
'Statistical thinking' mindset	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Empowerment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Prioritization of process	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Project management	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Measurement system analysis	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Larger company's size	☐	☐	☐	☐	☐		☐	☐	☐	☐
Availability of SPC expertise	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Q18: PART VI PERFORMANCE MEASUREMENT

This section asks about the status of your organisation's process performances.

Process performance metrics	Please tick the relevance of performance indicators, which your company uses.	Please rate the performance criteria on a scale (1= Worsens , 3=No changes to 5= Improved)				
	Applicable	1	2	3	4	5
Customer satisfaction	☐	☐	☐	☐	☐	☐
Customer complaints	☐	☐	☐	☐	☐	☐
Customer loyalty	☐	☐	☐	☐	☐	☐
Company's image	☐	☐	☐	☐	☐	☐
Competitive advantage	☐	☐	☐	☐	☐	☐
Quality awareness	☐	☐	☐	☐	☐	☐
Percentage of rework/scrap	☐	☐	☐	☐	☐	☐
Rates of defects/non-conforming	☐	☐	☐	☐	☐	☐
Waste (Overfill/ giveaway/ underfill)	☐	☐	☐	☐	☐	☐
Product quality and consistency	☐	☐	☐	☐	☐	☐
Cost of quality	☐	☐	☐	☐	☐	☐
Process capability (Cp, Cpk)	☐	☐	☐	☐	☐	☐
Process performance (Pp, Ppk)	☐	☐	☐	☐	☐	☐
Productivity	☐	☐	☐	☐	☐	☐

Answer Q19ifinDoes your company implements SPC? **No** Is Selected:

Q19: What are the reasons for not implementing SPC in your company? (Tick for more than one answer is allowed)

☐SPC is a too advanced technique to be applied.

☐Does not see the benefits of its application.

☐Insufficient statistical knowledge to apply SPC.

☐Does not understand the concept of SPC.

☐Insufficient time.

☐Insufficient resources (financial)

☐Top management does not support the implementation.

☐Others (please specify):____________________

☐Others (please specify):____________________

☐Others (please specify):____________________

Q24: Would you like to see the results of the survey?

☐Yes

☐No

Q25: Would you like to take part in our further studies in determining if a company is ready to deploy SPC technique for continuous process improvement in their facility through structured interviews?

☐Yes

☐No

Q26: Please provide your contact details

	Details
Name	__________________________
Email address	__________________________
Phone number (optional)	__________________________

Appendix C

Case study Invitation letter

STATISTICAL PROCESS CONTROL IN THE FOOD INDUSTRY

Doctoral Research Interview Invite

To:

I am writing to invite you to participate in a study on the SPC deployment in the food industry. The aim of this Doctoral research is to develop a systematic and practical framework for the food industry that would provide guidelines on how to get started with SPC journey and followed by sustaining the benefits achieved by SPC implementation. Furthermore, this research is intended to develop SPC Readiness Assessment Tool that enables companies to determine the areas they are excelling or underperform and subsequently suggest the improvement action based on the readiness level. Such objectives will be practical utility to the food industry companies like you to determine your status in continuous improvement (CI) practice and capability of implementing SPC.

These research objectives can be achieved through interviewing yourself and some of your colleagues including the Managing Director/ Head of Factory, Operations Director, Quality Director or Six Sigma Champion, Master Black Belts, Black Belts, Managers that involved in quality improvement aspect of your company. I am interested in getting insights based on your experiences and challenges you have faced in deploying continuous quality improvement initiatives in your company. The interview process will last approximately 90 minutes and will form, not only an integral part of my research but will also make a valuable contribution to the quality management field and food industry quality practices. The interviewees will not be identified and all information will be treated with the utmost confidentiality. There are no right or wrong answers as I am keen and interested in only for your views and experiences.

Please kindly let me know your two or three available dates in the next month to schedule the meeting. Thanks a lot in anticipation of your support.

Appendix D

<u>Case study protocol</u>

PHD RESEARCH PROJECT

The main objective of the research is to assess the status of SPC implementation and quality management practices in the food industry. Such objective will be achieved by mapping the quality management and SPC practices from two different types of companies, which are SPC Company and non SPC Company across different sizes. According to the systematic review of the previous studies in readiness assessment in other continuous improvement (CI) initiatives, semi-structured interview is suggested as the most appropriate method for this research. Semi-structured interview is preferred due to the exploratory characteristic of this research which required further information, which might not covered by researcher in the interview questions. This research expected the answer could be different depends on the individual opinions, level of expertise and background education. This phase of the research aims to collect qualitative data from the selected companies and compare the results found from the survey.

Unit of analysis

The present study is interested in understanding quality management practices in the food industry. The researcher aims to understand the underlying activities and practices within a company's quality management practices and captured the SPC implementation in an organisation. Thus, the company is the unit of analysis in this research.

Case study research: Field procedures

The data will be collected from the Quality Control/Assurance manager as the main samples and the managers who are involved in SPC deployment, quality control and assurances of the selected food manufacturing companies. The data will primarily be collected through a series of interviews session and observations to understand the related key themes of quality management and SPC implementation in the food industry, which the field procedures are as follow:

- Stage 1 Set up the interview strategy
- Stage 2 Formulating data collection strategy (semi-structured interviews for this study)

- Stage 3Validated the results
- Stage 4 Integrating and drawing the data collected

Stage 1: Setting up

- Identify the nature of business, type of organisation, quality management practices and SPC deployment in case study companies.
- administrative information (Six Sigma organization, development, etc.) gathered through online search and company web sites and from deployment champion.
- News and other information about SPC deployment in the case companies
- Throughout the case studies, the research confidentiality will be guaranteed at both organisation and individual level who participated in the interview.

As a part of the sequential mixed-method research (QUAN-QUAL) research, the selection of company was followed by a structured procedure. This type of research connected on another study and hence, the quality of results produced in one study may affect the quality of the inferences generated in the subsequent study. The criteria for companies' selection would help to elaborate any unexpected results from the survey research and allow any new themes to emerge. Wider contexts of research tend to provide more opportunities for checking alternative explanations and conducting multiple comparisons as various themes emerge. The companies that were selected must be a food manufacturing company, the company can be in all size but micro size (less than 10) such as artisan bakery (survey shows that larger company has a better change in implementing SPC). In order to get heterogeneity in type of companies, the companies were to be selected from a range of commodities in the food industry.

Stage 2: Conduct the interviews and data record

In conducting interview it was suggested the researcher to follow the critical point as below:

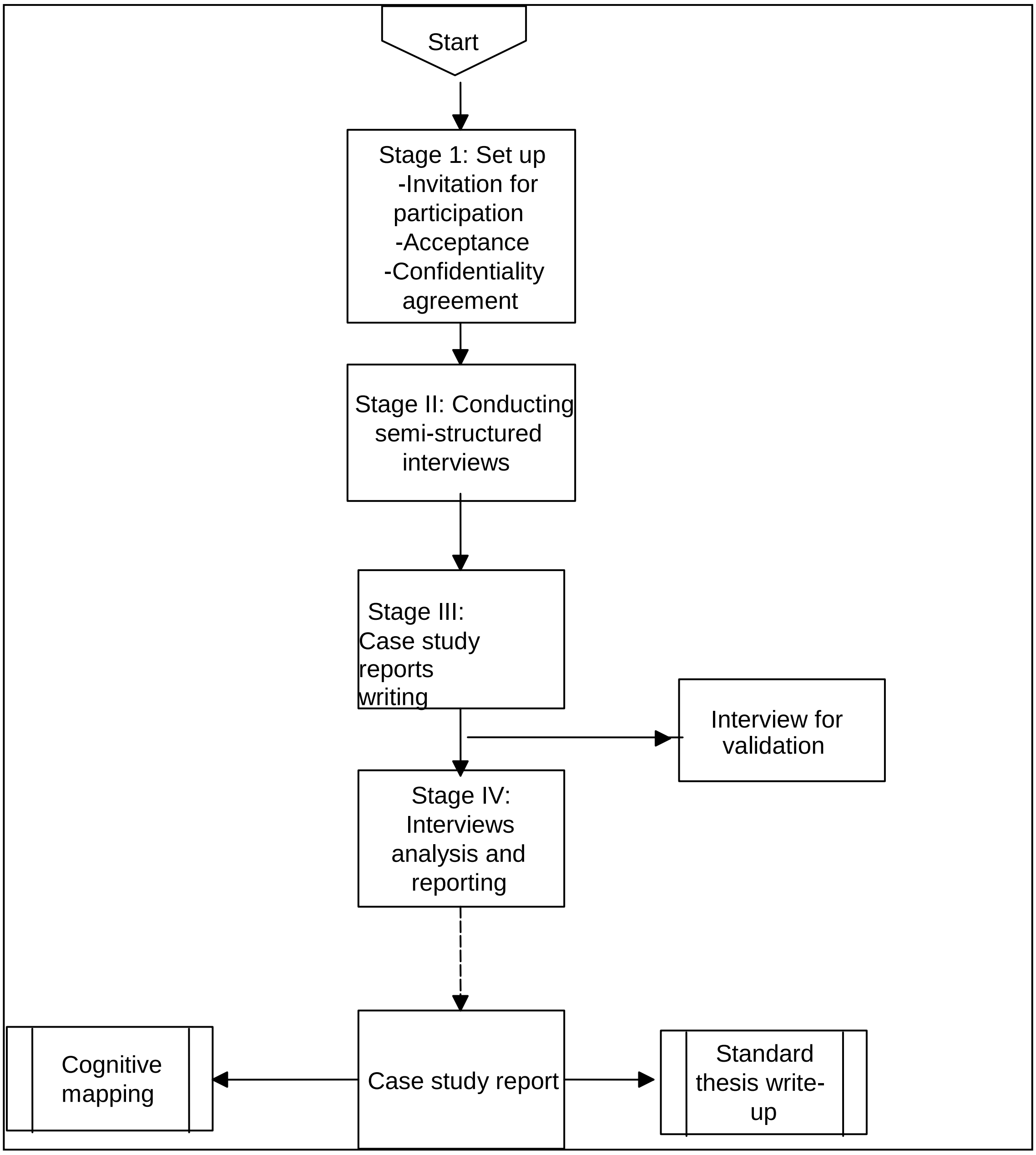


Figure D1: Phases of data collection in the case study

- Each of the interviews should not be longer than 90 minutes as the interviewees typically are managers with busy schedule.
- The interviewer to have a generic conservations with the with the interviewees to try to understand the quality management practices of the company following the sub-topic set by the researcher.
- It is also important to explicitly request the interviewee's opinion on the company's performance as a qualitative measurement of the company's performance.

- Ensure that the tools for recording were prepared such as electronic recorder, I-phone, me MP3 player
- The researcher should keep a note diary to facilitate the recording of all relevant observations, which is not captured by the recorder.

Stage 3: Case study report writing

In a stage the researcher is required to keep listening and to the interview recordings to transcribe and analyse the interviews. The evidence extracted from the case studies was documented and a detailed report was produced. The analysis produces at each case will be in within case analysis and cross-case analysis and facilitated by the prioritisation matrix and cognitive mapping.

Stage 4: Validation of the case study reports

The researcher will then present her findings to the interviewees (Quality managers) of the respective companies to confirm the result of the analysis. This review process will ensure the quality of the research and reliability of the collected data presented in a consistent manner.

Appendix E

SPC Food industry Interview Protocol

Section 1: Quality management in the food industry

- What is the main product of the company?
- What are the quality improvements/ CI initiatives are you undertaking at the moment?
- What are the food quality management certifications are you having at the moment? How does it facilitate the adoption of SPC?
- How the process performance was monitored? What are the metrics?
- What is the role of group activities within problem solving activities? Prompt: How does an SPC team was developed?
- Who lead the SPC implementation in the company?
- What is the role of employees for process improvement? Prompt questions: Process ownership?
- Describe the training programme used for SPC/quality improvement implementation. Prompt: Frequency, participants, training materials
- Who do you think should lead the implementation of SPC in the company? Prompt question: What are the characteristics of a good SPC leader?
- What types of learning involve in the SPC implementation

Section 2: The challenges faced from the initial implementation

- From your opinions, what are the challenges to implement SPC when it is introduced to the employees?
- Why your company does not adopt SPC?
- What factors were identified as critical to the success of SPC? Prompt: How has top management supported?

Section 3: Process performance

- What are the established performance metrics in the company?

Appendix F

Invitation to Join a Delphi Study Panel

Statistical Process Control Readiness Factors: Exploratory study

I'd like to take this opportunity to thank you for agreeing to participate in the second phase of this Delphi inquiry. The title of the study is “Organisational readiness factors to adopt Statistical Process Control (SPC)". The goal of this study is to develop a tool to measure the readiness of an organisation to adopt SPC objectively. This study will focus on identifying the factors, which can be used as the indicators for organisation readiness to adopt SPC. Due to readiness is an under explored field, your experiences in SPC is very valuable for this research. This study will incorporate with other SPC experts from the industry, consultants and academics. A Delphi enquiry is a procedure allows a group of experts to participate, jointly, but A Delphi enquiry is a procedure that allows a group of experts to participate, jointly but anonymously, in defining and analysing a complex problem or issue. **In our study, we envisage three rounds, each requiring a minimum of about 15 minutes to complete a questionnaire.** As this study is a structured 3 rounds short survey, with very few questions being asked, we will send a reminder for its completion in a week time.

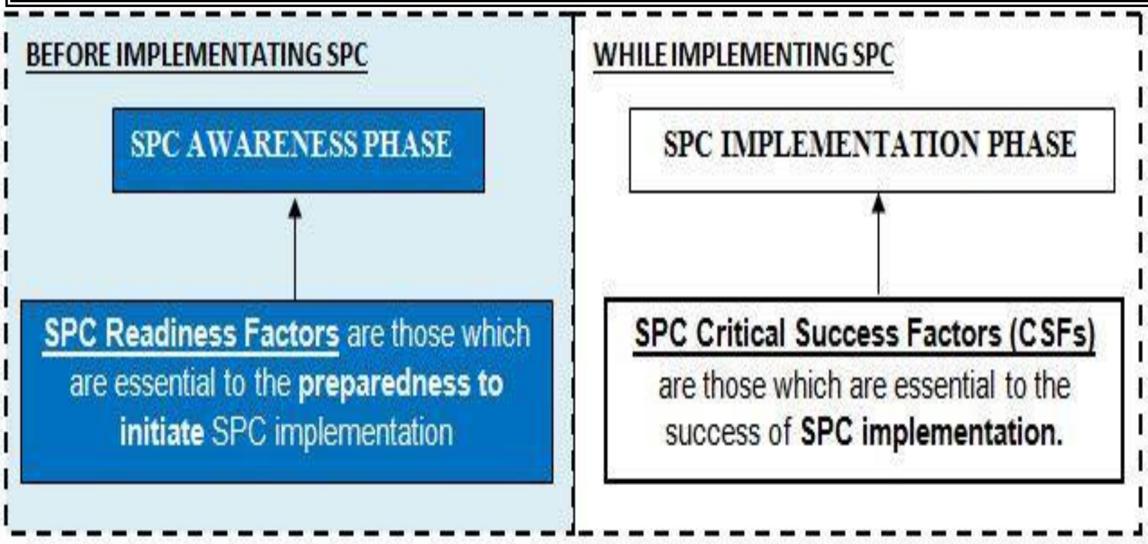
Many participants of this type of study find the process of feedback and benchmarking of their opinions particularly valuable. The opinions you provided should be personal, rather than reflecting the viewpoint of your organisation or affiliation. Please note that no travel will be required, as members of the panel do not have to meet physically at any time during the process. The members will be given a week to complete the questionnaire. To ensure the research captures our broad spectrum of expertise we are now seeking your active contribution and consensus between all participants. As such, this email serves as your invitation to participate in the proposed studies. Based on your expertise, I would like to invite you to contribute to this PhD study by completing the questionnaire at the given link. In return for your cooperation, we will provide, free of charge, pre-publication copies of the major reports being produced by this study. We are exceptionally keen to get your feedback on this invitation. Thank you. To start, please click/go to this link: https://qtrial2014.az1.qualtrics.com/SE/?SID=SV_e3Y4zli08Nlg5Lf

AppendixG

<u>A Delphi Survey</u>

This study aims to address SPC implementation from the operations management perspective, primarily on the organization's readiness to adopt SPC.

This study focus on the AWARENESS PHASE of SPC implementation (**COLOURED** in the diagram below); to evaluate whether the company is ready or not to adopt SPC implementation subsequently reduced the resistance for its adoption.



Therefore, by carrying out 2 rounds Delphi study, the researcher aims to identify the SPC readiness factors which are suggested by the SPC experts from academics, industries and consultants.

Online version is available at:

<u>https://qtrial2014.az1.qualtrics.com/SE/?SID=SV_e3Y4zli08Nlg5Lf</u>

PART 1 BACKGROUND INFORMATION

Q1: Please choose your field of profession

- Academics
- Industry (Please specify your position in the company: __________)
- Consultancy

Q2: Please specify number of years you have practice/research on Statistical Process Control:_____________

Q3: How many (if any) SPC projects have you carried out (approximately)?:___________________________

Q4: How many (if any) SPC projects have you carried out (approximately)?:___________________________

Q5: How many (if any) SPC projects have you carried out (approximately)?:___________________________

PART II BRAINSTORMING THE SPC READINESS FACTORS

This part is seeking to identify the factors we can use to assess the readiness level of an organization to initiate SPC implementation. These SPC readiness factors could include several aspects:

- Management aspect , Training aspect , People aspect, Operational aspect, Culture aspect

SPC readiness is defined as the organization's ability to reduce resistance in adopting SPC, and the preparedness to successfully initiate SPC implementation as their practice to achieve process stability for their core business processes through an effective application of SPC tools.

Q6: Please suggests Factor 1 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 1 :
Reasons:

Q7: Please suggests Factor 2 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 2: Reasons:

Q8: Please suggests Factor 3 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 3: Reasons:

Q9: Please suggests Factor 4 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 4: Reasons:

Q10: Please suggests Factor 5 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 5: Reasons:

Q11: Please suggests Factor 6 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 6: Reasons:

Q12: Please suggests Factor 7 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 7 : Reasons:

Q13: Please suggests Factor 8 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 8: Reasons:

Q14: Please suggests Factor 9 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 9: Reasons:

Q15: Please suggests Factor 10 that should be used to assess the readiness of an organization to start an SPC implementation? Please provide explanation/reasons based on the SPC readiness factors that you have suggested in the given boxes.

SPC Readiness factor 10: Reasons:

Q6: If you have further comment about this survey, please provide in the text below.

Cycle 2

Q1: Based on your opinion, would you retain or delete or modify the factor. Please provide explanation/reasons based on your selection (retain/delete/modify).

Do you think this factor should be retained/deleted/ modified?				Please provide the reasons to retain/modify/delete the factor. If you choose to modify, please describe how would you modify this factor?
	RETAIN	DELETE	MODIFY	EXPLANATION
Sense of urgency	●	●	●	
SPC leadership	●	●	●	
Top management commitment and involvement	●	●	●	
Availability of measurement system	●	●	●	
People/Employees management	●	●	●	
Training	●	●	●	
Organisational culture	●	●	●	
Customer focus	●	●	●	
Project management	●	●	●	

Q2: If you have further comment about this survey, please provide in the text below.

Q3: Please provide your personal details (This information will only visible to the main researcher)

	Details
Name	____________________________
Email address	____________________________
Phone number (optional)	_____________________________
Would you like the result of this study? (Yes/No)	_____________________________

Thank you for participating in the survey!

Appendix H

SPC Failure project: BetaCo

SPC was introduced to the bread-manufacturing company, BetaCo (245 employees), in March 2013 after a meeting with the top management of the company. The senior management was alarmed by the ten percent of waste. They were briefed on the underlying operational aspect of SPC and its advantage for the process excellence. The SPC team that was developed consisted of a manufacturing manager, two operators from different shifts, a maintenance technician, a QA representative and a production engineer. Each team also included a member who was responsible for operations before and after the study plus a coordinator/facilitator. After selecting a project by process prioritisation, the team focused on defining the scope of the processes.

Two months after initiation of the project, the company was sold to another company, and the senior management were replaced by new managers. The new BetaCo management decided to terminate the project because the management viewed the company was not ready for SPC. Apart from the shortage of employees with statistical skills, the new management decided that they are taking a different direction for their manufacturing practice (lean manufacturing) which lead to halt of the efforts of SPC adoption. The company has brought in a technique to initiate the lean implementation in the company. Hence, the current SPC pilot project was terminated due to the lack of support from the new management. The researcher argues that such condition can be categorised as a project failure due to the termination. Without top management support, this project will risk great challenge for its sustainability (Oakland, 2008).

Based on this experience, the lessons learnt is that the SPC implementation should not be initiated if there a possibility of change management in the company.

Appendix I

SPC Failure project: AlphaCo1

AlphaCo operates in Scotland and it is primarily known for its celebration cake production, but also expertise in the manufacture of biscuits and shortbreads for food for large-scale consumer outlets. AlphaCo is operated by 1013 employees, manufacturing 13 different types of bakery product on four production lines (L1, L2, L3, L4) at the site. The senior management demanded that the CI team reduce the percentage waste in production, which is why the lean programme was started in 2012 on L1 and L2 (not involved in this study). The researcher, her Ph.D. supervisor and a representative of an officer of the Knowledge Transfer Programme (KTP) attended the first meeting, as well as the manufacturing director (MD), and CI manager. The adoption of SPC is described in the following section from the process of following the guided steps in the conceptual roadmap of SPC implementation (see Chapter 3) through the AR cycle, as depicted in Chapter 4.

In general, the implementation of SPC in this company received a great deal of support from the top management, especially the MD as he had higher priority in making decisions, was briefed on the benefits of SPC, and was receptive to an SPC pilot study. On the basis of the first meeting, there was hesitancy for its use from the middle management, who feared implementing an advanced statistical technique. The senior management was alarmed by the percentage waste, which was exceeding the maximum baseline of five per cent set by the company. This was alleged to be due to inconsistencies in the characteristics of product quality. The CI manager was very enthusiastic about convincing the other managers of the need for SPC and the corporate upper management recognised her to be the SPC leader. Awareness meetings introduced the philosophy of SPC, the application of SPC to the food industry, the introduction of the concept of process variation and the benefits of SPC.

Among six other products, TCD was the product selected through process prioritisation with the application of Pareto analysis (Appendix H) based on the percentage of waste. Through process mapping by the team (Appendix H), the key processes (e.g. mixing and baking) were identified, a holistic view of the process determined, the process parameters involved and critical-to-quality parameters identified.

The SPC leader struggled to manage the project due to urgent new problems from top management requiring the attention of the CI manager. So, although there was an SPC leader and an SPC facilitator in the team, there was a need for an SPC coordinator act as the project manager to manage the progress of the project. In this project, the SPC coordinator is crucial as the SPC facilitator had less authority within the company due to her status as a postgraduate researcher, instead of an employee. After six months, the project was initiated, and the CI manager/SPC leader was promoted to a higher position within the organisation, which forced the leadership of the project to be delegated to another employee – the technical manager). However, the project was progressing very slowly as new league awards were reported for several reasons: product launching and changing suppliers. The company was also rearranging the L2 production line with the intention of transforming it from manual to semi-automatic, as an attempt to reduce process wastage. However, the researcher argued that the prevalent reason might the lack of a sense of urgency to execute the project of SPC implementation. There was no monthly project review carried out with the top management, reflecting insufficient commitment to the project by the top management. The SPC team members were unable to maintain their commitment to the project. Five months within the project, the product was delisted from the company due to a customer complaint that the company failed to address, causing AlphaCo to lose the trust of the customer.

The team in the company seems mostly comfortable with basic quality tools, which therefore the team applied Pareto analysis (waste percentages) were applied involving six products manufactured in L2 (e.g. AL, AC, AA, TCD TW, MA). TCD was determined as the SPC pilot project based on the data pointed that TCD is the product with the highest waste percentages with 29.3% and the highest waste percentages was recorded in September with 38.8%. The waste was comprise of the underweight of each slices, and the height of the cakes were inconsistent with averagely 28 mm despite the specifications height given by the customer 21 - 25 mm, icing cracked, Based on the quality control sheet, the specification limits were varied from day to day (e.g. September = 21-25 mm and November (26-28mm)). The varieties of specification limits communicated, shopfloor employees caused confusions, which subsequently affected the quality control of the product at the end of the production line.

Process description

Once the product is selected for the pilot project, the process involving the production of the product then was assessed in order to understand the processes key or key process related to the key objective of this project. In order to achieve such goal, a holistic and systematic process mapping is needed. However, there is no details and systematic view on the processes involved in the TCD production. The LS was delegated the responsible to carry out this step by following the exact blueprint the process involved in the production line. The process was numbered accordingly starting from raw material to the packaging process, which resulted the determination of 23 sub-processes as depicted in Figure I.2

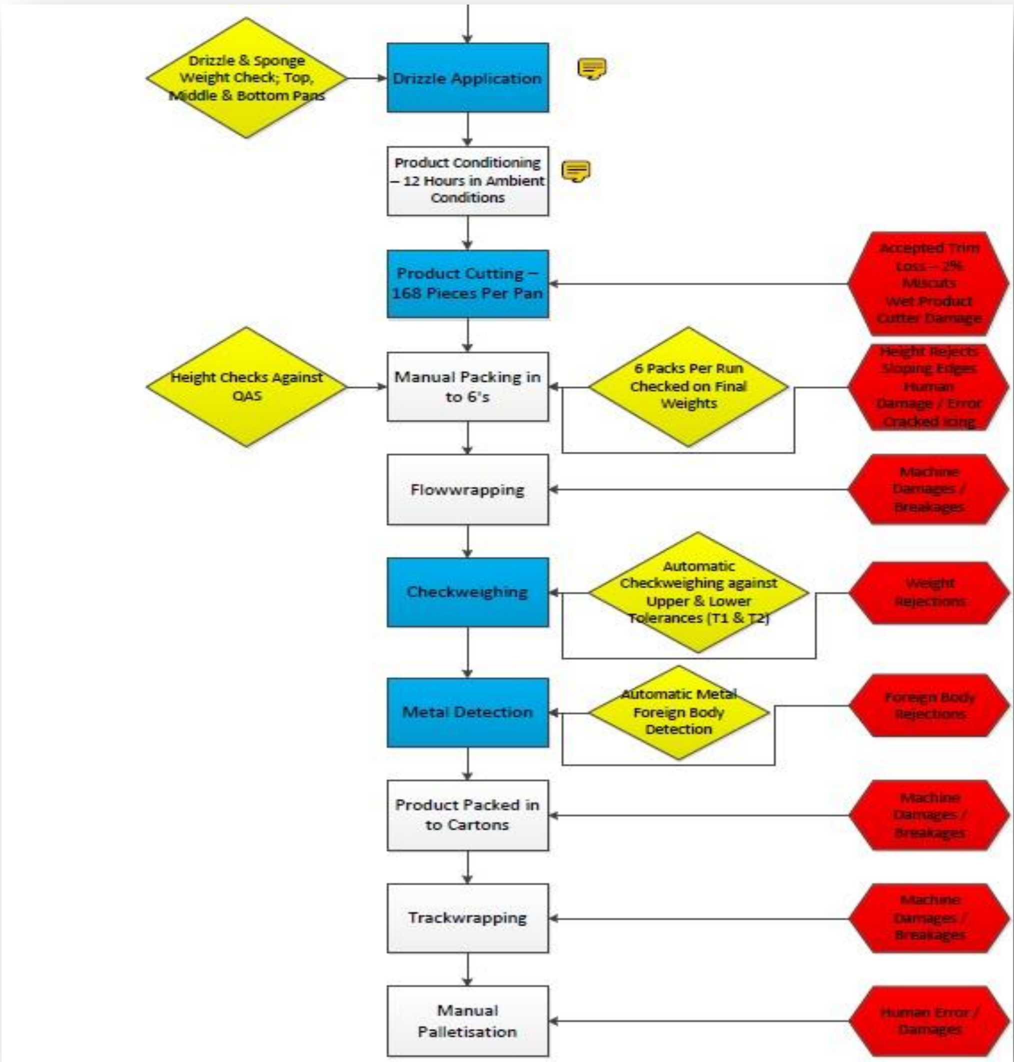


Figure I.2: Example of process flowchart for TCD production

Appendix J

SPC in Orange Slices (OS) project (AlphaCo2)

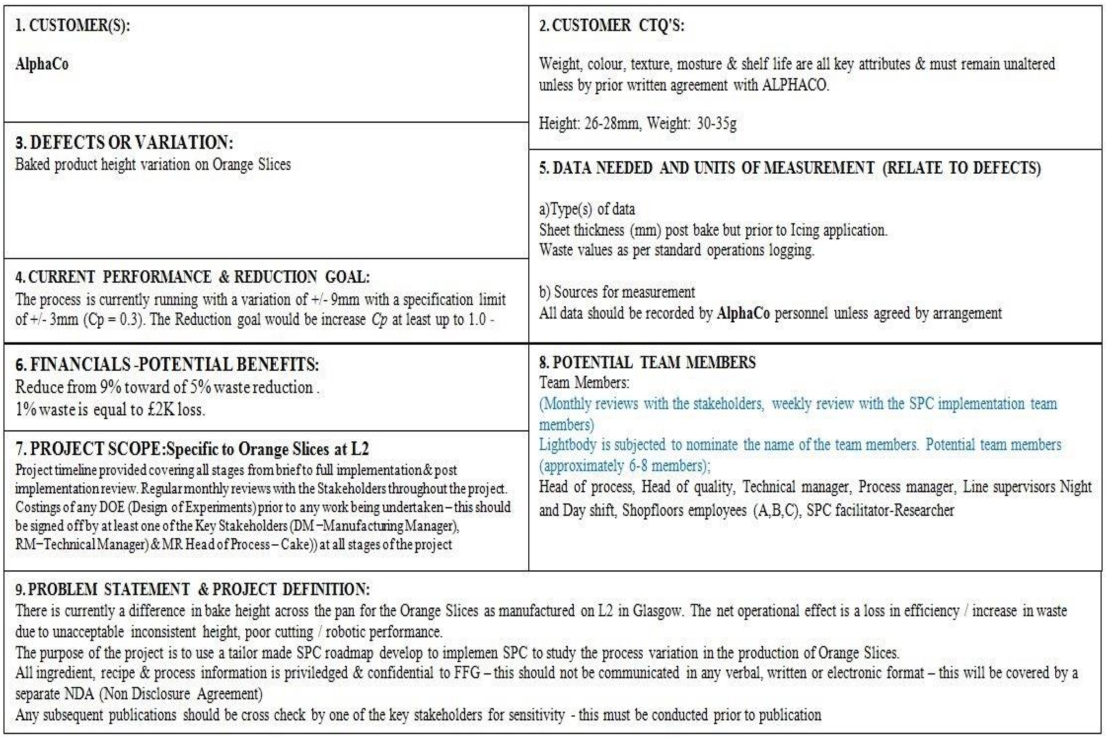
This project started after the failure of a previous project (see Appendix H, I). The SPC awareness session was attended by the Manufacturing Director, Quality Director, Head of Process and CI manager. The fundamentals of the SPC philosophy were explained by SPC facilitator and the participants made aware of the applicability of SPC, the advantages of implementing SPC, their roles and what would be expected of them.

In the preparation phase, a team of people associated with the process was assembled and the Head of Process was appointed SPC leader by the top management. The researcher acted as SPC facilitator; other team members were senior managers, middle managers, supervisors and shop floor employees (Table J.1).

Table J.1 SPC team members

Post	Years of experience in the food industry	Task (Belbin's team theory)
Head of Process	28	Shaper
Head of Quality	37	Completer/finisher
Technical manager	15	Resource,
Process manager	4	Coordinator, Monitor/evaluator, Investigator, Team worker
Line supervisor nightshift	7	Team worker, Implementer
Line supervisor dayshift	11	
Shop floor employee A	7	Implementer
Shop floor employee B	5	
Shop floor employee C	9	
SPC facilitator	Not applicable	Plant, Completer/finisher

The team had several meetings with the SPC leader to discuss various aspects of the project, including internal cost-related issues and who would be involved. A project charter (Figure J.1) was then drafted to communicate the plan and ensure everyone understood the project.



1. CUSTOMER(S):

AlphaCo

2. CUSTOMER CTQ'S:

Weight, colour, texture, mosture & shelf life are all key attributes & must remain unaltered unless by prior written agreement with ALPHACO.

Height: 26-28mm, Weight: 30-35g

3. DEFECTS OR VARIATION:
Baked product height variation on Orange Slices

4. CURRENT PERFORMANCE & REDUCTION GOAL:
The process is currently running with a variation of +/- 9mm with a specification limit of +/- 3mm (Cp = 0.3). The Reduction goal would be increase *Cp* at least up to 1.0 -

5. DATA NEEDED AND UNITS OF MEASUREMENT (RELATE TO DEFECTS)

a)Type(s) of data
Sheet thickness (mm) post bake but prior to Icing application.
Waste values as per standard operations logging.

b) Sources for measurement
All data should be recorded by **AlphaCo** personnel unless agreed by arrangement

6. FINANCIALS -POTENTIAL BENEFITS:
Reduce from 9% toward of 5% waste reduction .
1% waste is equal to £2K loss.

7. PROJECT SCOPE:Specific to Orange Slices at L2
Project timeline provided covering all stages from brief to full implementation & post implementation review. Regular monthly reviews with the Stakeholders throughout the project. Costings of any DOE (Design of Experiments) prior to any work being undertaken – this should be signed off by at least one of the Key Stakeholders (DM –Manufacturing Manager), RM–Technical Manager) & MR Head of Process – Cake)) at all stages of the project

8. POTENTIAL TEAM MEMBERS
Team Members:
(Monthly reviews with the stakeholders, weekly review with the SPC implementation team members)
Lightbody is subjected to nominate the name of the team members. Potential team members (approximately 6-8 members);
Head of process, Head of quality, Technical manager, Process manager, Line supervisors Night and Day shift, Shopfloors employees (A,B,C), SPC facilitator-Researcher

9. PROBLEM STATEMENT & PROJECT DEFINITION:
There is currently a difference in bake height across the pan for the Orange Slices as manufactured on L2 in Glasgow. The net operational effect is a loss in efficiency / increase in waste due to unacceptable inconsistent height, poor cutting / robotic performance.
The purpose of the project is to use a tailor made SPC roadmap develop to implemen SPC to study the process variation in the production of Orange Slices.
All ingredient, recipe & process information is priviledged & confidential to FFG – this should not be communicated in any verbal, written or electronic format – this will be covered by a separate NDA (Non Disclosure Agreement)
Any subsequent publications should be cross check by one of the key stakeholders for sensitivity - this must be conducted prior to publication

Figure J.1 Project charter

Process prioritisation

Pareto analysis was conducted to identify the three most problematic products in terms of waste generated in the production process. Orange Slices were identified as the line producing the highest number of defective items that were later identified as waste; total estimated waste in the production of the cake was 9% (£18K), 5% of which was due to inconsistent height. Hence, this was selected by the Head of Process as the product for the pilot project.

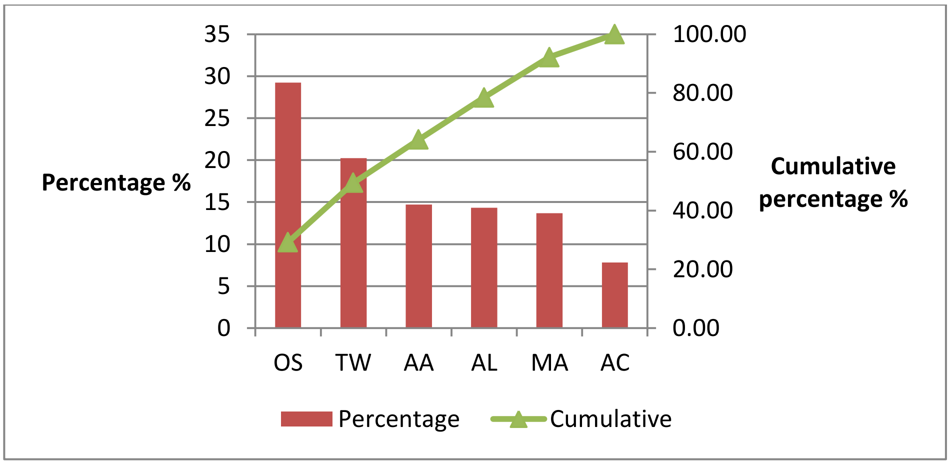


Figure J.2 Pareto analysis for mean of waste

Process description

Process mapping is crucial to define the scope of the project and the steps, inputs and outputs involved, and to ensure these are understood by everyone (Figure J.3).The team and relevant employees therefore mapped the process and recorded the quality parameters. They identified sixteen sub-processes within Orange Slice production, three of which were determined to be critical in the lead up to the cooling process.

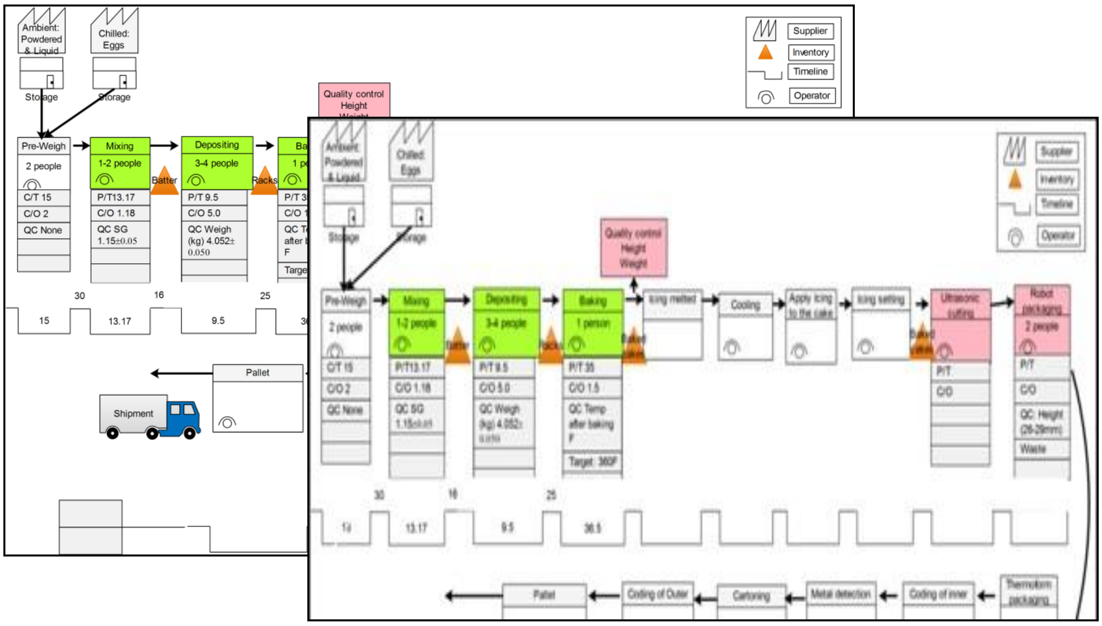


Figure J.3Process mapping

Process synthesis

After mapping the process, the SPC team assessed the potential causes of defects. The cause-and-effect analysis (CEA) was prepared after brainstorming sessions had been held with staff involved in the production process and the SPC team. Figure J.4 depicts the resulting CEA, which listed21 possible causes for the inconsistency in cake height. The top management insisted that the team prioritise the five most likely causes, so multi-voting was carried out by the SPC team. The vote identified the recipe balance as the most critical factor affecting the height of the cake.

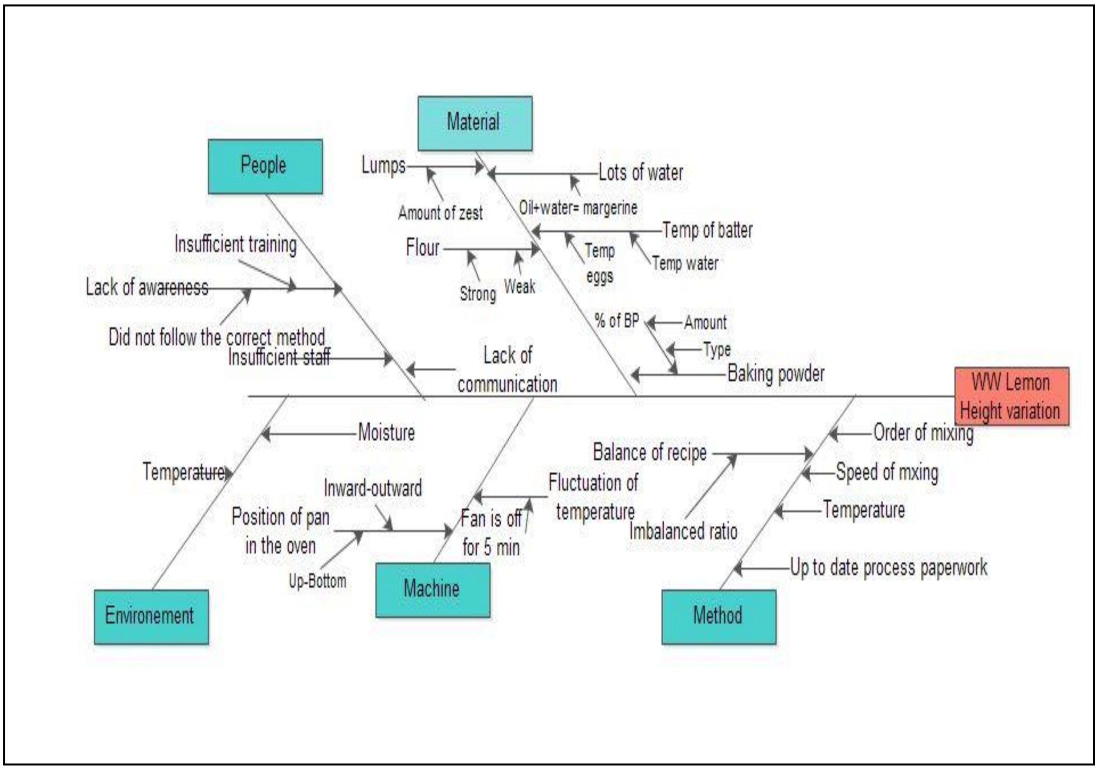


Figure J.4 Cause-and-effect analysis for height variation in Orange Slices

Measurement system analysis (MSA)

One of the crucial steps prior to the development of a control chart was to analyse the variation caused by the measurement system; if the data collected were not accurate and precise, they might not represent the true characteristics of the product measured, even if SPC was used correctly. Measurement system analysis (MSA) was therefore conducted using GRR. The total variation in the process also included the variability of the system used to measure the height of the cake. The height of the cake was measured after it had been left to cool to room temperature for twelve hours. Three operators using digital and manual verniers conducted the GR&R analysis. The team compared the results of the GR&R analysis with the Automotive Industry Action Group (AIAG) manual for its ability to determine its true capability with respect to different components of a measurement system (refer to Table J.2).

Table J.2 First GR&R results (height of the cake)

Source	Contribution (Variance components)	Study Variation (6*Standard Deviation)	% Study Variation
Total GR&R	19.26	6.70	43.89
Repeatability	13.29	5.57	36.45
Reproducibility	5.97	3.73	24.44
Operators	2.10	2.22	14.51
Operators*Parts	3.87	3.00	19.67
Part-to-part	80.74	13.72	89.80
Total Variation	100.00	15.27	100.00
Number of Distinct Categories (NDC)= 2			

Based on the AIAG manual the value of the'% study variation of total GR&R was 43.89%> 30%, indicating that the measurement system was poor (Yimer, 2013). The Number of Distinct Categories was 2, indicating that the gauges were only able to provide binary results such as Go/No Go, Good/Bad etc. The cakes were baked in industrial pans 45x76cm large and measured at six locations per pan, but there was no standard procedure for collecting data. The team also considered the type of verniers used (manual and digital), concluding that digital verniers provided more accurate data. (They were also found to be easier to use on a fast-moving production line.) As a result, operators were provided with standard manuals to collect data and told to use digital rather than manual verniers.

The second GR&R study revealed a reduction in the variability caused by the measurement system. The study variation percentage for total GR&R was26.80%<30% (see Table J.3), indicating, according to the AIAG manual, that the measurement system was capable of providing reliable data. The operators who collected the data were shown the results of the second MSA as proof of the improvement made since the changes. The purpose of data collection was explained to them, making them more aware of the importance of gathering high quality data.

Table J.3Second GR&R results

Source	Contribution (VariComp)	Study Variation (6*Standard Deviation)	% Study Variation
Total GR&R	0.80312	4.8187	26.80
Repeatability	0.67329	4.0397	22.47
Reproducibility	0.43782	2.6269	14.61
Operators	0.28129	1.6877	9.39
Operators*Parts	0.33550	2.0130	11.20
Part-to-Part	2.88664	17.3198	96.34
Total Variation	2.99628	17.9777	100.00
Number of Distinct Categories (NDC)= 5			

Developing a control chart

The control chart was developed, concentrating on the height of the cake. This involved: (1) selecting the control chart; (2) collecting data; (3) assessing process characteristics; (4) constructing the control chart; (5) on-line control using the chart. An$\bar{x}$-S chart is generally believed to be more effective for assessing the spread of data than an$\bar{x}$-R chart. An$\bar{x}$-S chart requires a sample size greater than 10; in this case, the sample size was 15 (Montgomery, 2012).

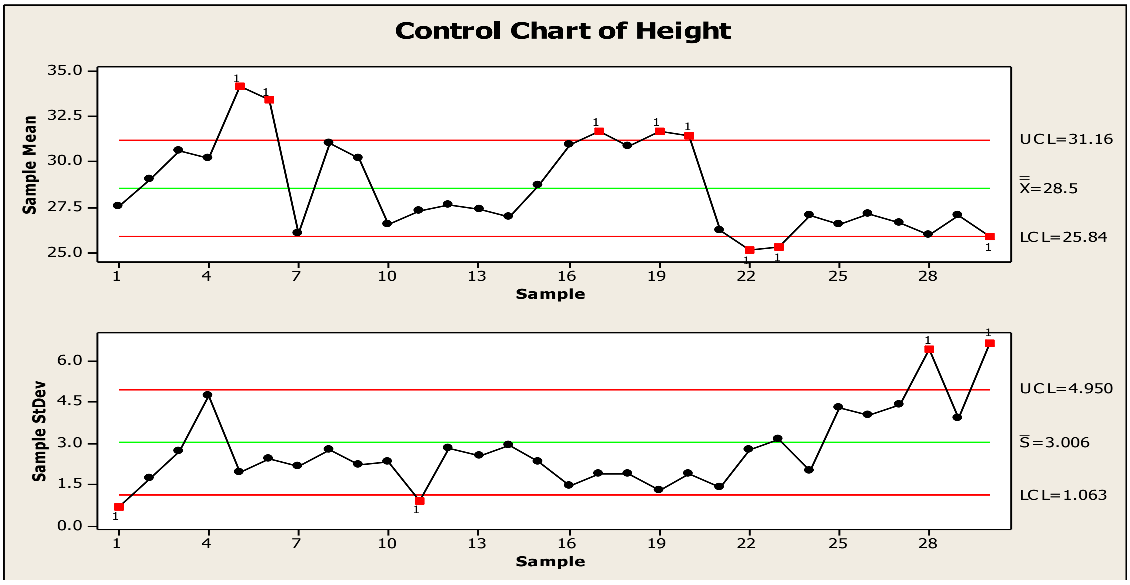


Figure 11.5Height of the cake (phase 1)

The control chart in Figure J.5 was developed at the beginning of the project when the team was attempting to analyse the company's existing process (i.e. to establish a baseline in terms of critical quality parameters). The chart reveals that the process was not statistically stable, as there were OOC points (runs no. 5, 6, 17, 19, 20, 22, 23, 30) and non-random patterns of behaviour (Montgomery, 2012). The process run with four out of five consecutive points beyond the one-sigma limit indicates an OOC point. It is not recommended to set up control charts on the basis of OOC data, as this will render the estimates of process characteristics inaccurate for 'normal' production (Montgomery, 2012).

The SPC team developed guidelines for identifying the causes of problems and taking corrective action. Trained shop floor employees could carry out immediate actions such as recalibration of the oven temperature or mixing machine and the process restarted. The reaction plan, which was displayed strategically (e.g. near to the machine),gave directions for identifying the action required to assess the root cause of the OOC situation. The main challenge was that the causes of problems were not always immediately obvious. Employees were therefore advised to call in colleagues with more expertise to investigate the root of the problem if the process was still unstable after the steps outlined in the OCAP had been executed.

The control chart in Figure J.6 was developed after the measurement system had been improved. The batter temperature and batter air level were assessed and corrective action was taken. The results of control charts were then presented to top managers to inform them about the stability of the process.

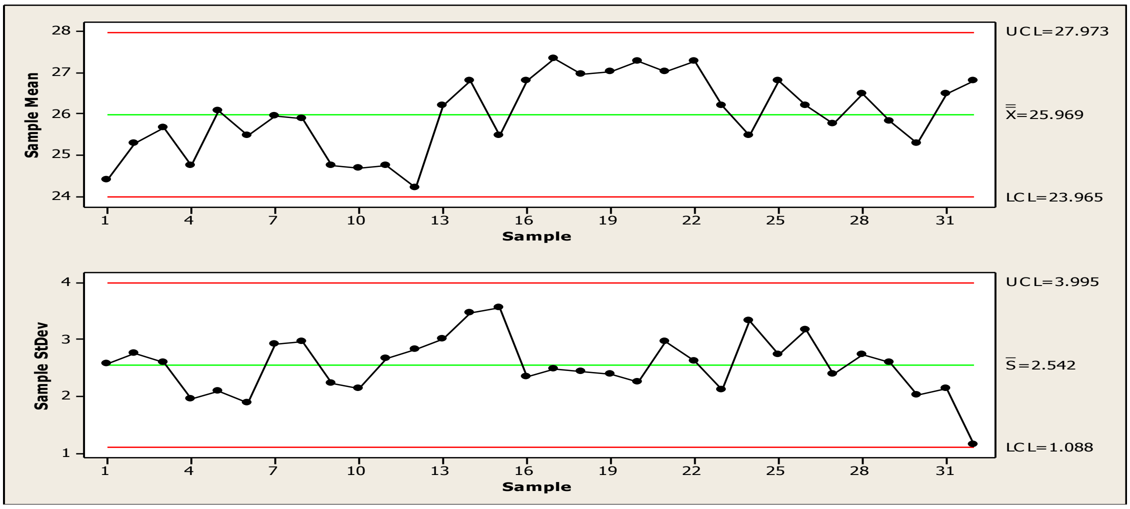


Figure J.6 Height of the Orange Slices

Figure J.6 reveals that although there were no OOC points in the $\bar{x} - S$ chart, there was a mean shift at the thirteenth data point that may cause the process instable. On this day, flour was used that came from a new supplier. This supplier was subsequently called in to overcome the problem. If the researcher considering other rule for interpreting the control chart, the chart was found to be OOC as four out of five points are situated at the 1 standard deviation from the centre line (one side CL).Although the initial objective of this study was to help AlphaCo implement SPC to understand process behaviour and resolve inconsistencies in product quality, at this point, the researcher also introduced the team to DOE (Nembhard and Valverde-Ventura, 2003).

The implementation of DOE at this stage was appropriate because the interaction between factors was not yet understood; the factor affecting cake height had not been identified and an optimum recipe had not been developed. To develop this recipe, the team had designed a fractional factorial experiment with four factors, two replications four blocks (four days), which required 23 trials. However, this experiment did not consider the relative proportions and constraints of the ingredients either in the design or the analysis of the results.

Therefore, the mixture DOE methodology was applied. Mixture designs are a special category of response surface designs where the relative proportions of the components/ingredients/factors are more important than their magnitude (Montgomery, 2008). In this case, the properties of the cake mixture were effectively a function of the relative proportions of the ingredients rather than their absolute values. In mixture experimental design, it is not possible to vary factors independently of each other. This means that when the proportion of one ingredient is changed, the proportion of other cake ingredients must also change to compensate (see Cornell (2011) a comprehensive survey of the technique). There were fourteen ingredients in the Orange Slice recipe including wet and dry ingredients. Based on their baking experience, the team agreed that the three ingredients listed in Table J.4 significantly affected the mean and variability of the cake height.

Table J.4 Minimum and maximum value for the factors

Percentages Min, Max	Proportion Min, max
18%< Flour <28% 16%< Eggs <27% 0.5%< Baking powder <2%	0.39< Flour <0.61 0.35< Eggs <0.58 0.01< Baking powder <0.04

The commercial software Minitab was used to set up the experiment, which covered three factors (ingredients) and two replications (see Table J.5).

Table J.5Proposed design of experiment

StdOrder	Run Order	Flour	Eggs	Baking Powder
8	1	0.28	0.1675	0.0125
6	2	0.18	0.265	0.015
4	3	0.185	0.27	0.005
1	4	0.18	0.26	0.02
3	5	0.18	0.27	0.01
16	6	0.2505	0.1935	0.016
7	7	0.2325	0.2225	0.005
17	8	0.221	0.227	0.012
18	9	0.221	0.227	0.012
2	10	0.28	0.175	0.005
5	11	0.28	0.16	0.02
15	12	0.203	0.2485	0.0085
10	13	0.23	0.21	0.02
11	14	0.221	0.227	0.012
13	15	0.2505	0.201	0.0085
9	16	0.1825	0.27	0.0075
12	17	0.2005	0.2435	0.016
14	18	0.2005	0.2485	0.011

The first four trials, which were led by the project manager, produced cakes that were too dry. Senior managers were concerned at these results, which were carried out in the costly commercial setting, and unfortunately, decided to discontinue the experiment. They were not ready to invest in the application of DOE, even though it could play a vital role in finding the cause of their current process variation. Their resistance towards implementing advanced statistical techniques such as DOE and SPC may have come from a fear of project failure (Hersleth and Bjerke, 2001), though they confirmed that SPC would continue to be applied to the Orange Slice production process and acknowledged that the measurement system had improved. However, it was determined that process capability analysis could not be carried out until the process is statistically stable (Montgomery, 2008).

Based on closed observation of this project, the researcher explained to the top management that the process could be significantly improved once the cake recipe had been optimised. However, senior managers' reluctance to embrace DOE made it impossible to achieve an optimum recipe or to discover any other root causes of process variability. Like other practitioners in the food industry, their resistance towards advanced CI techniques may have been due to a lack of understanding of their potential benefits (Bjerke, 2002). In the researcher's final meeting with the project manager, the latter explained that he could assess process behaviour and stability, but that any corrective action required support from the top management.

Statistical Process Control Readiness Assessment Tool

SPC readiness is defined as '*organisation's ability to reduce resistance in adopting SPC, and the preparedness to successfully initiate SPC implementation as their practice to achieve process stability for their core business processes through an effective application of SPC tools'*. It is also a way of assessing the strength and weaknesses of the current state of the company with the values needed to adopt SPC.

The companies are requested to rate the Readiness variables on a Likert scale of 0-4 (0= percept not implemented; 1= percept slightly implemented; 2= percept moderately implemented; 3= Good implementation of percept; 4 = percept fully implemented and practised).

Note:

If your company is going through a major organisational restructuring, then it is not the right time for the company to implement SPC. You are not required to answer the readiness questionnaire.

Thanks for your response!

Table G1 SPC Readiness Assessment Tool

Organisational readiness to implement SPC		Score 0=Not implement – 4=Fully implemented)				
	Top management readiness	0	1	2	3	4
T1	The management is readily to commit to SPC implementation (e.g. shut down the highly unstable variation for correction action).					
T2	Top management understand their roles and commitment to start implementing SPC					
T3	Top management demand daily reviews and held monthly review session related to the quality aspect.					
T4	Top management shows support CI activities.					
T5	Top management depicted the seriousness towards SPC implementation.					
	Measurement system readiness					
M1	Availability of measurement system					
M2	Employee awareness of the key processes					
M3	Employee training to conduct the measurement					
M4	Existence of appropriate measurement tools					
M5	Existence of a guideline to calibrate the measurement equipment					
	Organisational culture readiness					
O1	Decision-making is based on data					
O2	Problem is addressed by teamwork approach					

O3	Process performance is measured based on appropriate metrics (e.g. *Cpk*, P*pk*)					
O4	Regular meetings held to discuss quality problems using data.					
O5	The employees' accountability respected and blame culture discouraged.					
	Urgency to change					
U1	Top management communicate the legitimate reasons to adopt SPC					
U2	Confident that company will benefit from SPC implementation					
U3	Current process performances lower from the desired end-state					
	Employees readiness					
E1	Employees trained in basic statistics					
E2	Employees' ideas and opinions are appreciated					
E3	Availability of SPC facilitator to aid the SPC adoption					
E4	Employees understand the benefits of process improvement to the business and themselves.					
E5	Employees involved in the CI activities					
Level of readiness						
	More than 3	Ready				
	2<Mean score <3	Almost ready				
	Less than 2	Not ready				