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Software Process Improvement Implementation and Management Model (SPIIMM) for Global Software Development

面向全球軟件開發的軟件過程改進實施與管理模型（SPIIMM）

Submitted to

Department of Computer Science

電腦科學系

in Partial Fulfillment of the Requirements

for the Degree of Doctor of Philosophy

哲學博士學位

by

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September 2017

二〇一七年九月

Abstract

Global Software Development (GSD) has gained great attention during the past decade or so; and it is also being implemented by most of the software development organizations. Due to the economic and strategic effects of GSD, it is treated as a substitute to a collocated development. The geographically dispersed environment makes software development a complicated task and brings several challenges especially that related to Software Process Improvement (SPI) although SPI can play a significant role to successfully execute GSD projects.

Various process improvement standards and models have been developed in order to help software organizations to achieve effective management of software development processes. In particular, Capability Maturity Model Integration (CMMI) is one of the process improvement models that consist of structured and methodical practices for process assessment and improvement. The International Organization for Standardization (ISO) also developed standards and recommendations for SPI: for example, ISO 9000 is used to evaluate the quality of the established software systems in an organization, whereas ISO/IEC 15504 is targeted as the process improvement standard under the Software Process Improvement and Capability Determination (SPICE). ISO/IEC 15504 standard is evolved to the more advance process assessment and improvement family i.e. ISO/IEC 330XX. The ISO/IEC 330XX family covers the assessment of the deployed process in an organization, maintenance, change management, delivery and improvement of processes.

However, the deployment of SPI in the domain of GSD needs a long-term approach and require adequate resources and time. Despite the significance of SPI in GSD, little attention has been given to the following core question: “how to efficiently execute process improvement programs in the context of GSD?” Especially, development teams working in GSD operate beyond the geographical boundaries, which makes communication and collaboration more difficult and the need for the deployment of process improvement program much pronounced. SPI teams working in GSD environment face different challenges when it comes to developing process improvement practices, establishing the relationship among the dispersed team members, mitigating the time differences and managing the cultural issues.

The core objective of this thesis is to develop a software process improvement implementation and management model (SPIIMM) to help GSD organizations to effectively assess and implement the SPI activities. The model is based on the results drawn from the systematic literature review (SLR) and empirical study conducted in GSD organizations. To structure SPIIMM, I have adopted the concepts of critical success factors (CSFs), critical barriers (CBs) and different other available models, i.e. CMMI, implementation maturity model (IMM) and software outsourcing vendors' readiness model (SOVRM). I have extracted the data from 91 primary studies in order to identify the CSFs, CBs and their practices. I have classified the identified CSFs and CBs into five maturity levels based on CMMI, IMM and SOVRM. I have also conducted an empirical study with 111 SPI experts to validate the findings of the SLR study and extract additional new CSFs, CBs and practices.

In order to assess the effectiveness of SPIIMM for GSD industry, three case studies were conducted in three different GSD organizations. The findings of the case studies revealed that SPIIMM is significant in both theoretical and practical perspectives. The successful implementation of SPIIMM during the case studies demonstrated the use of SPIIMM in the GSD industry. The case study participants were satisfied with the use and overall performance of SPIIMM.

The main contribution of this research project is the development of SPIIMM, which is a significant model for GSD organizations to assess and improve the SPI related activities. The SPIIMM will also provide help to other researchers working in the domain of SPI and GSD in order to further improve and develop new SPI processes.

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List of Publications

Published and Accepted Journal Articles

1. **Khan, A. A.**, Keung, J., Amin, E. F., Abdullah-Al-Wadud, M. 2017. SPIIMM: Toward a Model for Software Process Improvement Implementation and Management in Global Software Development. *IEEE Access* (2017), 5, 13720-13741.
2. **Khan, A. A.**, Keung, J., Niazi, M., and Hussain, S. 2017. Understanding software process improvement in global software development: a theoretical framework of human factors. *ACM SIGAPP Applied Computing Review* 17.2 (2017): 5-15.
3. **Khan, A. A.**, Keung, J., Niazi, M., Hussain, S., Ahmad, A. 2017. Systematic Literature Review and Empirical investigation of Barriers for Software Process Improvement in Global Software Development: Client-Vendor Perspective, *Information and Software Technology* (2017), 87, 180-205, (2017).
4. **Khan, A. A.** and Keung, J. 2016. Systematic Review of success factors and barriers for Software Process Improvement in Global Software Development, *IET Software* 10.5 (2016): 125-135.

Under Review Journal Articles

5. **Khan, A. A.**, Keung, J., Niazi, M., and Hussain, S. 2017. Success Factors and Best Practices for Software Process Improvement in Global Software Development: A systematic study (*Under Review in Journal of Software: Evolution and Process*).
6. **Khan, A. A.**, Keung, J., Niazi, M., Kieffer, S. and Hussain, S. 2017. Dimensional Classification of Success Factors Affecting Process Improvement in Global Software Development: Client-Vendor Perspective (*Under Review IET Software Journal*).

Book Chapter

1. **Khan, A. A.**, Keung, J., Niazi, M., Hussain, S., and Zhang, H. 2017. Systematic Literature Reviews in Software Process Improvement: A Tertiary Study. In Communications in Computer and Information Science (CCIS) Series, vol.748:177-190, Springer, Cham, 2017.

Conference Proceedings

1. **Khan, A. A.**, Keung, J., Niazi, M., Hussain, S., and Zhang, H. 2017. Overview of Software process assessment and improvement model in the domain of global software development: (Accepted in *24th EuroSPI Conference*, Czech Republic, 2017).
2. **Khan, A. A.**, Keung, J., Niazi, M., and Hussain, S. 2017. Towards a Hypothetical Framework of Humans Related Success Factors for Process Improvement in Global Software Development: Systematic Review, *Presented in the 32nd ACM Symposium on Applied Computing (SAC),* Morocco, 4th to 6th April 2017.
3. **Khan, A. A.** "A Framework for Assisting Software Process Improvement program in Global Software Development" presented in *Student Research Competition (SRC) program of the 31st ACM Symposium on Applied Computing (SAC)* Italy, 2016.
4. **Khan, A. A.**, Keung, J., Hussain, S. and Bennin, K.E. "Effects of Geographical, Socio-cultural and Temporal distances on communication in Global Software Development during Requirements Change Management A Pilot Study," *International Conference on Evaluation of Novel Approaches to Software Engineering (ENASE), 2015*, pp. 159-168.

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my supervisor Dr. Jacky Keung for the continuous support of my Ph.D study and research, for his patience, motivation, enthusiasm, and immense knowledge. I could not have imagined having a better advisor for my Ph.D study.

Besides my advisor, I would like to thank my mentor Associate Professor Dr. Mahmood Khan Niazi, for his invaluable guidance, instructions, encouragement and full support that led my research work to success.

Besides my advisor and mentor, I would like to thank the rest of my qualifying panel members: Dr. Sarana Nutanong, and Dr. Yuen Tak Yu, for their comments, suggestions and encouragement.

Last but not the least, my deepest gratitude goes to my late father Afsar Ali Khan and mother Zarin Taja for their endless love, patience, prayers and encouragement throughout in my career.

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ACRONYMS AND ABBREVIATIONS

CSFs	Critical Success Factors
CBs	Critical Barriers
GSD	Global Software Development
SPI	Software Process Improvement
SLR	Systematic Literature Review
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
IMM	Implementation Maturity Model
SOVRM	Software Outsourcing Vendors' Readiness Model
CCCMM	Communication and Coordination Challenges Mitigation Model
SPIIMM	Software Process Improvement Implementation Management Model
ISO	International Standard Organization
KPAs	Key Process Areas
PAs	Process Areas
SEI	Software Engineering Institute
SMEs	Small and Medium Enterprises

DEDICATION

In the name of Allah, the Most Gracious and the Most Merciful

This thesis is dedicated to my late father Afsar Ai Khan, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother Zarin Taja, who taught me that even the largest task can be accomplished if it is done one step at a time.

CHAPTER 1: INTRODUCTION

1.1 Introduction

In this chapter the research problem of software process improvement (SPI) implementation in global software development (GSD) is briefly discussed. The key research objectives, research questions and research contribution are also reported.

This chapter is structured as follows:

- Research problem is discussed in section 1.2.
- Research objectives are reported in section 1.3.
- Research questions are provided in section 1.4.
- Research contribution is described in section 1.5.
- Thesis structure is discussed in section 1.6.

1.2 Research Problem

Global software development (GSD) is a relatively recent business strategy for developing high-quality software in low-wage countries at low cost. In GSD, software development activities are performed across geographical, cultural, and temporal boundaries. Different ethnic and temporal changes are faced by the geographically

distributed teams such as difference in language, cultural values, time difference and behavioural standards (Helena et al., 2006).

The geographically distributed approach to software development has been around before the inception of GSD. According to (Lee et al., 2000), in the 1970s, some organizations initiated the "contract programming" technique to contract out a small module of the given software system to a third party. A majority of software development organizations adopted the concept of contract programming due to a lack of resources, low budgets, the limited time available for development, and its rising cost (Bass, Herbsleb, & Lescher, 2009). In 1990's due to the lack of work force, the trend of GSD was started by the US software development organizations and it became very popular in a short time period (Ågerfalk et al., 2008). The continual improvement in ICTs (Information and Communications Technologies) since then has made it easier to develop software projects without regard for geographical boundaries (Conchuir, 2009).

The economic benefits offered by GSD projects constitute the most important factor that has motivated a majority of firms to adopt distributed development (Conchuir, 2009). GSD is considered a good choice because of the business profits it yields for development firms (Damian, 2007). GSD has also been welcomed by software development firms because of its high-quality productivity, its low development cost and time, the access that it offers to companies to skilful workers, and the demands of the international market (Cottmeyer, 2008; Herbsleb, 2007). GSD is being practiced by the underdeveloped countries like India, China and Vietnam. These countries offer services of software development in developed countries like USA and Europe (Khan, Niazi, & Ahmad, 2011).

However, GSD also faces different challenges (Da Silva et al., 2010). Due to the distributed nature of GSD, the quality of software products becomes an important issue. Several large GSD projects have yielded unsatisfactory results that have served as a blow to the industry (Carmel, Espinosa, & Dubinsky, 2010; G. Fitzgerald, & Russo, 2005). Attarzadeh and Ow (2008) highlighted this issue by conducting a survey, and reported that 31.1% of GSD projects that they considered had ended before completion. They also revealed that only 16.2% projects had been completed under the allocated time and budget. Gillies (2011) considered the quality of GSD projects a serious challenge to the software industry.

Research has been conducted to address software quality issues for many years, and GSD organizations have recognized that the failure to effectively direct the process of software development is one of the main causes of project failure (Unterkalmsteiner et al., 2012).

The CHOAS report released by the Standish Group mentioned that the failure rate of software projects that they had considered increased from 17% in 2012 (Standish Group, 2012) to 19% in 2105 (Standish Group, 2015). A study conducted by a group of Fellows of the Royal Academy of Engineering and British Computer Society, shows that regardless of spending 22.6 billion pounds on IT projects in the UK during 2003/2004, significant numbers of projects still fail to deliver key benefits on time and to target cost and specification (Royal Academy of Engineering, 2004).

Such problems are mostly considered as issues in the software quality and it got much attention in both industry and academia.

The Department of Trade and Industry (DTI) in the UK commissioned two reports on software quality (Logica, 1988; Waterhouse, 1988). The aim of these reports was to

manage and control quality-related challenges by motivating software firms to obtain certification for such standards as ISO 9001. However, the majority of the small- and medium-sized enterprises (SMEs) have been concerned with the budget required to attain and sustain ISO 9000 certification. Researchers and practitioners have since been striving for alternative ways to manage and control software quality challenges. They have realized that a fundamental issue in this vein is the inability to successfully manage the software process (Butler, 1995; Pitterman, 2000; Yamamura, 1999).

A number of techniques have been proposed to manage and control the software process, among which the prevailing one is software process improvement (SPI). SPI offers organizations with a commanding means of evaluating their existing abilities for evolving software systems and accordingly they can identify their weaknesses and strengths. Zahran (1998) defined SPI as *"the discipline of defining, characterizing, improving and measuring software management, better product innovation, faster cycle time, greater product quality and reduced development costs simultaneously".*

Various process improvement models and standards have been developed to assist software organizations effectively manage software development processes. Capability maturity model integration (CMMI) is one such model consisting of structured and methodical practices for process evaluation and improvement (SEI, 2010). The International Organization for Standardization (ISO) has also developed standards and recommendations for SPI: for example, ISO 9000 is used to assess the quality of established systems in an organization (ISO/IEC-15504, 1998), whereas ISO/IEC 15504 is used for process improvement under the Software Process Improvement and Capability Determination (SPICE) (Rout, 2003). According to (Rout, 2003), SPICE was developed to test and advertise process improvement

standards and models. The ISO/IEC 15504 standard has since evolved into more advance process assessment and improvement standards, i.e., ISO/IEC 330XX. The ISO/IEC 330XX family covers the assessment of processes deployed in an organization, including their maintenance, change management, delivery, and improvement (ISO/IEC-33001, 2015). Similarly, the UK government has developed the Information technology infrastructure Library (ITIL) framework that could assist the organizations to deliver quality information technology (IT) services (Cartlidge et al., 2012). These models and techniques can assist an organization to develop a quality product, reduce development cost, time, and promote user satisfaction (Butler, 1995; Pitterman, 2000; Yamamura, 1999; Ashrafi, 2003; Jiang et al., 2004).

Despite the availability of various process improvement standards, the success rate of SPI implementation is very low (Babar, & Niazi, 2008; Khan et al., 2013). The process improvement deployment is a long-term approach that requires sufficient time and resources (Niazi, 2015). It means that the implementation of SPI program is an expensive approach for many organizations and they should provide significant time and resources. However, the provision of these is not a guarantee of the successful execution of SPI activities. Ngwenyama and Nielsen (2003) reported in their study that the failure rate of SPI implementation programs was 70%, and a fundamental cause of this failure was the limited attention afforded to SPI issues (Babar, & Niazi, 2008).

SPI has a long tradition in software engineering and information systems research (Butler, 1995; Stelzer, & Mellis, 1998; Ashrafi, 2003; Habib, 2009; Niazi, Babar, & Verner, 2010; Staples et al., 2007; Bayona, Calvo-Manzano, & Feliu, 2013). Most of the literature has highlighted SPI in the context of collocated software development

(Ramasubbu, 2014), However, a majority of organizations are currently in the process of adopting GSD. Richardson et al., (2010) clarifies that process models such as CMM, CMMI, ISO/IEC 15504 and ISO/IEC 330XX operated successfully in collocated software development environments, but do not explicitly address the distributed nature of software development. Babar and Niazi (2008) shed light that the term GSD is extending from emphasizing only on cost reduction towards the improvement of all the software development phases. This change highlights the importance of SPI programs in the GSD environment. The arrangement and successful execution of SPI activities in a distributed environment require significant time and resources (Niazi, Babar, & Verner, 2010). (Ramasubbu, 2014) reported that the geographically distributed nature of GSD projects makes it challenging for team members to communicate and coordinate while implementing the SPI program. In a distributed environment, the deployment of process improvement activities becomes more pronounced. Ramasubbu (2014) further discussed that it is challenging for GSD team members to develop SPI practices, maintain strong relationships among dispersed organizations, mitigate the temporal distance, and overcome cultural challenges. It is vital for SPI practitioners to have a deep understanding and knowledge of different aspects of the process improvement program (Niazi, Babar, & Verner, 2010).

To summarize, regardless of the significance of SPI implementation, no technique has been identified in the literature to competently manage SPI programs in the domain of GSD. There is a pressing need for a technique that can provide an opportunity for SPI practitioners to successfully execute process improvement activities in GSD environment. The technique should assist is the way to decrease the cost, time and failure risk of SPI implementation.

1.3 Research Objectives

A brief survey of the literature indicates that there is a need for a framework or model that can contribute to the effective implementation of process improvement in the GSD environment. The main concern of this study is to experimentally investigate the views and opinions of SPI experts and develop a model that can help the GSD industry to successfully implement the SPI program.

The model is based on process improvement literature, industrial empirical studies, and factors that can influence the deployment of process improvement programs in GSD. The focus of this research project is on filling the research gap in process improvement research and practice such that it is accessible to both industrial practitioners and researchers.

1.4 Research Questions

There are nine research questions that have motivated the work reported in this thesis:

RQ1. What are the success factors, as identified in the literature, do GSD organizations need to address in order to have a positive impact on SPI implementation?

RQ2. What are the barriers, as identified in the literature, within GSD have a negative impact on SPI implementation?

RQ3. What are the success factors, as identified in the real practice, do GSD organizations need to address in order to have a positive impact on SPI implementation?

RQ4. What are the barriers, as identified in the real practice, within GSD have a negative impact on SPI implementation?

RQ5. Are there differences between the success factors identified in the literature and real practice?

RQ6. Are there differences between the barriers identified in the literature and real practice?

RQ7. What are the practices, as identified in the literature, to address the critical success factors and critical barriers for SPI in GSD?

RQ8. What are the practices, as identified in real practice, to address the critical success factors and critical barriers for SPI in GSD?

RQ9. How can a practically robust software process improvement implementation and management model (SPIIMM) be developed?

In order to address these research questions, systematic literature review (SLR) and industrial empirical study have been done that leads towards the development of the SPIIMM. The development of SPIIMM is the main contribution of this research project. An industrial study of process improvement issues has provided valuable insights into the design of the SPIIMM.

1.5 Research contribution

The aim of this research project is the development of the SPIIMM model for the assessment and implementation of SPI program in the GSD environment. The model will help SPI practitioners in investigating, assessing and mitigating the SPI related challenges by providing solutions. This research work is original and significant in

nature by addressing SPI implementation challenges by developing a software process improvement implementation management model in the context of GSD.

1.5.1 SPIIMM development

Brief SPI literature study and industrial empirical study highlight the need to develop a technique that could assist GSD organizations to successfully execute the implementation of process improvement programs. To address this need, a total of nine research questions were developed as discussed in section 1.4.

SPIIMM is a practical and robust model that presents a new process view of SPI implementation. It addresses SPI related issues in GSD through comprehensive and robust model strategy rarely known in SPI literature as shown in Figure 1.1.

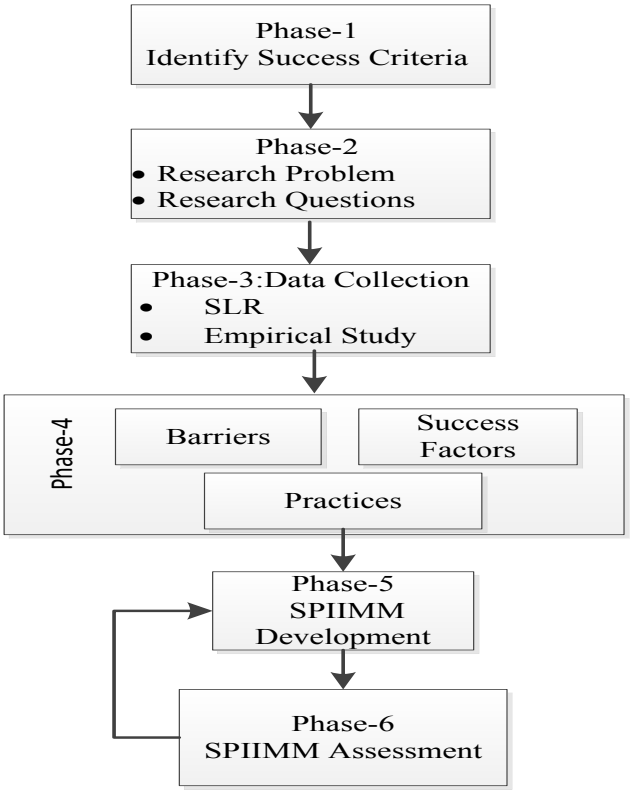


Figure 1.1 SPIIMM development phases

Figure 1.1 demonstrates the phases to develop the SPIIMM model. The first phase is the designing of success criteria to develop SPIIMM. The criteria were based on the available literature (Niazi et al., 2004; Niazi, Wilson, & Zowghi, 2005; Khan, 2011; Khan, 2015). In order to design the SPIIMM, we have determined the following criteria.

- **Ease of use:** The key objective of this criteria is to assess that how easily the GSD organization can understand and adopt the SPIIMM

- **User Satisfaction:** The SPIIMM should fulfil the different requirements of end users and they need to be satisfied with its results. The practitioners should be able to achieve their desired goals and objectives.

- **Structure of SPIIMM:** The aim of this criterion is to revise the structure of the SPIIMM based on the feedback provided by the expert's opinion.

To address the above criteria, total nine research questions were developed and discussed in 1.4. In phase 3 and phase 4, data are collected and analysed using systematic literature review (SLR) and empirical study conducted with SPI experts. Various critical success factors (CSFs) and critical barriers (CBs) were identified in these two phases. The list of CSFs and CBs is discussed in chapter-4. To implement the identified CSFs and CBS, different practices are identified and briefly discussed in chapter-4. Phase 5 is the phase where rationalization and structuring of all the collected data were performed in order to design SPIIMM. The SPIIMM is specialized, organized and comprehensive model that could assist GSD organizations to assess their readiness for SPI implementation. The last phase is an evaluation phase, where SPIIMM is evaluated using case study approach.

1.5.2 Systematic Literature Review (SLR)

Systematic literature review (SLR) approach was followed for identifying the CSFs, CBs and their implementation practices. The concept of CSFs was adopted from (Rockart, 1979) and is briefly discussed in chapter-4. SLR is the systematic way of reporting the results extracted from the available literature (Kitchenham, & Charters, 2007). SLR technique is briefly discussed in chapter-3.

1.5.3 Industrial Empirical Study

I have conducted questionnaire survey with 111 SPI and GSD experts in order to validate the findings of the SLR (i.e. CSFs, CBs and practices). Questionnaire survey approach could assist to collect data from a large group of people (targeted population). Surveys could also help to extract data related to people attitudes that are otherwise challenging by using the observational methods (Easterbrook et al., 2008). Detail implementation of the industrial study is discussed in Chapter-3.

1.5.4 SPIIMM assessment

SPIIMM was evaluated using a case study approach. A total of three case studies were performed in three different GSD organizations in order to evaluate the effectiveness of SPIIMM and are briefly discussed in chapter-5. Case study technique provides real world information and is considered as a powerful evaluation tool (Smite et al., 2010; Khan, 2011; Khan, 2015).

1.6 Thesis Structure

The thesis has been organized as follows.

Chapter 2: This chapter highlights the previously done studies, which describes various components and their associations by taking previous work into account. It presents a brief review of the literature on SPI in GSD, SPI standards and models, risks associated with GSD and limitations of existing studies in the domain of SPI and GSD.

Chapter 3: Research Methodology, presents the mode of research that has been set in order to resolve the research queries for this study. This chapter briefly discussed the selected research methods and their justification. It also contains the adopted statistical techniques selected to analyze the collected data.

Chapter 4: This chapter reports the results of the SLR and empirical study conducted with the SPI experts. Detailed analysis and clarification of the study variables have been presented in the form of data analysis. This chapter identified the CSFs and CBs along their practices.

Chapter 5: This chapter highlights the complete architecture of SPIIMM. It briefly reports different components of SPIIMM and also discusses the relationship among those components. The components of SPIIMM are based on the results discussed in chapter 4. This chapter also reports the results and analysis of the three case studies conducted with SPI experts in order to evaluate the effectiveness of SPIIMM.

Chapter 6: The research work is concluded in this chapter, which includes the results that have been drawn from the research, contribution, limitation, recommendation and proposed future work.

CHAPTER 2: BACKGROUND

2.1. Overview

This chapter studies the literature to better understand the terms that have been used in the research. The observed results and findings of other researchers have been reviewed in literature that is relevant to this study. Other important components are included software quality, software process, software process improvement (SPI), Global Software Development (GSD), benefits of GSD, and software process improvement in GSD.

The rest of this chapter is structured as follows:

- Software development process is described in Section 2.2.
- SPI standards and models are reported in section 2.3.
- GSD is discussed in section 2.4.
- Section 2.5 consists of limitations found in the existing studies.
- Summary of the chapter is reported in section 2.6.

2.2 Software Development process

Process can be defined as a set of actions and alterations that leads to a meaningful output. The process term has been used and adopted in various domains with different objectives. Process has usually been considered in term of natural phenomena e.g.

physical and chemical processes. However, there are different other contexts where the term process has been used i.e. organizational, business and software processes (Niazi, 2004).

The aim of organizational processes is to perform activities in order to accomplish the goals specified by an organization for itself (Niazi, 2004). (Gladwin, & Tumay, 1994) defined organizational process as *"a group of logically related tasks that use the resources of an organisation to provide defined results in support of the organisation's objectives"*. Organizational and business processes are people oriented and humans are considered as the key agents to perform the process actions.

Most of the researchers highlighted software development process as the most complex in comparison to different other processes (Aliee, 1996). The software development process can be defined as *" a set of rules, practices, actions and alterations that are made by people for the development and maintenance of software and related product (e.g. plan, documentation, code, test cases and user manual"* (Zahran, 1998).

(Sommerville, 2011) discussed four common software process activities i.e. software specification, software design and implementation, software validation and software evaluation. Every software process must include these four activities.

2.2.1 Software quality

The term 'quality' is complex and has many views.

(Gillies, 2011) define quality as *"the ultimate purpose of product manufacturing is the realization of the goods' function or benefits, and the satisfaction of users"*. Therefore, there is a close relationship between the quality of products and their customers.

The IEEE defines quality as *"the degree to which a system, component, or process meets specified requirements" or "the degree to which a system, component, or process meets customer or user needs or expectations"* (IEEE, 1991).

ISO define software quality as *"the totality of functionality and features of a software product that bear on its ability to satisfy stated or implied needs"* (ISO-9126, 1991).

All of the above definitions clarify that quality is mainly concerned with the user satisfaction. The term quality can be defined in both technical and user satisfaction perspectives. The technical aspect is concerned with the enhancement of the development process to deliver the most robust and efficient product. Similarly the main focus of the user oriented aspect is to satisfy the user requirements and make sure that the product is useful for use.

(Garvin, 1984) provided more complex perception about the term "quality" as shown in Table 2.1. Garvin defines quality in five views in the domain of both technical and user-oriented perspectives. In the domain of technical perspective, the manufacturing view is the most significant view among the software development teams (Gillies, 2011). Garvin highlighted that the user-based view is the most common view in the context of user-oriented perspective. He discussed that user-based view has been ignored in comparison to technical views.

Table 2.1 Garvin quality views

Technical Views • *The transcendent:* The quality view that can recognise but not defined. • *The product-based view*: The quality concept that specifies the product characteristics. • *The manufacturing view*: The quality view that assesses the quality in the sense of requirements conformance.
People-oriented views • *The user-based view*: it can be highlighted as "fitness for purpose". • *The value-based view*: regards quality as inherently connected to the costs to achieve it.

Due to the important role of software quality in business and everyday life, it gets considerable attention in the context of both research and industry. Researchers and practitioners are realizing that the quality of the software system can be improved by properly managing the development process of the software system (Pitterman, 2000; Yamamura, 1999). The most commonly used approach to effectively manage the software process is software process improvement (SPI). Different researchers discussed that SPI can assist organizations to develop quality software product, lessen the cost of software development and enhance development productivity (Niazi, 2004; Ramasubbu, 2014; Khan, & Keung, 2016).

The process improvement impact on the software quality is reported in the following studies:

- (Herbsleb et al., 1994) conducted an industrial empirical study and discussed that the sample organizations adopted the SPI approach and they had realised sustainable benefits. The analyses of the collected data in the terms of business value ratios specified that the returns can be very substantial.

- (Ashrafi, 2003) investigates the impact of SPI on the software quality by conducting an empirical study. She collected data from various SPI practitioners and concluded that practitioners are increasingly turned to SPI methodologies in order to develop quality products.

- A case study conducted by (Taufail, & Malik, 2012) highlighted that SPI enhance the quality of the software product by not only lessening the percentage of most significant errors and defects but also by increasing the success to fail ratio.

- (Herbsleb, & Goldenson, 1996) investigated an association between CMM maturity levels and improvement of software quality. His results highlighted that the customer satisfaction of those organizations increased whose maturity level moved from level-1 to level 3. Likewise, the ability to complete projects on schedule improved from 40% to 80% when the maturity level of an organization increased from level-1 to level-3

2.2.2 Software process improvement

The development of a software system is becoming a complex job in recent years due to the increasing demand of software products, competitive market and complicated software development activities. The increasing demand of software products and the competitive environment are becoming the most challenging factors for software organizations to develop the quality product within time and budget. It is vital for software organisations to address the quality challenges by improving the organizational practices, and processes. A mature software process can assist an organization to successfully execute software development activities (Islam, & Zhous, 2011).

Different techniques and methods were introduced for the effective management of software process among which the prevailing one is Software Process Improvement (SPI) (SEI, 2004). SPI is an approach used to comprehend the software process and to monitor the implementation of change in that process for the purpose of achieving specific objectives such as to enhance software development period and budget along with the required efficiency (Humphrey, 1995). The purpose of SPI is to emphasize on refining the steps involved in the software development activities. SPI offers organizations with a commanding means of evaluating their existing abilities for

evolving software systems and accordingly they can identify their weaknesses and strengths (Khan, & Keung, 2016).

The SPI approach can assist software development organizations to effectively manage organizational resources, people and processes, decrease development time and cost, high ratio of team productivity, increase workforce's skills and access to market (Khan, & Keung, 2016).

Below is the summary of some organizations that embark on SPI and the results they got using the SPI approach.

- Raytheon initiated SPI activities in 1988 and returned a significant growth in its productivity and achieved continuous, substantial, and measurable improvements to its software engineering process. In the time period of four and half years (mid-1988 to 1992), the company eliminated $15.8 million in rework costs (Diaz, & Sligo, 1997).

- Hughes Aircraft has figured a 5 to 1 return ratio for its process improvement initiatives, based on changes in its cost–performance index. This has generated an annual savings of about $2 million above Hughes' process improvement expenditures (Diaz, & Sligo, 1997).

- Tinker Air Force Base adopted SPI approach and calculated 5-to-1 return on investment for SPI initiatives. A report published by (Butler, & Lipke, 2000) discussed that Tinker Air Force Base generated a savings of $3.8 million from a $0.64 million investment.

2.3 Software process improvement standards and models

Different standards and models for SPI have been developed to move organizations towards optimizing their software processes and also numerous instruments are developed to evaluate process efficiency (Khan, & Keung, 2016). Capability Maturity Model Integration (CMMI) is among the SPI models that have been developed (SEI, 2010). It is a structured and systematic collection of best practices for process assessment and improvement (SEI, 2010). Moreover, the International Organization for Standardization (ISO) also embarked on the program to develop a software process assessment standard. ISO 9000 developed by ISO is a sequence of standards used to verify the quality of the system deployed by an organization (ISO, 2005). Moreover, the ISO/IEC 15504 was developed by ISO for SPI under the SPICE (Software Process Improvement and Capability determination) (ISO/IEC-15504, 1998). SPICE was recognized as a project to come up with draft standards to test and create the awareness of the developing standards (Viadiu, Fa, & Saizarbitoria, 2006; Route, 2003). The research indicate that the effort given to these standards and models can help in developing a standard software systems, decreasing time and cost, improving employee satisfaction and productivity (Butler, 1995; Pitterman, 2000; Yamamura, 1999; Ashrafi, 2003; Jiang et al., 2004). SPI models like capability maturity model (CMM) (Paulk, 1998), CMMI and standards like ISO's SPICE (Viadiu, Fa, & Saizarbitoria, 2006) emphasize on practices to accomplish quality software system.

2.3.1 Capability Maturity Model (CMM)

In 1984, US government established a Software Engineering Institutes (SEI) at Carnegie-Mellon University in Pittsburgh. The aim of SEI is to develop standards and models for software development activities (Niazi, 2004).

In 1986, SEI initiated a project to develop a model to assess the capability of software development contractors to complete software product within budget and estimated time. In that sense, SEI developed the Capability Maturity Model (CMM) to improve software development processes (Paulk et al., 1993). The main objective of CMM is to assess and refine organizational processes. CMM consists of total five maturity levels (i.e. Initial, Repeatable, Defined, Managed, and Optimizing) (Paulk et al., 1993).

(Paulk et al., 1993) defined maturity as *"the extent to which a specific process is explicitly defined, managed, measured, controlled and effective"*. In CMM maturity levels, level-1 refers to the lowest maturity state of an organization where level 5 refers to the highest maturity level. Each maturity level consists of different key process areas (KPAs) as shown in Figure 2.1.

Level	Focus	Key Process Areas
5 Optimizing	*Continual process improvement*	Defect Prevention Technology Change Management Process Change Management
4 Managed	*Product and process quality*	Quantitative Process Management Software Quality Management
3 Defined	*Engineering processes and organizational support*	Organization Process Focus Organization Process Definition Training Program Integrated Software Management Software Product Engineering Intergroup Coordination Peer Reviews
2 Repeatable	*Project management processes*	Requirements Management Software Project Planning Software Project Tracking & Oversight Software Subcontract Management Software Quality Assurance Software Configuration Management
1 Initial	*Competent people and heroics*	

Figure 2.1 CMM maturity levels and KPAs (Paulk et al, 1998)

Each KPA consist of different sections called 'common features'. The common features specify the key practices that, when collectively addressed, accomplish the goals of the key process area. It's mandatory for each organization to address all the goals of KPAs

before moving to the highest maturity level. The key practices assist a firm to accomplish maturity goals at a specific maturity level. CMM can help an organization to evaluate its maturity level, process strengths and limitations.

Overall, CMM is an effective model for process improvement with defined maturity levels, KPAs and key practices. However, CMM does not provide any information about the effective implementation strategies and deployment of key practices. CMM model does not debated on issues related to humans, such as employee's motivation, hiring and selection (Niazi, 2004).

Most of the small and medium size organization felt reluctant to adopt CMM because of the lack of resources and its suitability view for large organizations (Hareton, & Terence, 2001). (Hareton, & Terence, 2001) have tailored the CMM to small projects in order to motivate small and medium size organizations to adopt CMM. They used eight key process areas of CMM to develop a framework for small projects. The proposed framework was assessed by conducting a pilot industrial study and they obtained positive results.

2.3.2 Capability Maturity Model Integration (CMMI)

CMMI is the successor of the CMM and it was developed by Software Engineering Institute (SEI) in order to overcome the issues of CMM (SEI, 2002; SEI, 2010). CMMI model integrates three source models, i.e. CMM for Software, Electronic Industries, the Alliance Interim Standard (EIA/IS) 731, and the Integrated Product Development Capability Maturity Model (IPD-CMM). CMMI is based on information collected from different other models and real world experiences of organizations that had adopted CMM for years. CMMI has the following main objectives.

- To make sure that the development of products are with the International Organization for Standardization (ISO/IEC-15504, 1998).
- To reduce the redundant usage and cost of using multiple and separate CMMs.
- To implement a more robust high- maturity practices.
- To link organizational and engineering activities more explicitly to business objectives.

CMMI also consist of five maturity levels (i.e. initial, managed, defined, quantitatively managed and optimizing). In CMMI, KPAs are represented as process areas (PAs) and it has total 25 PAs. CMMI consist of two views: continuous and staged (CP. Team, 2006). The continuous view is developed to allow the organization to emphasize processes that are significant to achieve immediate business goals or the practices having a high degree of risks. The staged view is developed to provide a standard sequence of improvements, to achieve the process improvement in stages.

In comparison to CMM, CMMI gives an innovative view of maturity levels, process areas and key practices. However, CMMI model like CMM does not provide information about the implementation of key practices and also does not recommend any implementation strategy (Niazi, 2004).

2.3.3 SPICE (ISO/IEC 15504)

SPICE (ISO/IEC 15504) was developed by the International Standards Organisation (ISO) and the International Electrotechnical Commission (IEC) for SPI under the SPICE (Software Process Improvement and Capability determination) (ISO/IEC-15504, 1998). SPICE was recognized as a project to come up with draft standards to test and

create the awareness of the developing standards. SPICE (ISO/IEC 15504) consists of two dimensions i.e. process and process capability (Zahran, 1998; Basri, 2010). Process dimension consists of measurable objectives for each process and relates to the process life cycle model (Zahran, 1998). The technical report of SPICE (ISO/IEC 15504) divided the process dimension into the following three categories (AutomotiveSIG, 2007):

- Primary life cycle processes category involves those processes that could use by customers when ordering products and can also be used by the supplier when supplying the products.

- Supporting life cycle processes category consists of those processes that may be used by other processes at different life cycle phases.

- Organizational life cycle processes category comprises of those processes that develop the business objectives for an organization.

Process capability dimension is characterized by a series of process attributes. It is measured by capability levels. (Zahran, 1998) define capability level as, "a set of attribute(s) that work together to enhance capability to perform a process. Each level provides a major enhancement of capability in the performance of the process". Process capability dimension is divided into total six levels of capability as follows (AutomotiveSIG, 2007).

- Level 1: Performed process (the deployed process achieves its goal).

- Level 2: Managed process (the performed process is appropriately implemented and its work products are properly established, organized and consistent).

- Level 3: Established process (the managed process is appropriately employed using a defined process that could accomplish its process outcomes).

- Level 4: Predictable process (the established process works within defined limits to attain the outcomes of its process).

- Level 5: Optimizing process (the predictable process is incessantly enhanced to meet current and future goals of the businesses).

These levels of capability characterise milestones towards the successful execution of SPI.

SPICE integrates the existing process improvement methodologies, but does not provide an explicit process improvement path.

2.3.4 ISO/IEC 330XX

ISO/IEC 15504 has been revised and replaced by more advanced process assessment and improvement standards, such as ISO/IEC 330XX (ISO, 2015). The ISO/IEC 330XX series covers the assessment of the SPI programs within an organization, and the maintenance, change management, delivery, and improvement of those processes. ISO/IEC 330XX series gives detailed information about the process evaluation, process evaluation application, characteristics of process quality and the application of the results of process assessment (ISO, 2015).

2.3.5 ISO 9000

ISO 9000 developed a series of standards in order to certify quality systems implemented in firms. These standards could be used to assess the quality of the

systems in an organization irrespective to the size of the organization or the complexity of the products or services.

ISO 9001: Consist of guidelines to implement standards organizational management systems. It would assist organizations to fulfil the customer needs and any other involved parties based on the quality management principles presented by ISO.

ISO 9001 help organization to achieve definite requirements, sort out by the supplier from design phase to servicing phase. The aims of those requirements are to achieve customer satisfaction by avoiding nonconformity from design phase to servicing phase.

Like CMMI, ISO 9001 provides complete guidelines for organizations in order to assess the quality of their management systems (Basri, 2010). ISO 9001 is more about the quality and process management, but CMMI emphasized on continuous software process improvement (Coleman, & O'Connor, 2008). ISO 9001 is a generic standard that mainly focus on manufacturing and services of different types of organizations, but CMMI strictly emphasize on software (Chrissis, Konrad, & Shrum, 2003; CP. Team, 2006; Basri, 2010).

In 1991 the ISO issued ISO 9000-3, "Quality Management and Quality Assurance Standards - Guidelines for the application of ISO 9001 to the development, supply and maintenance of software" (N. Ashrafi, H. Ashrafi, & Kuilboer, 1995). ISO 9000-3 interprets 9001 for software.

ISO 9001 is a quality management standard, but fail to provide information regarding the issues faced by SPI.

2.3.6 TRILLIUM

TRILLIUM is a quality assessment model established by Bell Canada and Northern Telecom in 1991 (April, & Coallier, 1995). The development of TRILLIUM is based on CMM and benchmarking. This model consists of eight capability areas and each capability area has multiple road maps (April, & Coallier, 1995). Each road map consists of different practices in order to address the specific capability area. TRILLIUM was developed to assess the quality of embedded systems; however it can also assist an organization to evaluate the information management systems.

2.3.7 BOOTSTRAP

BOOTSTRAP methodology was proposed to evaluate and improve the quality of the software process (Kuvaja, 1995). BOOTSTRAP was mostly adopted in European based organizations. The key characteristics of BOOTSTRAP are the model evaluation, assessment and rating the capability principles and provide SPI guidelines.

2.3.8 Implementation Maturity Model (IMM)

Niazi [22] developed a maturity model to assist the process improvement practitioners in order to effectively manage the SPI activities. IMM was based on the key concepts of CMMI [8]. The structure of IMM consists of three core components (i.e. factors, assessment, and implementation). IMM provides the detail information about the deployment of key practices and recommend implementation strategies. The humans related aspects of SPI implementation are explicitly discussed in IMM. However, IMM does not differentiate the collocated and distributed nature of the software development organizations.

2.4 Global Software Development (GSD)

Software development process can be done in two different ways i.e. collocated software development and GSD (Conchuir et al., 2009). In collocated software development process, all the development activities take place on a single site, while in GSD the development activities are accomplished from various distributed sites (Conchuir et al., 2009). In collocated (single site) software development the team members have close interaction with each other and they can easily carry out the development activities. On the other hand in GSD is the plan of action in which the knowledge workers preform the software development activities beyond the geographical, socio-cultural and temporal boundaries (Carmel, Espinosa, & Dubinsky, 2010).

2.4.1 Geographical boundaries

Geographical boundaries causes hindrance in the meeting of one team member with another (Carmel, Espinosa, & Dubinsky, 2010). If two sites are located at a large distance but they have regular flights then they can be considered as close to each other, whereas, if two sites are few kilometers away but they lack proper transportation or even intervening borders then they cannot be considered as close. The latter case would imply a high geographical distance (Lee, & Lings, 2008). Furthermore, the two members in the same building but separated by long corridors and floors will be influenced by geographical distance (Lee, & Lings, 2008).

Several factors have greater impact on the ease of relocating like the necessity to attain visa and the time required completing the journey. In a nutshell, low geographical distance enhances the mutual team work and offers more unplanned informal

communication (Conchuir et al., 2009). Therefore, low geographical distance offers high communication opportunity for team members (Conchuir et al., 2009).

2.4.2 Socio-cultural boundaries

Socio-cultural distance is a degree of actor's understanding of another actor's morals and normative practices (Carmel, Espinosa, & Dubinsky, 2010). Culture is widely affected by the discussions of different people on certain issues and their reaction. Cultural distance involves national cultural, organizational background, policies and moral principles (Shah et al, 2012).

National culture refers to the values, languages and communication style of the people. National cultural distance stems from the relative distance between the team members (Carmel, Espinosa, & Dubinsky, 2010). Mostly, the socio-cultural distance is related to the geographical distance. The small geographical distance between the members also causes cultural distance because even the people in the same country have difference in culture. Similarly the team members in large countries can have low cultural distance even they are widely separated geographically (Carmel, Espinosa, & Dubinsky, 2010).

Organizational culture refers to the values, rules and regulations of an organization (Conchuir et al., 2009). The views of two team members from different organizations regarding management, dress code and authority can vary. Organizational culture also includes the policies and different working styles in an organization (Conchuir et al., 2009). The particular vocabulary and various abbreviations are difficult to understand for a person who has never worked in specific organization is also regarded as an organizational culture (Conchuir et al., 2009). Diversity of organizational backgrounds is increased due to the organizational distance.

In GSD people from all over the world are involved having diverse national and organizational backgrounds which cause conflicts and misinterpretations (Agerfalk et al., 2008).

2.4.3 Temporal boundaries

Temporal distance is the measure of time difference experienced by two actors wishing to communicate (Carmel, Espinosa, & Dubinsky, 2010). Temporal distance is caused due to various factors like two team members are located at different time zones. Geographical distance also creates a temporal distance between the members trying to communicate with each other (Conchuir et al., 2009). Temporal distance occurs when working hours do not overlap between two locations. Temporal distance increases between two locations as the number of overlapping hours decrease.

Therefore, the difference in time zone and time shifting work pattern causes either an increase or decrease in temporal distance. For example, a one hour difference in time zone can, because of different routines (e.g. tea break) during a working day, lead to very few overlapping hours and appear higher than expected temporal distance (Conchuir et al., 2009). On the other hand, a European liaising with a counterpart working on a late shift in India may suffer low temporal distance (Lee, & Lings, 2008).

Geographical distance and temporal distance are linked with each other (Carmel, Espinosa, & Dubinsky, 2010), making it harder to differentiate between effects from geographical distance and those that result from temporal distance based on current literature. Finally, large geographical distance does not necessarily imply temporal distance because the two locations may be within the same time zone.

2.4.4 Benefits of GSD

In the era of globalization and especially during the last decade, GSD has become a necessity for the software organizations (Carmel, Espinosa, & Dubinsky, 2010). The concept of developing software in a distributed environment was introduced even before the use of the term GSD (Carmel, Espinosa, & Dubinsky, 2010). In 1960's, large computer vendors like IBM started developing software in a globally distributed environment. Later in 1970's, another distributed software development variant "contract programming" was introduced in which some part of the software development was outsourced to another third party for development (Lee, & Lings, 2008). PC revolution in 1990's marked the beginning of globalization of software that entirely changed the software industry culture (Lee, & Lings, 2008). Before that, software development was considered to be in the domain of only large organizations, but with this revolution, smaller organizations also stepped in the field of software development, which boosted competition in the industry (Carmel, Espinosa, & Dubinsky, 2010).

Late in 1990's, the shortage of labor in the US started a new trend of offshoring and its getting more and more popular among software developing organizations ever since (Conchuir et al., 2009). Presently, the organizations are developing software systems throughout the world by distributing their work using the electronic networks (Conchuir et al., 2009). The value of offshore software development market has been increased 25-times in the US during the past decade and forecasts are that one-quarter of the US based organizations are spending on offshoring the software development activities, incorporation and management services to offshore companies (Shah et al, 2012).

GSD is a blend of advancement towards a new technology and beginning of freshly established business models (SIIA, 2007). This phenomenon serves as a key component in the development as well as overhauling of software. The development of 'core product' along with customer service and technical support is also geographically distributed in GSD (SIIA, 2007). The assessment of the projects that are being developed on the model of GSD allows the team members to operate the software development activities beyond the geographical boundaries (Pilatti, & Audy, 2006). The team members working in GSD environment either belong to the same organization or contracted out from other organization. The geographical distance between the developing teams can range from a few meters (when the teams work in adjacent buildings) to different countries (Jimnez, & Audy, 2009).

The multi sites developing teams in GSD projects are geographically, culturally and temporally distributed (Holmstrom et al., 2006). Geographical distance separates the team members physically from each other and temporal distance offers hindrance in direct contact and lack of opportunities in collaboration, whereas, cultural distance negatively affect the level and struggle of team members (Beecham et al, 2010).

The lack of workforce has forced the organizations to start off shoring which has been widely adopted by the software industry (Aspray et al., 2006). The software developing organizations have been encouraged to start offshoring i.e. locate their work in different countries to achieve number of benefits (Herbsleb, 2007). According to observed results, 20% software development companies in the USA and out of 1000 world's leading organizations are globalizing their work (Conchuir et al., 2009). The Software development projects are outsourced to low cost countries (offshore vendors) and due to the enormous benefits it is gaining worldwide popularity (Richardson et al., 2008). Most of the organizations in developed countries (offshore Client) get various benefits from

outsourcing their work to offshore vendor organizations in developing countries. Offshore vendor organizations charge one third less than the onshore vendor organization and even less than collocated software development (McLaughlin, 2003, Khan, 2011). Most of the client organizations outsource software development activities to offshore vendor organizations in order to achieve the cost and quality advantages. Among many other reasons for outsourcing, generally client organizations outsource their software development work to offshore locations to achieve and endure the financial advantages, access to advanced technologies, and the capability to emphasize on the key competencies (Stetten et al., 2010, Khan, 2011). On the other hand, vendor organizations improve their expertise by using novel approaches to fulfill the requirement of the client organizations. It is believed that organizations adopting GSD also add value to their clients' supply chains (Khan, 2011). This is proved to be a quick and inexpensive way of software development.

The outsourcing is beneficial for the organizations in the sense that in offshore vendor organizations the labor cost is approximately one-third less than onshore retailers and it provides very less cost for software development (Khan et al, 2011). Due to the highly skilled and cheap labor, India is more popular than any other country for taking outsourced projects (Conchuir et al, 2009). For every dollar of USA client companies spent on outsourcing to vendor organizations in India, they get $1.14 and India by 0.33 percent (Conchuir et al., 2009, Khan, 2011). Similarly, other countries like China are also gaining popularity for outsourcing. The Chinese outsourcing industry has been developed vastly since 1990 and recently Shanghai has been named as China's Silicon Valley (Khan et al., 2011). Countries like Russia, Ireland, Brazil, Singapore and some European countries like Estonia, Poland and Latvia are also getting outsourcing projects in recent times (Conchuir et al., 2009). The possible benefits that can be obtained using

a distributed development approach have been observed in several research studies. Table 2.2 summarizes the benefits of GSD reported in literature.

Table 0.2: GSD Benefits

Benefit	Explanation
Economic development	The process of development is carried out in countries where wages are low (Agerfalk et al., 2008; Conchuir et al., 2009).
Timely delivery	The time-zone management between the distributed locations can help to maintain fast and timely delivery of products (Herbsleb, 2007).
Component based development process	Component based software development helps to carry out the development of features and modules in parallel (Agerfalk et al., 2008; Conchuir et al., 2009).
Access to skilled workforce	The process of outsourcing helps software developing organizations to utilize the expertise throughout the world (Khan et al, 2011).
Advancement and new concepts	The distributed software development provides opportunities to the people having different expertise to work together and share their ideas which are beneficial for organizations (Agerfalk et al., 2008; Conchuir et al., 2009).
Proximity to market	The benefit of proximity to business market includes customer's response, local environment and facilitating more effective requirements elicitation (Conchuir et al., 2009).

2.4.4 Risks in GSD

Apart from the GSD benefits, GSD also encounters many risks in an outsourcing process (Damian, 2007; Agerfalk et al., 2008), such as geographical distance, temporal incompatibility and cultural differences. (Islam, Joarder, & Houmb, 2009) conducted an empirical study and discussed that lack of understanding between client and vendor organizations, ambiguous requirements and informal software development processes may return undesired results. They discussed that eight out of ten software development organizations outsourced their projects to offshore vendors and they faced different challenges due to inadequate preparation and poor management. (King, 2005; Khan, 2011) discussed that JP Morgan performed collocated development for software projects that were previously outsourced to vendor organizations and refused to renew the outsourcing contract of $5 billion with IBM due to the failure of those projects. The

root cause of the outsourcing projects failure is the complex environment of GSD. (Khan, 2013) highlighted the following risks associated with GSD projects.

2.4.4.1 Lack of trust

Trust acts as a major factor in the development of personal networks and personal relationships (Boutellier et al., 1998). Trust prevails when the interacting groups acknowledge the right of the other parties to evaluate the capability and the intentions of their acts (Babar, Verner, & Nguyen, 2007). Understanding and confidence are levels of relationships that must be crossed before trust is developed. Acquiring and sustaining trust is therefore challenging in global teams as compared to collocated teams (Jimnez, & Audy, 2009). In GSD environment the members hardly meet each other that hinder the building of trust. The trust can also be corroded because of the faults that are produced due to the ignorance of teams by not trying to contact other remote teams before any alterations to the system (Boland, & Fitzgerald, 2004). The lack of trust causes lack of willingness to communicate that may result in various communication challenges in offshore development (Boden, Nett, & Wulf, 2007).

2.4.4.2 Lack of Culture Awareness

Every culture has its own styles, values and norms, which can produce unseen issues when the communication takes place among the people from diverse cultural backgrounds (Holmstrom et al., 2006). In GSD, lack of cultural awareness might cause misunderstanding between the culturally distributed team members. Imsland, Sahay and Wartiainen, (2003) quoted an example of misunderstanding happened between the team members located in Russia and Norway. Both the teams were communicating in English. In that case the misunderstandings arose due to the different communication style and diverse cultural backgrounds of each team. The Norwegian developers

belonged to a ‘low-context’ society, where intentions are normally explicitly stated without much depending on context. Instead, the Russian developers communicated in a ‘high-context’ style, where intentions can be indirect rather than clearly stated. Outside of Anglo and Northern European cultures, nonverbal communication is specifically significant for the high-context cultures (Owens, 2008).

2.4.4.3 Less time Overlapping

The temporally distributed sites may face different challenges due to less number of overlapping hours (Holmstrom et al., 2006). For example, a team located in eastern U.S and one in Ireland has a total of three overlapping hours throughout the working day (Casey, & Richardson, 2008). Even a one-hour time zone difference can result in a huge reduction of overlapping hours. For example, the team located in Germany works from 8am-4pm with a 12pm lunch time, coordinates with a team in the UK that works from 9am-5pm with a 1pm lunch, results in four overlapping hours during a work day which reduces the rate of communication (Herbsleb, 2007).

2.4.4.4 Delay in response

Delay in response behaves as an unbearable and an annoying factor for team members who are working in different time zones and geographically distributed from each other (Nguyen, Wolf, & Damian, 2008). Due to temporal distance, the delay factor becomes even more annoying when a quick response is needed (Noll, Beecham, & Richardson, 2010).

2.4.5 Software process improvement in Global Software Development

This section overview state of the art based on SPI in the context of GSD. The main objective is to summarise and discuss the outcomes of existing studies in order to understand the problem context.

- Caprihan (2006) worked on managing software performance in the context of global software development. He discussed that it is difficult to manage software development activities in GSD as compared to collocated software development. In GSD environment the development activities carried out over geographical boundaries which increase the need of reliable infrastructure. He proposed a methodology in order to address performance related issues such as increasing response time, CPU utilization and decreasing outputs at a rate proportional to the workload. He further states that, "*the proposed methodology attempts to address these issues by providing, both, a prescriptive approach and a set of tools wherever applicable to help de-skill and de-mystify the what, when and how of managing performance during the application development life cycle*".
- Laredo and Ranjan (2006) accomplished a project in a geographically distributed environment. In that article they discussed various process improvement challenges faced by the development teams and the practices used to address those challenges. They highlighted that SPI challenges in GSD environment are to understand the nature of the distributed teams, project variables and adjust the team performance in order to assess the productivity over a period of time. They focused on the need of innovative ideas for the development of SPI management tools in the context of GSD. They suggested the key features of integrated collaboration, project planning, management and smart estimation for future SPI implementation tools development for GSD organizations.
- Babar and Niazi (2008) conducted an empirical study in the Vietnamese GSD industry to explore views and opinion of SPI practitioners in order to investigate issues that can impact the initiation of SPI program. They also explored the reasons for embarking on SPI program and the barriers that could hinder the

effective implementation of SPI activities in GSD organizations. The results shed light that software quality improvements, less software development cost and customer satisfaction were the main factors that motivated the Vietnamese GSD organizations to initiate the SPI program. The practitioners emphasized on the need of proper training, skilled workforce and allocation of adequate resources for effective SPI design and employment. They discussed that lack of project management and lack of resources are the most critical challenges and organizational management should emphasize on these challenges in order to achieve the estimated outcomes.

- Cristal, Wildt and Prikladnicki (2008) discussed two experience reports of using SCRUM practices in a distributed environment. They emphasized on the significance of using SCRUM practices in the GSD as SCRUM consist of project management as part of its practices. The objective of using SCRUM is to simplify the project control using simple processes; easy to update the documentation and focus on continues software process improvement. They documented that in both experienced reports the development teams pointed out the following challenges.

    i. Lack of formal requirements documentation
    ii. Inadequate structure of teams
    iii. Communication problems
    iv. Lack of awareness of the management teams regarding agile practices

- Mongkolnam et al. (2009) conducted an empirical study in Thailand based offshore software development organizations in order to evaluate the status of software process improvement in those organizations. The aim of this investigation was to develop near term and long term SPI strategies in Thai

offshore organizations. They reported that the deployment of proper SPI approach could assist an organization to have proper control over new projects, accurate project estimation and planning, limited number of project risks and less staff turnover. They indicated the need of proper SPI implementation techniques and approaches for Thailand based offshore software development organizations.

- Beecham, Noll and Richardson (2010) developed a model that consists of key practices specified for project management and architectural knowledge management areas in GSD organizations. The model was based on the existing literature and the empirical studies conducted in geographically distributed organizations. They reported that most of the organizations ignored the systems software architecture with the fact that architectural knowledge management is challenging and costly to maintain. They believe that architectural knowledge management works as a coordination tool among the distributed teams. They argued that the practices of proposed model can assist the SPI practitioners to address issues related to project management and architectural knowledge management in GSD environment.
- Smite et al. (2010) conducted a systematic literature review study in order to investigate various trends in global software development. They highlighted that the results obtained from the selected empirical studies are lacking of empirical evaluation of methods, techniques and tools. They reported that most of the studies focused on different other aspects of global software development rather than a comprehensive analysis of process improvement practices and methods.
- Niazi, Babar and Verner (2010) have conducted an empirical study in Vietnamese and Australian software industries in order to investigate barriers

that could impact SPI in the context of GSD. Based on the results obtained from both the industries, they reported the most common and critical barriers that could undermine the implementation of SPI initiatives. They highlighted that the reported barriers could assist researchers and practitioners to develop an effective strategy for the implementation of SPI activities.

- Richardson et al. (2010) argues that, in GSD the geographical distance brings physical separation among the team members and management, temporal distance decrease the direct communication opportunities and cultural distance negatively impacts on the understanding and appreciation level of the activities and efforts of the distributed teams. Therefore, GSD has experienced more complications as compared to collocated development. They mentioned that process models such as CMM, CMMI and ISO/IEC 15504 operate successfully in collocated software development environment but do not explicitly address the distributed nature of the software development.
- Galvina and Smite (2011) conducted an extensive literature review study in order to overview the software development processes in the domain of GSD. They concluded that most of the existing studies are lacking of research on the SPI models and practices in the domain of globally distributed projects. They mentioned that following are some of the key process improvement challenges faced by the distributed team members.
    i. Joint execution with no standards for the interface between the sites,
    ii. Joint execution with limited synchronous interaction,
    iii. Joint execution requires more time than collocated work.
- Faizan, Ulhaq and Khan (2014) worked on defect prevention in GSD projects. They proposed a framework to address the defects related to the projects quality

in the context of GSD. The framework is only limited to address defect related to client GSD organizations. They adopted a case study approach to evaluate the proposed framework within practitioners.

- Kuhrmann, Diebold and Munch (2016) conducted a systematic mapping study to report the available SPI related studies. In this article they analysed a total of 769 publications and provide a broad picture of state of the art in the context of SPI and GSD. Their reported results reveal that currently most of the SPI studies focused on different proposals for SPI, experience reports and empirical studies, but only a few researchers have discussed theories and models to address the SPI related issues.

2.5 Software Process Improvement literature limitations

Significant consideration has been given for the development of different process improvement models and techniques. Such standard and models encourage organizations to develop quality software systems (Pettersson et al., 2008; Kitchenham, & Charters, 2007). However, regardless of the availability of different SPI models, the success rate of SPI programs is very low (Niazi, Babar, & Verner, 2010; Niaiz, 2004; Khan, & Keung, 2016), about 30% according to (Ngwenyama & Nielsen, 2003). One of the major reasons of this failure is that currently most of the software development organizations are adopting the phenomena of GSD and the nature of SPI related issues are quite different in GSD as compared to collocated software development. (Ramasubbu, 2014; Khan, & Keung, 2016) shed light that the available literature about SPI does not address the issues related to those organizations who adopted GSD. No matter the type (client *versus* vendor) of organization, team member's work beyond geographical boundaries where the implementation of SPI programs is more puzzling

(Ramasubbu, 2014). Regardless of the significance of SPI problems in GSD, little empirical research has been carried out to develop techniques and practices that could address the challenges face by the SPI practitioners working in GSD environment. Research in this area is expected to provide useful insight into the views of SPI practitioners about the readiness of their organizations for process improvement implementation.

Most of the available studies do not focus on success factors, barriers and their practices for the implementation of SPI activities in the domain GSD. I tried to address this issue by first identifying the success factors, barriers and implementation practices using systematic literature review approach and then validated them in the domain of GSD using questionnaire survey. I have encouraged the survey respondents to mention additional success factors, barriers and practices other than those already mentioned in the survey questionnaire. However, like the researchers of many studies based on experience data (Baddoo, & Hall, 2002; Beecham, Hall, & Rainer, 2003; Niazi, Wilson, Zowghi, 2006, Khan, 2011), I am confident about the findings of the data collected from SPI practitioners having wide experience in SPI related activities.

The findings of the systematic literature review reveal that there is no SLR study that has address success factors, barriers and practices for SPI implementation in the domain of GSD. These findings confirm the novelty of the SLR approach for SPI in the domain of GSD. An SLR is the type of secondary study that review all primary studies (studies which are used for exploring a specific research area) in terms of identifying, analyzing and exploring all evidences related to research questions in an unbiased and iterative way (Kitchenham, & Charters, 2007). (Beecham et al., 2008; Khan, 2013) reported that the unsystematic review of literature is not a methodical approach which could bring unreliable results. In this study, the systematic literature review protocol was developed

which consist of the plan develop to conduct the SLR study. The protocol is briefly discussed in Appendix A.

Various challenges have been discussed that could affect the initiation of the SPI program in the GSD (Ramasubbu, 2014; Khan, & Keung, 2016; Niazi, Babar, & Verner, 2010). In order to address those challenges in GSD, there is a need of process improvement implementation techniques and methods that could assist the practitioners to successfully execute the SPI activities (Laredo, Ranjan, 2008; Babar, & Niazi, 2008; Richardson et al., 2010; Khan, & Keung, 2016, Khan et al., 2017).

2.6 Summary

The chapter has provided a detailed background study on the research topic. It covers the brief introduction of SPI and GSD. This chapter has also discussed various approaches that have been discussed for SPI. The available SPI studies are thoroughly investigated in order to understand the research problem. Most of the studies focused on the need of proper SPI implementation technique to successfully address SPI related issues in geographically distributed environment. Literatures reveal that the nature of process improvement activities is different in GSD environment as compared to collocated or in-house development. In GSD the development teams performed software development activities beyond geographical boundaries which cause various problems such as communication, coordination, unavailability of reliable infrastructure and proper SPI implantation technique. So far no approach has been identified that could help in the design and effective implementation of process improvement activities in GSD environment. Further research in this area could assist SPI practitioners and researchers to successfully execute SPI related activities in distributed software development.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Overview

This chapter gives the brief overview of different philosophies of research, including qualitative and quantitative research techniques. Systematic literature review (SLR) approach is also discussed that is used to collect the data from the literature. This chapter consists of the adopted research techniques and their justification. It explains the complete research design that has been followed in this study. The data collection and analysis processes will also be explained in detail.

This Chapter is organized as follows:

- Section 3.2 gives a philosophical view of research methodology.
- In Section 3.3, the background of research methodology is discussed.
- In Section 3.4, choosing a research method and justification is reported
- Section 3.5 consists of data collection approaches.
- In Section 3.6, data analysis techniques are discussed.
- Section 3.7 consists of limitations of the selected research methodologies.
- In section 3.8, the chapter is concluded.

3.2 Philosophical View

The most important condition for all research studies are based on the pertinent set of methods that fit into the research questions (Kothari, Hu, & Roehl, 2007). The most pertinent methods are those, which relate to the underlying epistemology that provides the guidance throughout the research process. According to (Audi, 2010), epistemology is an assumption about knowledge and the way it can be obtained. Two categories that are based on the underlying research epistemology are: Positivist and Interpretivist.

3.2.1 Positivist

According to Levin (1988), a positivist approach to research is based on knowledge gained from 'positive' verification of observable experience, for example, introspection or intuition. Scientific methods or experimental testing is the best way of achieving this knowledge. Easterbrook et al. (2008) argues that positivist views the world in order and regular form and can investigate its objective. Positivists also believe that the observer is not a part of research and science is not driven by human interest.

3.2.2 Interpretivist

Interpretive methods of research start from the position that our knowledge of reality, including the domain of human action, is a social construction by human actors and it applies equally to researchers. Thus, there is no objective reality which can be discovered by researchers and replicated by others, in contrast to the assumptions of positivist science (Walsham, 2006). According to Audi (2010), interpretive approach more focused to identify, explore and explain the full complicity of human sense making as the situation emerges rather than defined hypothesis. They added that interpretive researchers aim for the plausibility rather than proof as in the case of the

positivists. The positivist paradigm is more on the generalizability of the previous research while an interpretive paradigm could enhance the depth of understanding of the phenomenon in question (Walsham, 2006).

3.3 Research Methodology background

Research methods are the way to collect the data, such as surveys and interviews, whereas research methodologies refer to the strategies used to conduct the research activities in order to generate the reliable research outputs (Bryman, 2012). Qualitative and quantitative are two terms that have been used to differentiate the research concept (Creswell, & Clark, 2010). Qualitative research techniques are based on an interpretivist paradigm, while quantitative methods are based on the positivism paradigm and (Firestone, 1987).

3.3.1 Quantitative research

Quantities research technique is an approach that explains a particular phenomenon by collecting, analysing, and reporting the results of numerical data using various statistical methods (Creswell, 1994). Most of the researchers adopted the quantitative research approach with the aim to conclude that whether the generalization of a theory hold true or not (Creswell, & Clark, 2010). It could assist to evaluate the relationship between the dependent and independent variables by proposing and testing the research hypotheses (Bryman, 2012). There are different types of quantitative research (Sukamolson, 2011) which are briefly discussed in the following sections.

3.3.1.1 Survey research

The terms survey and survey research have important distinction. A survey is a means of "gathering information about the characteristics, actions, or opinions of a large group

of people, referred to as a population" (Adams, 1982). As such, there are various processes of data collection that are called surveys e.g. research surveys, marketing surveys and opinion surveys. Survey research is conducted to focus on advancement of scientific knowledge (Rea, & Parker, 2014). Survey research generates quantitative data using a large number of people who are to be a population in order to test hypothesis.

3.3.1.2 Correlation Research

Correlation research refers to the investigation of the relationship between the independent and dependent variables (Borrego, Douglas, & Amelink, 2009). Correlation research is the degree to which the variables are interrelated. The correlation coefficient (r value) is used to quantitatively measure the extent of the relationship (Stangor, 2010).

3.3.1.3 Experimental Research

Experimental research technique is mostly adopted in the natural sciences research such as medicine, physics etc. It is a collection of research designs which use manipulation and controlled testing to understand the causal processes (Bryman, 2012). In experimental research, the researchers manipulate one or more variables in order to determine their effect, control and change on a dependent variable (Wiersma, & Jurs, 2005).

3.3.1.4 Causal-comparative Research

Causal comparative research is just like descriptive research because it describes the conditions that already exist (Sukamolson, 2011). In causal comparative research the researcher's attempts to determine the cause of the existing differences between the behavior of groups or individuals. Established groups that are already different for some variable and the researcher's attempts to identify the major factor that has led to this difference (Abawi, 2008).

3.3.2 Qualitative research

Most of the researchers, working in the social sciences, were interested in studying human behaviour and the social world occupied by human beings (Glaser, & Strauss, 1967). They found increasing difficulty in trying to explain human behavior in simply measurable terms (quantitative research methods) (Hennink, Hutter, & Bailey, 2010). Measurements tell us how often or how many people behave in a certain way, but they do not sufficiently answer the question "why?" (Bryman, 2012). Research which attempts to increase our understanding of why things are the way they are in our social world and why people act the ways they do is "qualitative" research (Bryman, 2012). Qualitative research is concerned with finding the answers to the questions which begin with: Why? How? In what way? Quantitative research, on the other hand, is more concerned with questions about: how much? How many? How often? To what extent? (Sekaran, & Bougie, 2010).

The four major types of qualitative research design are classified as follows (Silverman, 2010):

3.3.2.1 Phenomenology

The term phenomenology used to study the phenomena. It provides the description about the things which are already exists in this world. Phenomena might be occasions, circumstances, experiences or perceptions (Silverman, 2010). This world has lots of phenomena but we do not have deep knowledge and understanding of those phenomena. It is not necessary that the phenomenology research provides exact but it just raises attentiveness and increases insight.

3.3.2.2 Ethnography

Ethnography has a background in anthropology. The term means “portrait of a person” and it is a methodology for descriptive studies of cultures and peoples (Bernard, 2011). The cultural parameter is that the people under investigation have something in common. Examples of parameters include: geographical - a particular region or country, religious, tribal, shared experience etc. (Bernard, 2011). Ethnographic research can be problematic when researchers are not sufficiently familiar with the social mores of the people being studied or with their language.

3.3.2.3 Grounded theory

Grounded theory method (GT) is a systematic research approach that used to discover the theory by analyzing the targeted data (Glaser, & Strauss, 1967). It goes beyond phenomenology because the explanations that emerged are genuinely new knowledge and are used to develop new theories about a phenomenon (Carver, 2007). Case study research is used to describe an entity that forms a single unit such as a person, an organization or an institution. Some research studies describe a series of cases (Glaser, & Strauss, 1967).

3.3.2.4 Action Research

Action research is a strategy educators can use to study educational issues, implement change and document professional growth (Munn-Giddings, & Winter, 2013).

Action research is either research initiated to solve an immediate problem or a reflective process of progressive problem solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems (Munn-Giddings, & Winter, 2013).

3.4 Selected research methods and justification

In empirical research, I have used both qualitative and quantitative approaches (mixed method) to collect the data in order to create and test number of research questions. In mixed research method, both the quantitative and qualitative data have been collected concurrently in a single study (Borrego, Douglas, & Amelink, 2009). Mixed research method assists to overwhelm the limitations of both the qualitative and quantitative research approaches (Creswell, & Clark, 2010). The implementation of quantitative and qualitative methods involved data collection that divided into two approaches; sequential or concurrent with the priority to one method over the other or having same and equal status (Creswell, & Clark, 2010).

Qualitative and quantitative data collection techniques are complementary (Walker et al., 2003; Khan, 2011). Qualitative data can be converted into quantitative by using the coding technique and this process will not impact the subjectivity or objectivity of the data (Baddoo, & Hall, 2002; Burnard, 1991; Khan, 2011). Bryman (2012) noted that the reverse can also occur. One of the examples in which quantitative research can facilitate qualitative research is by the selection of case studies for further research.

The brief overview of both quantitative and qualitative research methods specifies that empirical research methods can assist researchers towards well-founded decisions (Perry, Porter, & Votta, 2000). In this research, I have used the mixed method approach for data collection and the same methodology has been followed by other researchers in different other domains (Niazi, 2004; Khan, 2011; Khan, 2015). The qualitative data were collected using SLR and survey questionnaire approaches. The collected qualitative were converted into quantitative (i.e. frequencies) in order to perform the statistical analysis. The overall research process is depicted in Figure 3.1.

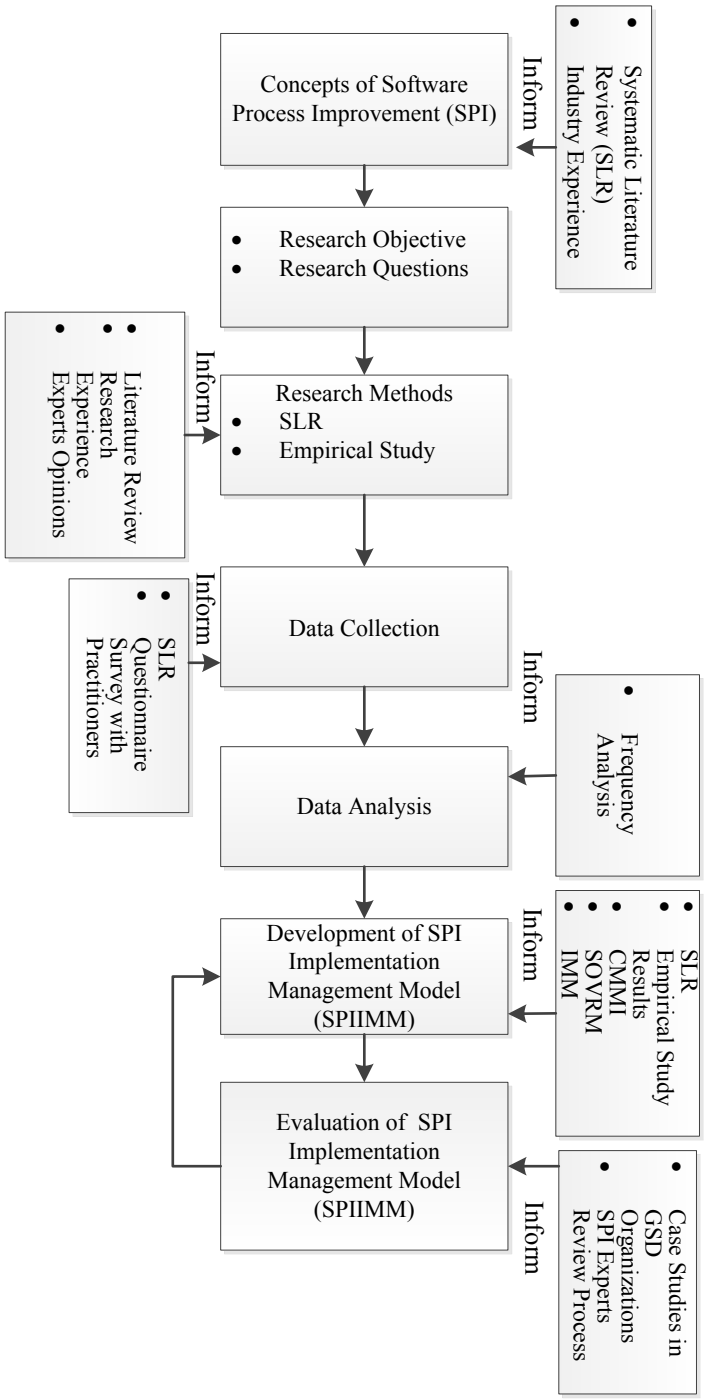


Figure 3.1 Research Process

3.5 Data collection

The data collection methods should be clearly described and justified as it has a significant effect on the analysis process (Niazi, 2004; Khan, 2011). I have used an SLR

and a questionnaire survey to collect data from existing literature and practitioners. These approaches were chosen because they are best for the type of the data analyzed and reported in this study (Rockart, 1979; Niazi, 2004; Khan, 2011).

Systematic literature review (SLR) is the systematic way of reporting the results extracted from literature (Kitchenham, & Charters, 2007). SLR method provides a way of exploring, classifying, and analyzing the existing research related to any research area and questions of interest (Kitchenham, & Charters, 2007). The main objective of SLR is to search out maximum relevant literature by applying explicit inclusion and exclusion criteria at primary studies and also to define the quality criteria for evaluation of primary results and extracted data from those studies (Kitchenham, & Charters, 2007).

In this thesis, the guidelines provided by Kitchenham and Charters (2007) were followed in order to perform SLR. According to Kitchenham and Charters (2007), SLR consists of three phases i.e. planning the review, conducting the review and reporting the review as shown in Table 3.1.

Table 3.1 SLR phases

Planning the Review/Review Protocol development	• Research questions • Search strategy and search terms • Inclusion and Exclusion criteria • Data sources • Quality Criteria for studies selection
Conducting the Review	• Primary Studies Selection • Data Extraction • Data Synthesis
Reporting the Review	• Document all the extracted results

3.5.1 Planning the review/Review protocol development

Planning the review consists of different other sub phases to develop the SLR protocol. The complete SLR protocol is reported in Appendix A.

3.5.1.1 Research Questions

Complete list of all the proposed questions is discussed in section 1.4. I used the SLR approach to answer the following research questions:

RQ1. What are the factors, as identified in the literature, do GSD organizations need to address in order to have a positive impact on SPI implementation?

RQ2. What are the barriers, as identified in the literature, within GSD have a negative impact on SPI implementation?

RQ7. What are the practices, as identified in the literature, to address the critical success factors and critical barriers for SPI in GSD?

3.5.1.2 Search strategy and search terms

The following strategy has been developed in order to construct search terms (Khan et al., 2013):

a. Derive the major terms from the research questions, by identifying population, intervention and outcome of relevance.

b. Derive the major terms and search for their alternative spellings and synonyms.

c. Verify the major terms in any relevant papers.

d. If the database allows, use Boolean "OR" operator to integrate the alternative spellings and synonyms and use the "AND" operator to integrate the major terms.

I have assessed each research question according to the above search strategy.

(RQ1) What are the success factors, as identified in the literature, do GSD organizations need to address in order to have a positive impact on SPI implementation?

Results for a:

[What are the success factors, as identified in the literature] "INTERVENTION" [do GSD organizations need to address] "POPULATION" [in order to a have positive impact on SPI implementation] "OUTCOME OF RELEVANCE".

Results for b:

Factors: ("factors" OR "aspects" OR "items" OR "elements" OR "drivers" OR "motivators" OR "variables" OR "characteristics" OR "parameters")

GSD: ("GSD" OR "global software development" OR "global software engineering" OR "distributed software development" OR "software outsourcing" OR "offshore software development" OR "information technology outsourcing" OR "software contracting-out" OR "IT outsourcing")

SPI: ("SPI" OR "software process improvement" OR "software process enhancement" OR "CMM" OR "CMMI" OR "SPICE" OR "software process enrichment" OR" software process evaluation" OR "software process assessment" OR "software process appraisal")

Positive impact: ("positive impact" OR "conclusive" OR "absolute" OR "concrete" OR "perfect" OR "reliable" OR "good effect" OR "best results")

Results for c:

The keywords and their alternatives were based on existing literature in the domain of SPI and GSD (Babar, & Niazi, 2008; Ramasubbu, 2014; Khan et al., 2011; Khan, & Keung, 2016).

Results for d:

Factors: ("factors" OR "aspects" OR "items" OR "elements" OR "drivers" OR "motivators" OR "variables" OR "characteristics" OR "parameters") AND ("GSD" OR "global software development" OR "global software engineering" OR "distributed software development" OR "software outsourcing" OR "offshore software development" OR "information technology outsourcing" OR "software contracting-out" OR "IT outsourcing")

AND

SPI: ("SPI" OR "software process improvement" OR "software process enhancement" OR "CMM" OR "CMMI" OR "SPICE" OR "software process enrichment" OR" software process evaluation" OR "software process assessment" OR "software process appraisal") AND ("positive impact" OR "conclusive" OR "absolute" OR "concrete" OR "perfect" OR "reliable" OR "good effect" OR "best results")

(RQ2) What are the barriers, as identified in the literature, within GSD have a negative impact on SPI implementation?

Results for a:

[What are the barriers, as identified in the literature] "INTERVENTION" [within GSD] "POPULATION" [have a negative impact on SPI implementation] "OUTCOME OF RELEVANCE".

Results for b:

Barriers: (“barriers” OR “obstacles” OR “hurdles” OR “risks” OR “risk analysis” OR “critical barriers” OR “difficulties” OR “impediments”)

GSD: (“GSD” OR “global software development” OR “global software engineering” OR “distributed software development” OR “software outsourcing” OR “offshore software development” OR “information technology outsourcing” OR “software contracting-out” OR “IT outsourcing”)

SPI: (“SPI” OR “software process improvement” OR “software process enhancement” OR “CMM” OR “CMMI” OR ”SPICE” OR “software process enrichment” OR” software process evaluation” OR “software process assessment” OR “software process appraisal”)

Negative impact: (“negative impact” OR “negative effects” OR “bad impact” OR “bad effects” OR “unwilling impact” OR “unreliable outcomes” OR “undesired results” OR “unsatisfactory results”)

Results for C:

The keywords and their alternatives were based on existing literature in the domain of SPI and GSD (Babar, & Niazi, 2008; Ramasubbu, 2014; Khan et al., 2011; Khan, & Keung, 2016).

Results for D:

Barriers: (“barriers” OR “obstacles” OR “hurdles” OR “risks” OR “risk analysis” OR “critical barriers” OR “difficulties” OR “impediments”) AND (“GSD” OR “global

software development" OR "global software engineering" OR "distributed software development" OR "software outsourcing" OR "offshore software development" OR "information technology outsourcing" OR "software contracting-out" OR "IT outsourcing") AND ("SPI" OR "software process improvement" OR "software process enhancement" OR "CMM" OR "CMMI" OR "SPICE" OR "software process enrichment" OR" software process evaluation" OR "software process assessment" OR "software process appraisal") AND ("negative impact" OR "negative effects" OR "bad impact" OR "bad effects" OR "unwilling impact" OR "unreliable outcomes" OR "undesired results" OR "unsatisfactory results")

(RQ7) What are the practices, as identified in the literature, to address the critical success factors and critical barriers for SPI in GSD?

Results for a:

[What are the practices, as identified in the literature] "INTERVENTION" [to address the critical success factors and critical barriers for SPI] "OUTCOME OF RELEVANCE" [in GSD] "POPULATION".

Results for b:

Practices: ("practices" OR "recommendations" OR" implementation practices" OR" improvements" OR "best practices" OR "solutions" OR "exercise" OR "suggestions" OR "execution")

Critical success factors: ("critical factors" OR "important factors" OR "success factors" OR "positive elements" OR "critical success factors" OR "significant variables" OR "significant positive factors")

Critical barriers: (“critical barriers” OR “significant barriers” OR “important obstacles” OR “key barriers” OR “important barriers” OR “critical risks” OR “difficulties” OR “impediments”)

GSD: (“GSD” OR “global software development” OR “global software engineering” OR “distributed software development” OR “software outsourcing” OR “offshore software development” OR “information technology outsourcing” OR “software contracting-out” OR “IT outsourcing”)

Results for C:

The keywords and their alternatives were based on existing literature in the domain of SPI and GSD (Babar, & Niazi, 2008; Ramasubbu, 2014; Khan et al., 2011; Khan, & Keung, 2016).

Results for d:

Practices: (“practices” OR “recommendations” OR” implementation practices” OR” improvements” OR “best practices” OR “solutions” OR “exercise” OR “suggestions” OR “execution”) AND (“critical factors” OR “important factors” OR “success factors” OR “positive elements” OR “critical success factors” OR “significant variables” OR “significant positive factors”) AND (“critical barriers” OR “significant barriers” OR “important obstacles” OR “key barriers” OR “important barriers” OR “critical risks” OR “difficulties” OR “impediments”) AND GSD” OR “global software development” OR “global software engineering” OR “distributed software development” OR “software outsourcing” OR “offshore software development” OR “information technology outsourcing” OR “software contracting-out” OR “IT outsourcing”)

3.5.1.3 Inclusion and Exclusion criteria

In this section, I have developed the criteria for inclusion/exclusion of the articles in the final selected primary studies.

- **Inclusion criteria:** The selected primary studies must be available in English language. Each primary study article must be conference, journal or book chapter. I have focused on the articles that have discussed process improvement programs in the GSD environment. More focus was on those papers that discussed SPI success factors and barriers along their practices.

- **Exclusion criteria:** I have excluded those papers which have not reported the software process improvement success factors and barriers. Those articles were also excluded that did not provide the detail information regarding the process improvement standards and models. The duplicated articles were also not considered. Additionally, those articles were also excluded that were reported in other languages except English.

3.5.1.4 Data sources

After identifying major keywords and their alternative, various databases were chosen in order to identify the relevant articles, journals, conference papers etc. Databases were chosen based on previous research experience, personal knowledge, preferences or suggested by other researchers (Chen, Babar, & Zhang, 2010). The data sources include:

a. IEEE Explore
b. ACM Digital Library
c. Springer Link
d. Wiley Inter Science
e. Science Direct

f. Google Scholar

3.5.1.5 Quality Criteria for studies selection

Quality Assessment (QA) of the selected articles was performed concurrently with the data extraction phase. The guidelines provided by (Petticrew, & Helen, 2008; Crombie, & Davies, 1997) were followed in the design of the checklist shown in Table 3.2.

For each given item QA1 to QA5, the evaluation was done as follows:

a. The articles containing answers to the checklist questions were assigned 1 point.

b. The articles containing partial answers to the checklist question were assigned 0.5 points.

c. The articles not containing any answers to the checklist questions were assigned 0 points.

The selected studies were also assessed through an informal external review, which confirmed that these studies had sufficient quality to be considered in this SLR study.

Table 3.2 Checklist for Quality assessment of selected studies

S. No	Checklist Questions
QA1	Do the selected methodologies have addressed the research questions?
QA2	Does the article have discussed software process improvement success factors or barriers?
QA3	Do the study report practices for the SPI success factors or barriers in GSD?
QA4	Is the reported results are related to process improvement?
QA5	Do the results have addressed the research questions?

3.5.2 Conducting the review

3.5.2.1 Primary studies selection

During the primary study selection process, various research articles were found and tollgate approach proposed by (Afzal, Torkar, & Feldt, 2009) was used to refine the

selection process. As can be seen from Figure 3.2 and Table 3.3, the tollgate approach consists of five phases Ph-1 to Ph-5:

- Phase 1 (Ph-1): explore using the search terms.
- Phase 2 (Ph-2): Title and abstract based inclusion/exclusion.
- Phase 3 (Ph-3): Introduction and conclusion based inclusion/exclusion.
- Phase 4 (Ph-4): Full text based inclusion/exclusion.
- Phase 5 (Ph-5): final selection of the articles to be included in the primary studies selection.

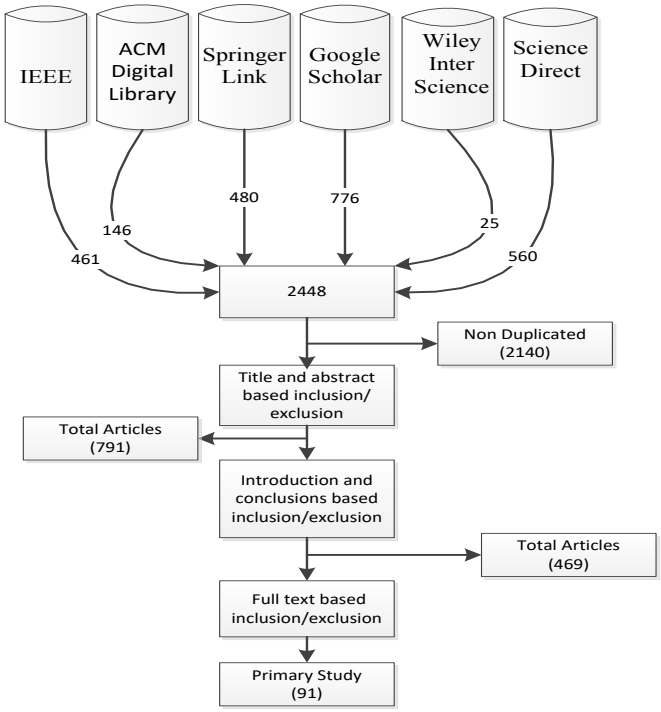


Figure 3.2 Tollgate approach for primary studies selection

Initially, a total of 2448 articles were extracted from the selected databases based on the inclusion and exclusion criteria (section 3.5.1.3) and search strings step (section 3.5.1.2). Then, the tollgate approach (Afzal, Torkar, & Feldt, 2009) led to a short list of 91 remaining articles to be included in the primary studies. Finally, the selected papers

were assessed using the quality assessment criteria (section 3.5.1.5). The list of the selected articles is mentioned in Appendix B.

Table 3.3 Total selected primary studies using tollgate approach

E-Databases	**Ph-1**	**Ph-2**	**Ph-3**	**Ph-4**	**Ph-5**	**% of final selected articles (n=91)**
Wiley Inter Science	25	24	17	11	6	7
IEEE Xplore	461	390	135	76	16	18
Science Direct	560	511	194	117	16	18
ACM Digital Library	146	112	37	25	10	11
Google Scholar	776	673	232	154	24	26
Springer Link	480	430	176	86	19	21
Total	2448	2140	791	469	91	100

3.5.2.2 Data Extraction

In order to answer the research questions, I have extracted the following data from each article: title, year, study type (journal, conference, thesis, research report), reference, success factors for SPI implementation, barriers for SPI implementation, practices to address the critical success factors and critical barriers, research method (QS= Questionnaire Survey, INT= Interview, SLR= Systematic literature review, ILR= Informal literature review, CS= Case Study , MM=Mixed Method, AR=Action Research), continent (AS= Asia, EU= Europe, AUS= Australia, NA= North America, SA= South America , MX=Mixed), company size (small, medium, large)

A detailed list of the selected articles is presented in Appendix B. Inter-reliability analysis was performed to unbiased the inter-person selection process. I have selected three external reviewers and each reviewer has selected ten papers from the “Ph-1” of tollgate approach and followed the selection process “Ph-2- Ph-5”. Kendall’s coefficient of concordance (W) [33] statistical test was applied in order to analyse the inter-reliability agreement between the reviewers (Eye, & Mun, 2014). The value of (W) is

from 0 to 1, where 0 represent a strong disagreement and 1 indicate complete agreement among the reviewers. In this study, the calculated value of (W) was “0.80” with the significance of “p=0.003”. It illustrates that there was a strong and positive agreement level between the external reviewers and the authors of the article.

3.5.2.3 Data Synthesis

The author performed the data synthesis process. As a result of the extraction phase, a list of success factors and barriers from the remaining 91 articles (91 selected primary studies) was created. The results extracted from all the selected articles were reported together and all the research questions were evaluated against these results.

3.5.3 Reporting the review

3.5.3.1 Quality attributes

Appendix C shows the list of the scores for each selected study against the five QA questions discussed in Table 3.2. The final QA score for each selected study was given by adding the scores for all the QA questions. All the selected 91 studies were those that provided adequate information about SPI success factors and barriers and therefore 75% of the selected studies scored 50% or above each in the QA checklist as shown in Appendix C.

3.5.3.2 Temporal distribution of selected primary studies

Figure 3.3 provides the complete summary of the selected 91 primary studies and shows their frequencies based on the publication year, decade and research method. Out of total 91 articles, 30 studies were published in the first decade (1996-2005) and 61 in the second decade (2006-2015). Summarizing, the picture from analysis, there was more than 50% increase in the research studies that focused on the topics related to the software process improvement and GSD.

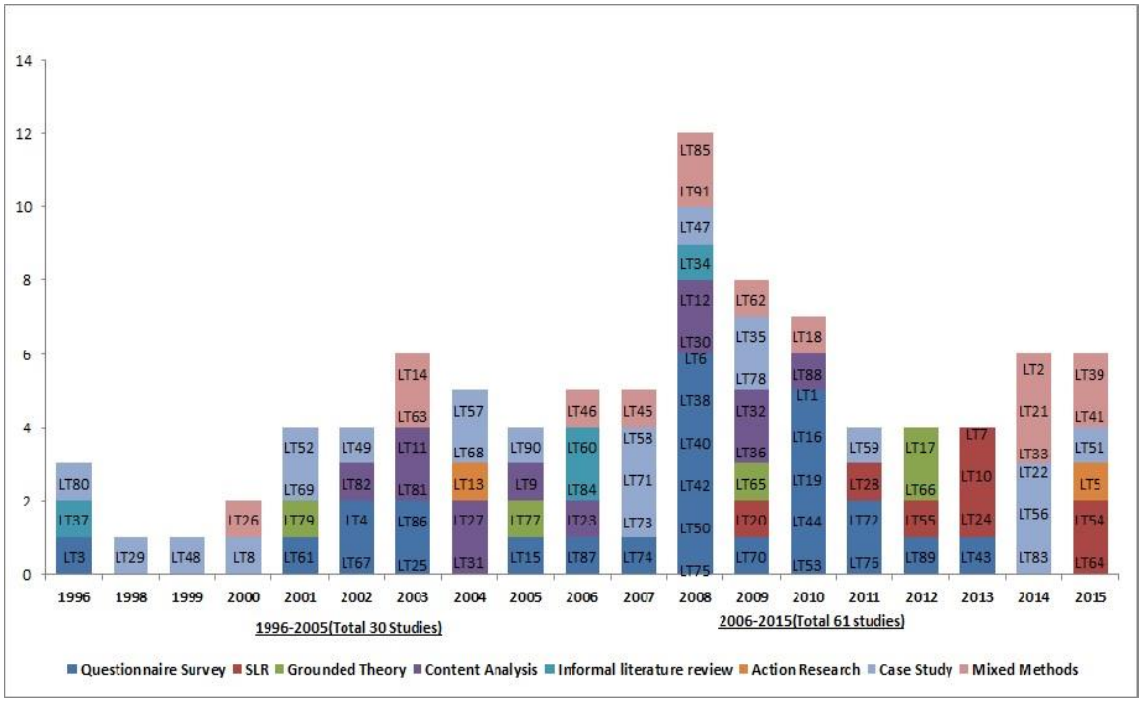


Figure 3.3 Temporal distributions of selected primary studies

3.5.3.3 Research Methods

The selected primary studies include 25 questionnaire surveys (QA), 22 case studies (CS), 13 mixed methods (MM), 12 content analysis (CA), 8 SLRs, five grounded theory (GT), four informal literature reviews (ILR) and two action research (AR). The percentage of research methods used in the selected studies are: QA (27%), CS (24%), MM (14%), CA (13%), SLR (9%), ILR (4%), GT (5%) and AR (2%) as shown in Figure 3.4.

In the first decade (1996-2005), 33% of the studies adopted case study approach and most of them have high quality score. In the second decade (2006-2015) there was dramatic increase in questionnaire survey technique. It illustrates that currently most of the research studies are adopting questionnaire survey approach to conduct empirical studies related to SPI as shown in Figure 3.4. In the selected primary studies, 27% have used questionnaire survey technique to collect the data and the second most adopted

methodology is case study which has been followed by 24% of the primary studies (Figure 3.4). The results illustrate that questionnaire survey (QA) and case study (CS) approaches are the most influential techniques adopted by the SPI researchers.

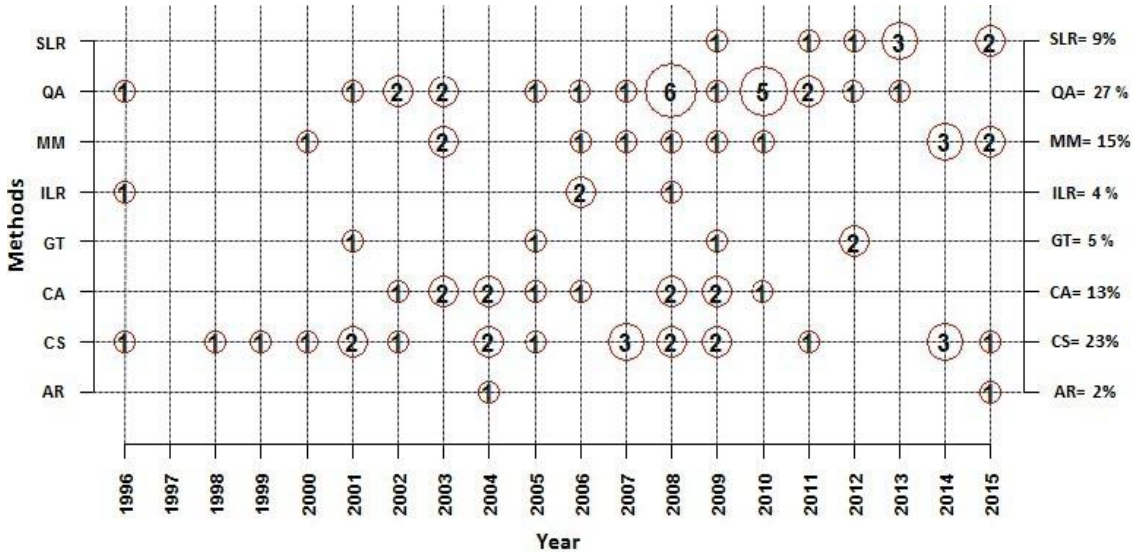


Figure 3.4 Research methods used by selected primary studies

3.5.4 Empirical data collection

Researchers have a broad selection of empirical research methods from which they can choose the most suitable one to solve their research problems. The selection of empirical research methods should be based on type of data, available resources, control over the selected approach, and the capability to operate variables of interest (Bryman, 2012).

The complete empirical research design of this study is shown in Figure 3.5, which consists of various steps involved in the selection of the targeted population and respondents, sample design, instrument development and data analysis. These steps are briefly explained in the following sections.

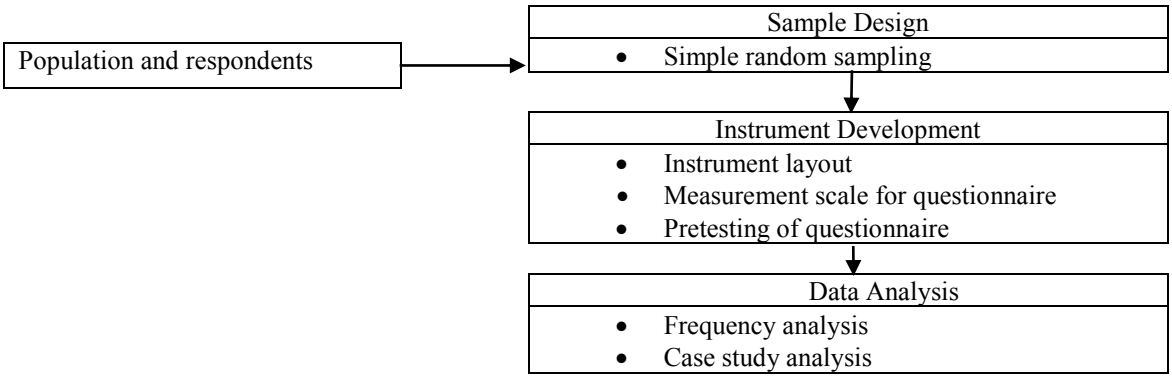


Figure 3.5 Empirical research design process

3.5.4.1 Population and Respondents

It is significant in empirical studies to explicitly identify the targeted population. Population is a set of elements about which the researchers want to make an inference (Borrego, Douglas, & Amelink, 2009). Survey research technique provides an opportunity to select the proper sample size because it is challenging to collect the data from the entire population (Borrego, Douglas, & Amelink, 2009).

Since the aim of this empirical study is to gain an understanding of factors having positive or negative impact on SPI implementation in GSD environment. As the context of this empirical study is GSD, therefore I need to collect the data from a diverse range of SPI experts engaged in GSD projects across the world.

3.5.4.2 Sampling design

Sampling is the process in which the sufficient numbers of elements are selected from the population (Sekaranm, & Bougie, 2010). Sampling method provides different techniques to collect the data from the target population. There are basically two sampling techniques; probability and non-probability sampling (Malhotra, 1996). Probability sampling can be further classified into stratified sampling, simple random sampling and cluster sampling. Similarly, non-probability sampling can be classified

into quota sampling, convenience sampling and judgment sampling (Malhotra, 1996) as shown in Figure 3.6.

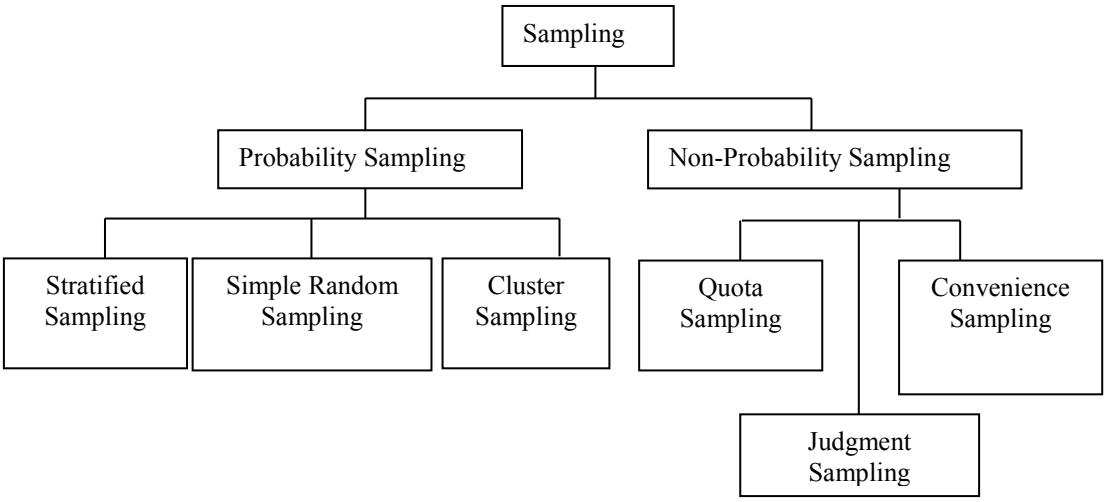


Figure 3.6 Sampling techniques

In this research simple random sampling technique is used. Generally random sampling is used when the quantitative research method is used to collect the data (Bryman, 2012). In random sampling, each variable of the target population has an equal chance of selection in the sample (Bryman, 2012). If the population is large, random sampling is the best way to obtain a proper sample of the population (Fraenkel, Wallen, & Hyum, 2011). It is a proper selection method for the listed members of the population (Lee, & Lings, 2008). As the target population of this study was large, since it consisted of a diverse range of GSD organizations, therefore the simple random sampling technique was appropriate. The proposed model for this work was intended to be applicable to all GSD organizations with regard to generalization; the simple random sample technique is mostly used in such cases.

It was not simple to approach the target population as I did not have the contact details of the experts and also did not find any online repository which has such information. Based on our experience, and discussions with research colleagues and experts at City University of Hong Kong, I decided to approach the target population using different

online sources. I have joined various online SPI- and GSD-related groups hosted by LinkedIn (www.linkedin.com) and Facebook (www.facebook.com). These groups provided an opportunity for the SPI and the GSD communities across the world to exchange views, ideas, and information related to growing trends. We also used email to contact SPI and GSD experts. Besides that, I have used an email approach to contact the SPI and GSD experts. An online request was posted on the social media groups, and separate emails were sent to certain experts to invite them to participate.

I have contacted 569 participants of which 111 completed the questionnaire. I have manually reviewed all responses to exclude incomplete entries. However, I did not find any incomplete responses. We have collected data from different continents and majority of the organizations were from Asia and Europe. The respondents ranged from software developers to CEOs with expertise in SPI and GSD. The complete details of the respondents are given in Appendix D.

3.5.4.3 Survey instrument development

The instrument development for data collection consists of various steps and processes to refine the final questionnaire. A closed and open ended questionnaire was developed for the survey. The following steps were followed to develop the survey instrument.

- **Instrument layout:** The development of survey instrument is an important task. Each part of the questionnaire should be developed according to the research questions and research objectives. The other important aspects of the questionnaire development are to arrange all of the questions in such a way that it becomes easy in reading and understanding for the respondents (Rea, & Parker, 2014).

The questionnaire for this research is divided into four sections i.e. A, B and C.

Section-A1 consists of the questions related to respondent's general information. In this section the questions were designed to gather information regarding respondent contact details, position and experience in SPI and GSD projects.

Section-A2 involves questions designed to gather information regarding primary business of the organization, size of the company, number of employees, type and adopted SPI models and standards.

In section-B1 a closed ended checklist of the success factors was provided to the respondents. These success factors were extracted from the literature using SLR approach. In this section the respondents were asked to specify those success factors which could positively impact SPI in GSD ranged from extremely agree to extremely disagree. This section also contains open ended questions in order to identify additional new success factors in the industry.

In section-B2 a closed ended checklist of barriers was provided to the respondents and they were asked to specify barriers which could negatively impact SPI activities in GSD ranged from extremely agree to extremely disagree. I have also added an open ended text box to identify additional new barriers in the industry.

Section-C1 involves practices to address the identified critical success factors discussed in section B1. Total six success factors were ranked as critical and a checklist of different practices were provided for each factor. The respondents were asked to rank each practice for the specific critical success factor, ranged from extremely agree to extremely disagree.

Section-C2 is a last part of the survey instrument. In this section a checklist of practices was provided to the experts in order to rank each practice for the identified critical

barriers. Total five barriers were identified as the most critical barriers and different practices discussed for each barrier.

- **Measurement scale for questionnaire:** I have selected seven-point Likert scale for the survey instrument. Researchers have mentioned various reasons for using the seven-point Likert scale. The disadvantage of the neutral against the seven-point Likert scale is a "myth" and most of the researchers believe that it is desirable (Finstad, 2010). Moreover, it is understandable that respondents might have a neutral opinion regarding a statement or specific subject (Rea, & Parker, 2012). The unavailability of neutral answers in survey questionnaires would compel the respondents to select either a positive or a negative option in response to each question, which can induce bias in the results. Seven-point Likert scale gives more accurate measures of respondent's true evaluation (Finstad, 2010). The seven-point Likert scale is more suitable for online survey data collection (Finstad, 2010). The survey questionnaire sample is exhibited in Appendix E.

- **Pretesting of questionnaire:** It is important to pretest the survey instrument in order to assess the validity of its content by measuring the significant variables (Willis, Royston, & Bercini, 2006). Pretesting can be categorized into four different stages i.e. content validity, questionnaire readability, pilot study and final review as shown in Figure 3.7 (Dillman, 2007).

Content validity: The content validity of the survey instrument is important in order to assess the validity of its content by measuring the significant variables (Rea, & Parker, 2012). In this study, the content analysis was conducted with the five experts in the field of empirical software engineering at the Department of Computer Science, City

University of Hong Kong. The following questions were asked from the reviewers (Dillman, 2007).

- Is the variables of interest properly presented?
- Does the survey content consist of any ambiguous items?
- Does the survey instrument have proper measurement scale?

The participants have reviewed the key variables, terms and the measurement scale. The reviewers suggested of updating the measurement scale to seven-point Likert instead of five. They have mentioned that seven-point measurement scale give more accurate results and suitable for online questionnaire surveys. After this review all of the suggested changes were made in the survey questionnaire.

Questionnaire readability: Different experts were selected in order to check the wording and the clarity of elements and variables discussed in the questionnaire. These experts included researcher co-supervisor, associate professor of Software Engineering at the Information and Computer Science Department, King Fahd University of Petroleum and Minerals, Saudi Arabia, a researcher's supervisor who is an expert in empirical software engineering and two doctoral students working in the software engineering research group, City university of Hong Kong. The following questions were asked from the experts (Dillman, 2007).

- Are the survey questions properly understood?
- Can the survey respondents properly interpret the survey questions?
- Can the survey respondents read and answer the survey questions?
- Is the survey instrument structured professionally?

After assessment from the experts, all their comments and suggestions were noted and modified the questionnaire accordingly.

Pilot study: A pilot study is a trial study that is carried out before a research design is finalized to assist in defining the research questions or to test the feasibility, reliability and validity of the proposed study design (Bernard, 2011). It is a small scale study conducted to test the plan and method of a research study (Thabane et al., 2010). Pilot study was carried out to check and revise the instrument items' reliability and precision from the respondent's point of view. The instrument was distributed among PhD students working in software engineering research group at City university of Hong Kong.

At this stage I have checked the following information (Rea, & Parker, 2012):

- Responses were checked whether the answers are uniformly distributed among the respondents.
- Each response was evaluated to check any question that has been missed by the respondents.
- The instrument was evaluated in subjects that could harm the response rate.
- Correlation analysis was performed in order to check the multi-collinearity.

The results of the pilot studies assist to improve the quality of the survey instrument (Dillman, 2007). I have modified the survey instrument based on the comments and suggestions reported during the pilot study. The summarized comments are given below.

- Most of the comments were related to the design of the instrument and the respondents suggested designing the questionnaire in the tabular form for more clarity and interest.
- The second most was respondent's complaint about the length of some questions.

- The regression analysis test was employed between the proposed variables and factors. While the sample size in the pilot study was small, the correlation achieved with each other and overall alpha (correlation) was 0.83.

Based on the pilot study feedback, the instrument has been modified and redesigned for more clarity and appropriateness.

Final review: The survey instrument was finalised based on the final review of my supervisor and co-supervisor. The survey questionnaire was finalised after a final review feedback and minor corrections were made in the instrument for the final version.

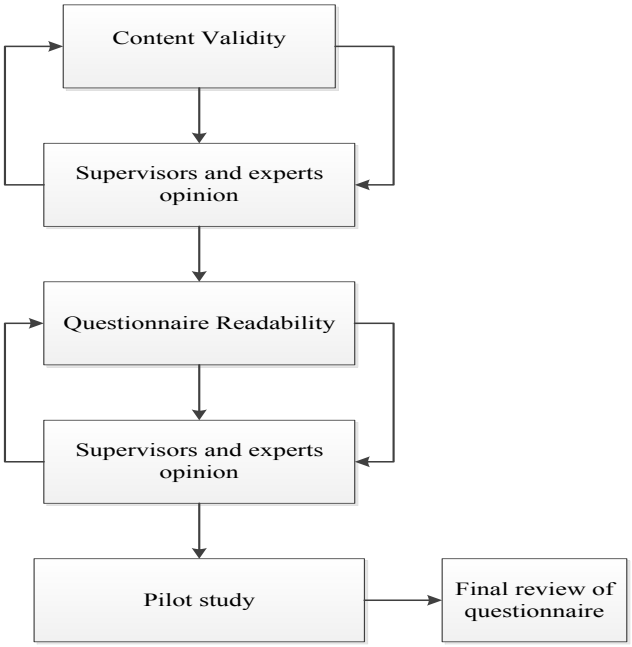


Figure 3.7 Pretesting of Survey Instrument

3.6 Data analysis

The researcher used the following research methods to analyse the collected data.

3.6.1 Frequency Analysis

Frequency analysis shows the number of observations for each variable. Frequency analysis is useful within groups of variables or across them (Khan, 2011). It can be used to analyze nominal, ordinal, and numerical data (Khan, 2011, Ali, & Khan, 2016). In this research, both the SLR and survey questionnaire data were analyzed using frequency analysis because it is helpful in analyzing descriptive information (Khan, 2011). I have followed the frequency analysis in order to calculate the occurrences and comparative analysis of each success factor and barrier. The comparative analysis of the identified success factors calculated the relative importance of each factor. Similarly, the comparative analysis of the identified barriers highlighted the relative importance of each barrier.

Coding is used to change qualitative data into quantitative data for analysis purposes (Seaman, 1999; Khan, 2011; Niazi, 2004). In this research, the data collected using an SLR and survey questionnaires are categorised using coding technique in order to perform frequency and comparative analysis of the identified success factors and barriers. I have calculated the frequency of each factor identified using SLR process. To compute the relative significance of a specific factor in a number of papers, I have compared the frequency of that specific factor against different other factors in the same number of papers. For example, if a factor has frequency 46 out of 91 then it's have 50% importance as compared to other factors. I followed this frequency analysis approach to rank all of the identified factors. In the same way, I have calculated the frequencies of the identified factors in all the collected survey questionnaires. I have performed comparative analysis for each factor by comparing the frequency of a specific factor in all the survey questionnaires against the frequencies of other factors in

the same number of survey questionnaires (Niazi, 2004; Khan, 2011; Ali, & Khan, 2016). The same approaches of frequency analysis and coding are used by different other researchers for the same nature of the data (Khan, 2011; Niazi, 2004; Ali, & Khan, 2016).

3.6.2 Case study for SPIIMM evaluation

Case study approach was adopted in order to evaluate the proposed model (SPIIMM), since it is considered the most influential evaluation technique (Yin, 2009). Total three case studies were conducted in three different GSD organizations to evaluate SPIIMM (see chapter 6). A feedback session was also conducted with the participants of the case studies to get feedback regarding the functionality of the SPIIMM.

The following criteria were developed in order to obtain the feedback of the participants:

- Ease of use
- User satisfaction
- Structure of SPIIMM

The above criteria can be used to assess and measure the quality and effectiveness of products, and can help explore areas featuring defects (Khan, 2011).

These criteria were based on the studies conducted by different other researchers in different other domains (Khan et al., 2011; Khan, 2011; Niazi, 2004; Niazi et al., 2004; Niazi, Wilson, & Zowghi, 2005; Khan, 2015; Ali, & Khan, 2016).

3.7 Threats to Validity with research methodologies

3.7.1 Threats to validity (SLR)

There are several limitations to the systematic literature review studies. One possible limitation is that most of the SLR data were collected by an author of this research study

and due to the numerous number of research articles on SPI and GSD, this research study may have missed some relevant articles. However, this is not a systematic omission like other researchers of SLR (Khan, & Khan, 2013).

For the selected primary studies, the possible limitation is that their reported success factors and barriers might not have assuredly reported the primary reason. It is challenging for me to alleviate this threat. In the selected research articles, the authors have not discussed the basic reasons why the success factors and barriers were considered.

I have performed Inter-rater reliability analysis during both the initial and final selection phases of SLR to neutralize the inter-person bias and to enhance the review process. However, it was not possible to review all the selected 91 primary studies by the independent reviewers.

3.7.2 Threats to Validity (Empirical Study)

In this research work I have explored the views and opinions of experts regarding SPI implementation in GSD organizations. I was not able to directly verify the views and opinions of the experts. It means that the feedback from experts regarding the factors may not necessarily be authentic.

Construct validity represents whether or not the measurement scales denote the attributes being measured. The factors considered in this study were obtained from an extensive body of literature reported in (Babar, & Niazi, 2008; Niazi, Babar, & Verner, 2010; Niazi, 2015) and discussion with the SPI practitioners. The feedback from practitioners demonstrates that all the selected factors were related to their work. Internal validity refers to the overall evaluation of the results. The outcomes of the pilot study provided an acceptable level of internal validity as the factors considered in this

research work were obtained from detailed literature review and piloting of questions. External validity refers to the generalization of the outcomes for all other domains (Regnell, Runeson, & Thelin, 2000). In this study, I was not able to generalize our study outcomes as most of the respondents were from Asian countries. We cannot claim that all the respondents from the selected countries would agree with them, but we are certain that they provided a representative sample.

In this survey questionnaire, the experts were provided close ended questions in order to rank the identified success factors and barriers along their practices. The close ended questions limit the survey respondents to only those success factors, barriers and practices that are provided in the list. I tried to eliminate this problem by providing an open ended text box to the respondents in order to mention additional factors besides the reported factors. However, like other researchers (Baddoo, & Hall, 2002; Beecham, Hall, & Rainer, 2003; Niazi, Wilson, & Zowghi, 2006, Khan, 2011), I have confidence on the collected responses because the experts working in diverse roles, responsibilities and directly involved in SPI and GSD activities.

3.8 Summary

This chapter presented detailed research methods, which have been described briefly. This chapter contained the comprehensive overview of the SLR method. In an SLR, the phases of planning the review, conducting the review and reporting the review were discussed. For empirical research method, a brief research design was discussed with their conceptual references stated where applicable. In addition, the reasons for choosing target population, sampling, instrument development and its pre-testing, data collection approach, collection questionnaire and a brief method for data analysis were

explained in detail. At the end the limitations of the selected research methodologies were reported.

CHAPTER 4: SLR AND EMPIRICAL STUDY RESULTS

4.1 Overview

This study consists of results obtained using SLR and empirical study conducted using survey questionnaire approach. The aim of this study is to present success factors, barriers, their practices and also discussed the most Critical Success Factors and Critical Barriers (CBs). The CSFs and CBs presents some of the key areas related to SPI implementation and the understanding of CSFs and CBs could assist GSD organizations to successfully execute SPI activities.

The ultimate aim of this research study is to develop a software process improvement implementation and management model (Chapter 5).

This chapter is organised as follows:

- In Section 4.2, the success factors identified using an SLR and survey study is discussed.
- In Section 4.3, the barriers identified using an SLR and survey study is discussed.
- In Section 4.4 the practices of CSFs and CBs are reported.
- Sections 4.5 consist of the results and analysis of the identified success factors and barriers discussed in various aspects.

- The summary of the chapter is given in section 4.6.

4.2 Identified success factors using SLR and survey questionnaire

This section consists of success factors identified using SLR and survey approaches. The results presented in this section have addressed the following research questions of this study.

RQ1. What are the factors, as identified in the literature, do GSD organizations need to address in order to have a positive impact on SPI implementation?

RQ3. What are the factors, as identified in the real practice, do GSD organizations need to address in order to have a positive impact on SPI implementation?

RQ5. Are there differences between the success factors identified in the literature and real practice?

4.2.1 Success factors identified using SLR

In order to address the RQ1, Figure 4.1 and Table 4.1 shows a list of the success factors identified using SLR approach. The identified factors were extracted from the list of 91 selected primary studies. The most frequently occurred success factors were selected with the original wording and the others were paraphrased in order to decrease the similarity index of the factors. For example SF1: management commitment and SF2: allocation resources were reported as discussed in the literature. Similarly, some of the factors were paraphrased, for example, SF16: SPI consultancy, SF21: process improvement standards and procedures and SF19: strong relationship between team members.

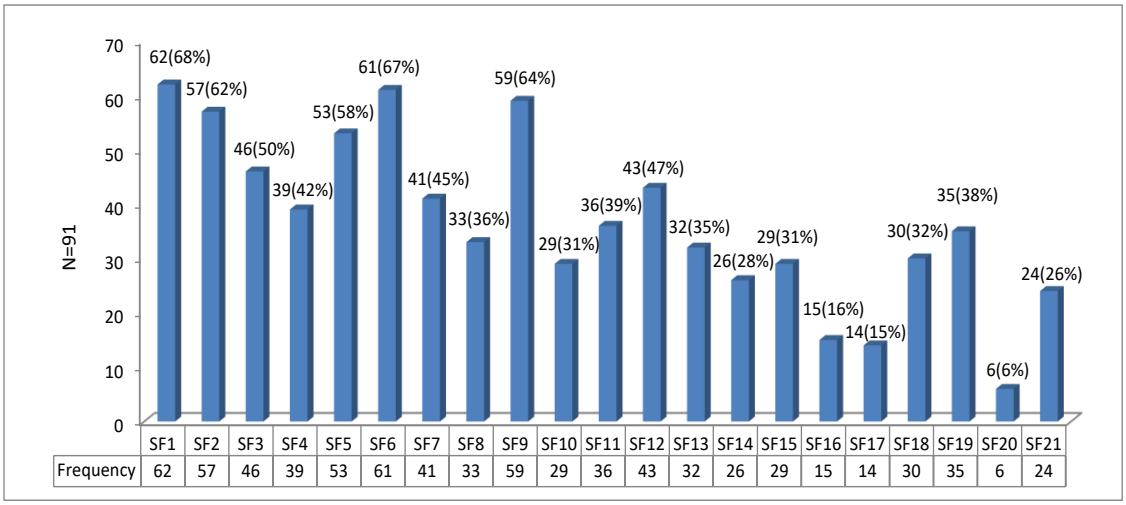


Figure 4.1 Identified success factors using SLR

In Figure 4.1, (N = 91) is the total number of articles selected for the primary study and these articles are cited in Appendix B. Each of the selected primary study labelled as [LT], which aims to present the primary studies of SLR as the "Literature Review" articles, as shown in Appendix B.

Table 4.1 Success factors identified through literature

S.No	Identified success factors	Rank	S.No	Identified success factors	Rank
SF1	Management commitment	1	SF12	Process improvement leadership	7
SF2	Staff involvement	4	SF13	Organizational culture	13
SF3	Project pilot implementation	6	SF14	Organizational infrastructure	16
SF4	Information sharing	9	SF15	Overseas site's response	15
SF5	Process improvement expertise	5	SF16	SPI consultancy	18
SF6	Allocation of resources	2	SF17	Joint management infrastructure	19
SF7	Process improvement awareness	8	SF18	Setting process improvement goals	14
SF8	Skilled human resources	12	SF19	Strong relationship between team members	11
SF9	3C's (communication, coordination and control)	3	SF20	Process improvement evaluation	20
SF10	Mutual understanding between team members	15	SF21	Process improvement standards and procedures	17
SF11	Continuous organizational support	10			

Among the identified twenty one success factors' 'SF1: management commitment' (68%) is the most common success factor for process improvement implementation as

shown in Figure 4.1. According to (Sulyman et al., LT2), management commitment is the extent to which the higher and lower level management in an organisation support, finance, realise and participate in SPI program. Sulyman et al. [LT2] identified management commitment as a positive influential factor for SPI implementation. Ramasubbu, [LT5] emphasised on the commitment and participation of organisational management in SPI implementation activities. He mentioned that management should evaluate and track the contribution of GSD team members in process improvement activities. Herbsleb and Dennis [LT3] conducted a survey in 56 software development companies. They argued that some organisations were successful and others were not and have stated that respondents from organisations with effective SPI efforts inclined to agree that managers actively monitor the SPI program and they allocate sufficient resources for SPI implementation. Rainer and Hall [LT4] conducted a study and highlighted that management commitment has been considered as one of the most significant human factors.

About (67%) of the articles cited 'SF6: allocation of resources' as the second most success factor for SPI implementation. According to (Sulyman et al., LT2), allocated resources are the dedication of time and resources to process improvement implementation. Along the same lines, any SPI program requires staff, documentation, time, planning, tools and budget investment (Emam, & Koru, LT6). Khan, Niazi and Ahmad [LT1] conducted an empirical study in offshore outsourcing organizations and acknowledged that organizations must commit their resources for the effective execution of development activities in GSD environment. According to (Niazi, Babar, & Verner, LT16), the organization should brief the managers towards the allocation of all the required resources in order to achieve long-term SPI benefits.

'SF9: 3C's (communication, coordination and control)' was mentioned by (64%) of the selected primary studies as a success factor for SPI implementation. Khan et al. [LT43] define 3Cs as the process of knowledge transmission between the distributed team members and the mode of transfer they adopt to enhance this interaction. Effective communication channels are claimed to assist process improvement (Oza et al., LT46). Effective communication alleviates any noise, persuades team members of the necessity of process change and lessens their resistance to change (Oza et al., LT46). Coordination refers to the contribution of different people working together on a task for a specific goal (Khan et al., LT43). Coordination makes team members interdependent on each other. If the team members are working on the same project, but in different directions than they are lacking of coordination (Taweel et al., LT35). Control refers to "the process of adhering to goals, policies, standards or quality levels" (Khan et al., LT43). The Control manages the basic structures needed for SPI implementation i.e. on time, in budget and desired quality software development. Control and coordination are correlated with each other and both of them depend on communication (Conchúir et al., LT36). The way of coordination between the team members sets control of their development activities.

The findings of this study also show that 'SF2: staff involvement' (62%) is the fourth most common factor among the reported success factors. It is the degree to which employees of the organization owns, trust, acquire, perform and believe the SPI program (Sulyman et al., LT2). Ramasubbu [LT5] conducted a study in GSD industry and highlighted that without the interest of staff members the implementation of SPI program is impractical. He shed light that the staff involvement in SPI activities reduces the resistance for the deployment of new processes. Emam and Koru [LT6] conducted a survey in various organizations and concluded that coordination, commitment and

collaboration among SPI team members are important for successful process improvement program. Bayona et al. [LT21] highlight that staff involvement during the process definition of SPI programs is important to make them feel part of the program.

Success factor 'SF5: process improvement expertise' yielded 58% occurrence from the selected articles. Bayona et al. [LT21] define SPI expertise as the extent to which individuals can achieve specific SPI goals. Process improvement expertise denotes to the process improvement's understanding and knowledge. According to (Rainer, & Hall, LT14), the success of SPI implementation program depends on the expertise of team members. More specifically, if the management staff of SPI program has appropriate process improvement knowledge and awareness, then there is more chance of process improvement success and adoption in the best practice of domain (Bayona, Manzano, & Feliu, LT24). Otherwise, the deployment of the process improvement program may end with the failure and frustration (Bayona et al., LT21).

'SF3: project pilot implementation' was quoted in the (50%) of the selected primary studies. Pilot implementation includes both development and testing of the selected frameworks and models for implementation of process improvement programs. The pilot implementation of SPI program is necessary to evaluate how successful a given SPI program would be in a particular department. The results of pilot implementation can assist the SPI teams to estimate the resources and workforce required to implement the process improvement program across other departments of the firm (Niazi, Wilson, & Zowghi, LT11).

SLR results exhibit that 'SF12: Process improvement leadership' (47%) is cited as the important success factor. Hall et al. [LT30] reported in their empirical study that most of the respondents highlighted the importance of the managers' leadership. They specified that the leadership of SPI team is vital for the successful execution of the SPI program.

The management should have the ability to direct and encourage team members to achieve the specific goals (Bayona et al, LT21). If the process manager has good awareness and adequate skills, there is increased possibility of SPI success and acceptance in the best practice of domain (Bayona et al., LT21). Otherwise, the SPI program might finish with the frustration and failure or no change and is not capable to meet the actual aims of the business (Rainer and Hall, LT4).

The findings of this study revealed that 'SF7: process improvement awareness' (45%) is an important module for SPI implementation. Sulayman et al. [LT2] defined SPI awareness as the degree to which the top management takes the initiatives of SPI certification and provide team members with training opportunities. SPI awareness denotes to the process improvement's understanding and knowledge. (Kautz, & Nielsen, LT8) and (Sulayman, & Mendes, LT19) shed light that SPI awareness has significant influence on SPI implementation. It is because of the costly as well as a long-term strategy of SPI and it takes time to achieve the actual benefits of SPI program. The deployment of SPI program is the practice of implementation of new processes in an organization. It is necessary to conduct awareness sessions for the team members in order to deliver them adequate information regarding SPI (Niazi, Wilson, & Zowghi, LT9).

'SF4: information sharing' was mentioned in (42%) of the selected studies as a success factor. Information sharing is the extent to which SPI team members collaborate and share the information to participate in the SPI activities (Sulayman et al., LT2). Niazi, Wilson, and Zowghi [LT9] conducted an empirical study to investigate the relationship between success factors, barriers and SPI implementation. Respondents from the organizations with effective SPI attempts inclined to agree that the information sharing among the team members is crucial to the successful SPI program. In the absence of the

strong relationship, the GSD team members will not be able to share the required information properly (Ramasubbu, LT5). In the GSD environment, the SPI team members should show strong commitment towards information sharing in order to attain successful planning, coordination and knowledge integration (Ramasubbu, LT5). Team members can appropriately manage the SPI implementation activities based on the knowledge exchange, information partnership and information management (Khan, & Khan, LT7).

Nearly a quarter of the articles cited 'SF11: continuous organizational support' as a success factor. Top management should show strong commitment towards the continuous support in the sense of the provision of resources, qualified team members and technological infrastructure as both a well-defined infrastructure, and a stable environment is required for the effective implementation of process improvement activities (Bayona et al., LT21).

The SLR results show that 'SF19: strong relationship between team members' (38%) is an essential factor to successfully deploy the SPI process. It is the extent to which the SPI team members could effectively communicate and collaborate to implement the SPI program (Niazi et al., LT31). According to (Ramasubbu, LT5), strong relationship among the distributed teams could help the team members to define new SPI policies, procedures and enhance the existing. Richardson et al. [LT18] concluded that not only managing staff, but also a lower level staff should have complete understanding of the factor 'strong relationship between team members'. Niazi, Babar and Verner [LT16] mentioned that without support and trust, the distributed process improvement teams might not be able to complete the SPI tasks within budget and time. Top management should encourage the distributed team members towards belief and willingness to participate in associated SPI activities (Ramasubbu, LT5). Moreover, it leads towards

team coordination, decision making, risk management and satisfaction (Khan, & Khan, LT7).

The results reveal that success factor 'SF8: skilled human resources' (36%) can play a significant role in SPI implementation program. Various researchers have discussed the significance of skilled humans for SPI activities. Khan, Niazi and Ahmad [LT1] emphasized on the deployment of qualified workers having professional certification and experience in the field of computer science, management and other related fields. They consider the skilled staff as the backbone of the GSD industry.

The findings indicate that 'SF13: organizational culture' was mentioned in (35%) of the studies. According to (Khan et al., LT43), organizational culture is widely affected by the discussions of the different people on certain issues and their reaction. It is vital to understand the organizational norms and values before the initiation of the SPI program. Cultural difference should be considered when the organization shows an intention towards the initiation of SPI implementation (Khan et al., LT43).

'SF18: setting process improvement goals' (32%) was cited as a success factor that could positively impact the implementation of SPI program. Sulayman et al. [LT2] define 'setting process improvement goals' as the degree to which everyone can make the translation from leading management goals towards the goals that everyone has been asked to achieve. Setting relevant goals stands for the efforts required to contribute to the successful implementation of the SPI programs (Bunditwongrat, Mathupayas, & Atcharawan, LT76). To set realistic goals means that they may be achieved in the foreseeable future with a reasonable amount of resources. As the implementation of SPI program is expensive and spreads over time, it is important to clearly define the SPI goals and objectives in order to successfully execute the process improvement activities (Babar, & Niazi, LT75).

Mutual understanding between team members, overseas site's response, organizational infrastructure, process improvement standards and procedures, SPI consultancy, joint management Infrastructure and process improvement evaluation were also cited as the success factors that have positive impact on process improvement activities.

4.2.2 Success factors identified using survey questionnaire

In order to address RQ3, Table 4.2 shows the list of success factors identified during empirical study conducted in GSD organizations. Total 111 responses were collected from a total of 23 countries.

Table 4.2 is divided into three main categories of 'Positive' (Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA)), 'Negative' (Extremely Disagree (ED), Moderately Disagree (MD), Slightly Disagree (SD)) and 'Neutral' (NS). The positive category from the table presents the percentage of the respondents who agree with the success factors identified using SLR technique. The negative category shows the percentage of those respondents who consider that the identified success factors might not be effective for SPI implementation in the context of GSD. In the neutral category, I have mentioned the percentage of those respondents who were not sure about the ranking of the identified factors.

The results shown in Table 4.2 exhibit that all the factors have a frequency greater than 50% and success factor 'SF1: management commitment' is the most common factor in the positive list i.e. 96%. Success factors 'SF12: process improvement leadership (94%)' and 'SF20: process improvement evaluation (94%)' are the second most common success factors highlighted by the experts. 'SF18: setting process improvement goals (93%)' is the 3rd most important factor in the positive list of the responses.

Other common factors are 'SF5: process improvement expertise (92%)', 'SF7: process improvement awareness (91%)', 'SF8: skilled human resources (91%)', 'SF11: continuous organizational support (91%)', 'SF6: allocation of resources (90%)', 'SF9: 3C (communication, coordination and control (90%)' and 'SF2: staff involvement (88%)'.

Table 4.2 Success factors identified through a survey questionnaire

S. No	Success Factors	Experts Opinion (N=111)									
		+Ve				-Ve				Neutral	
		EA	MA	SA	%	ED	MD	SD	%	NU	%
SF1	Management commitment	61	37	9	96	0	1	1	2	2	2
SF2	Staff involvement	30	47	21	88	0	3	1	4	9	8
SF3	Project pilot implementation	31	42	20	84	0	2	6	7	10	9
SF4	Information sharing	41	41	11	84	0	3	4	6	5	4
SF5	Process improvement expertise	38	50	14	92	0	0	3	3	6	5
SF6	Allocation of resources	44	39	17	90	1	3	2	5	5	4
SF7	Process improvement awareness	40	44	17	91	0	0	3	3	7	6
SF8	Skilled human resources	29	46	26	91	1	1	2	3	6	5
SF9	3C (communication, coordination and control)	54	28	18	90	0	1	1	2	9	8
SF10	Mutual understanding between team members	34	41	17	82	0	3	5	7	11	10
SF11	Continuous organizational support	51	40	11	91	0	2	2	3	5	4
SF12	Process improvement leadership	53	37	15	94	0	1	1	2	4	3
SF13	Organizational culture	28	42	10	72	3	10	9	20	9	8
SF14	Organizational infrastructure	18	42	31	81	1	2	5	7	12	10
SF15	Overseas site's response	17	31	37	76	2	2	2	5	20	18
SF16	SPI consultancy	17	39	20	68	0	4	7	10	24	22
SF17	Joint management infrastructure	18	36	11	58	3	20	3	23	20	18
SF18	Setting process improvement goals	54	35	14	93	0	2	1	3	4	4
SF19	Strong relationship between team members	38	47	10	85	5	4	3	11	7	6
SF20	Process improvement evaluation	32	47	25	94	1	0	3	3	3	2
SF21	Process improvement standards and procedures	38	31	22	82	3	0	3	5	14	12

In the negative list of the responses, 'SF17: joint management infrastructure (23%)' is the most common factor as shown in Table 4.2. It shows that 23% of the survey

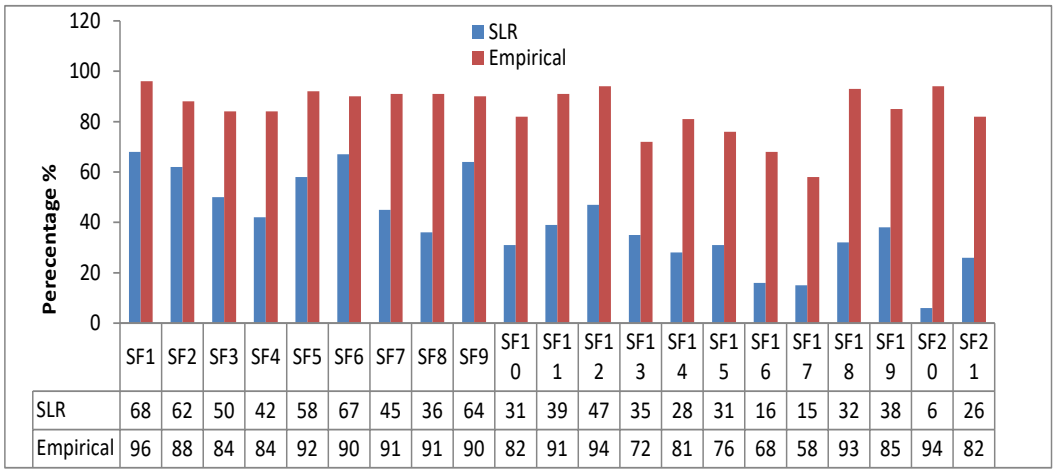
respondents declined ‘SF17: joint management infrastructure’ as the success factor for SPI implementation. Other common factors discussed in the negative category are ‘SF13: organizational culture (20%)’ and ‘SF19: strong relationship between team members (11%)’. These results suggest that practitioners should not consider these factors as success factors of SPI.

In the neutral category of the factors, ‘SF16: SPI consultancy (22%)’ is the most significant factor which demonstrates that 22% of the experts are not completely sure about the role of the factor ‘SF16: SPI consultancy’. Second most significant factors in the neutral category are ‘SF15: overseas site's response (18%)’ and ‘SF17: joint management infrastructure (18%)’.

In this empirical study, I have identified one new success factor i.e. ‘shared cyber space’ which has not been identified in literature during the SLR study.

4.2.3 Comparison of success factors identified using SLR and survey questionnaire

In order to address RQ5, I have discussed the comparison of the results of both SLR and empirical studies as shown in Figure 4.2.



	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12	SF13	SF14	SF15	SF16	SF17	SF18	SF19	SF20	SF21
SLR	68	62	50	42	58	67	45	36	64	31	39	47	35	28	31	16	15	32	38	6	26
Empirical	96	88	84	84	92	90	91	91	90	82	91	94	72	81	76	68	58	93	85	94	82

Figure4.2 Percentage wise comparisons of success factors identified using SLR and survey questionnaire

The aim of this comparison is to understand the similarities and differences between the two data sets. Table 4.3 demonstrates summary of all the factors identified in SLR and questionnaire based on their average ranks. I have also performed an independent t-test to evaluate the mean difference of the ranks of both SLR and empirical study as shown in Table 4.4 and Table 4.5.

Table 4.3 Comparison of success factors across SLR and empirical study

S. No	Success Factors	Occurrence in SLR (n=91)		Positive occurrence in survey (n=111)		Average Rank
		%	Rank	%	Rank	
SF1	Management commitment	68	1	96	1	1
SF2	Staff involvement	62	4	88	7	6
SF3	Project pilot implementation	50	6	84	9	8
SF4	Information sharing	42	9	84	9	9
SF5	Process improvement expertise	58	5	92	4	5
SF6	Allocation of resources	67	2	90	6	4
SF7	Process improvement awareness	45	8	91	5	7
SF8	Skilled human resources	36	12	91	5	9
SF9	3C (communication, coordination and control)	64	3	90	6	5
SF10	Mutual understanding between team members	31	15	82	10	13
SF11	Continuous organizational support	39	10	91	5	8
SF12	Process improvement leadership	47	7	94	2	5
SF13	Organizational culture	35	13	72	13	13
SF14	Organizational infrastructure	28	16	81	11	14
SF15	Overseas site's response	31	15	76	12	14
SF16	SPI consultancy	16	18	68	14	16
SF17	Joint management infrastructure	15	19	58	15	17
SF18	Setting process improvement goals	32	14	93	3	9
SF19	Strong relationship between team members	38	11	85	8	10
SF20	Process improvement evaluation	6	20	94	2	11
SF21	Process improvement standards and procedures	26	17	82	10	14

Using Levene's Test, I have calculated the significance difference for the ranks of both SLR and empirical study. In table 4.5 it is shown that the results of t-test are ($t=2.36$, $p=0.01<0.05$), which demonstrates that there is a significant difference between the ranks of the success factors identified using SLR and empirical studies. For example, it is shown in Table 4.3, that success factor 'SF20: process improvement evaluation' has rank 20 in SLR but ranked 2 in the empirical study. It illustrates that 'SF20: process improvement evaluation' got more attention from practitioners as compared to the

available literature. Similarly, different other factors i.e., (SF18: setting process improvement goals, SF8: skilled human resources and SF21: process improvement standards and procedures) have much variation in their ranks for both SLR and empirical study. They got high ranking in one type of study, but low consideration in the other type.

Table 4.4 Group Statistics for success factors

	Group	N	Mean	Std. Deviation	Std. Error Mean
Rank	SLR	21	10.714	5.849	1.276
	Survey	21	7.142	3.718	0.811

Table 4.5 Independent Sample t-test for success factors

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2 tailed)	MD	SD	95% Confidence Interval of the Difference	
									LW	UP
Rank	Equal variances assumed	6.05	0.01	2.36	40	0.02	3.57	1.51	0.51	6.62
	Equal variances not assumed			2.36	33.89	0.02	3.57	1.51	0.49	6.64
UP=Upper, LW=Lower, MD=Mean Difference, SD= Std. Error Difference										

Besides independent t-test analysis, I have performed the correlation data analysis test using Spearman's rank-order correlation in order to evaluate the significance of the similarity among the success factors identified using SLR and survey study. In Table 4.6, it's shown that Spearman's correlation coefficient is 0.474, whereas p=0.030. The correlation coefficient (0.474) is showing a positive correlation among the ranks obtained from the SLR and empirical data. The significance value p (0.030)

demonstrates that Spearman's rank-order correlation is statistically significant. These results are also depicted in the scatter plot, as shown in Figure 4.3.

Table 4.6 Correlation of success factors ranks across SLR and empirical studies

			SLR_Rank	Empr_Rank
Spearman's rho	SLR_Rank	Correlation Coefficient	1.000	.474*
		Sig. (2-tailed)	.	.030
		N	21	21
	Empr_Rank	Correlation Coefficient	.474*	1.000
		Sig. (2-tailed)	.030	.
		N	21	21

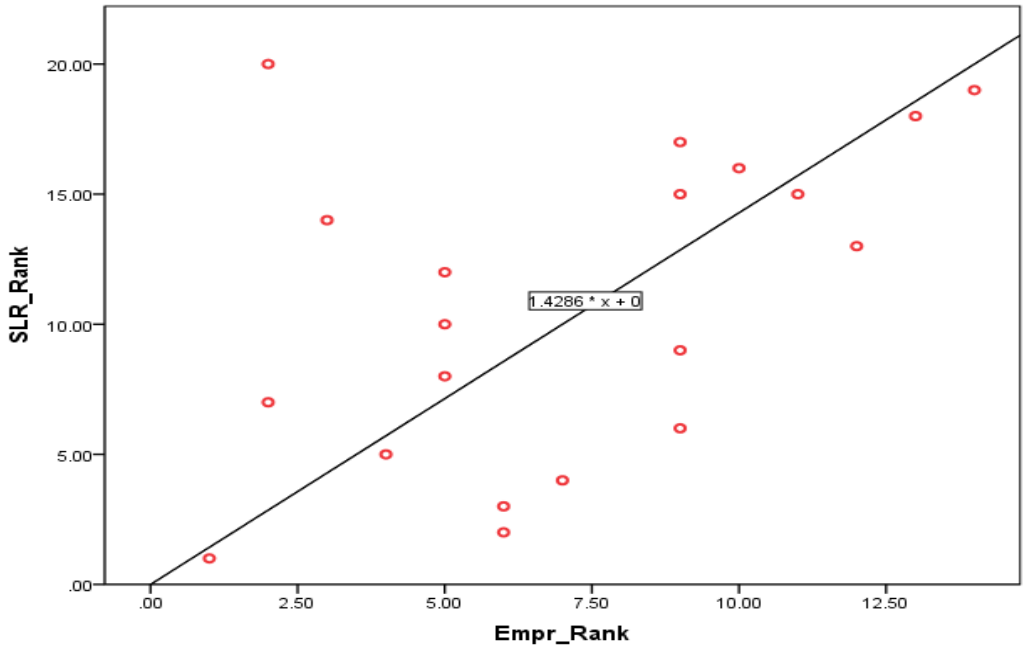


Figure 4.3 Scatterplot of the success factors ranks obtained from SLR and Empirical study

4.2.4 Critical success factors identified using both SLR and survey questionnaire

The concept of critical factors was introduced by (Rockart, 1979) in order to identify the information needs of chief executive. The concept of critical factors is based on the

concept of factors discussed in the literature of management (Daniel, 1961). (Niazi, 2004) highlighted the concept of critical factors as the key areas where the organizational management must focus to achieve specific business goals. The limited attention given to those key areas can undermine the performance of the business (Khan, & Jacky, 2016). Critical factors may differ from person to person as it depends on the position of individual's hold in an organization. It also depends on the geographical regions of the managers and may change with the passage of time (Khandelwal, & Ferguson, 1999; Rockart, 1979).

I have followed the following criteria in order to conclude the criticality of a specific factor:

- If a factor has frequency ≥50% in both literature and empirical study then the factor is considered as a critical factor.

The same criterion of critical factors has been used by researchers in different other domains (Khan, & Keung, 2016; Khan et al., 2017; Ang, & Slaughter, 1998; Khan, & Khan, 2013; Bryson, & Sullivan, 2003; Khan, 2011). The criterion has been used to conclude the most critical success factors (CSFs) and critical barriers (CBs) for SPI implementation regardless of significant difference between the two data sets (i.e. SLR and questionnaire survey). The aim of the CSFs and CBs is to develop the factors component of the proposed model SPIIMM (Chapter 5).

By using the above criteria, the identified CSFs are: management commitment, staff involvement, project pilot implementation, process improvement expertise, allocation of resources and 3C (communication, coordination and control). The identified CSFs have frequency ≥50% in both data sets (SLR, empirical study).

4.3 Identified barriers using SLR and survey questionnaire

This section provides a brief understanding of the barriers identified using SLR and empirical study conducted in GSD organizations. The results presented in this section will answer the following research questions, discussed in section 1.4 (Chapter 1).

RQ2. What are the barriers, as identified in the literature, within GSD have a negative impact on SPI implementation?

RQ4. What are the barriers, as identified in the real practice, within GSD have a negative impact on SPI implementation?

RQ6. Are there differences between the barriers identified in the literature and real practice?

4.3.1 Barriers identified using SLR

This section consists of results and analysis in order to answer RQ2. Figure 4.4 and Table 4.7 show a list of barriers extracted from existing literature using SLR approach.

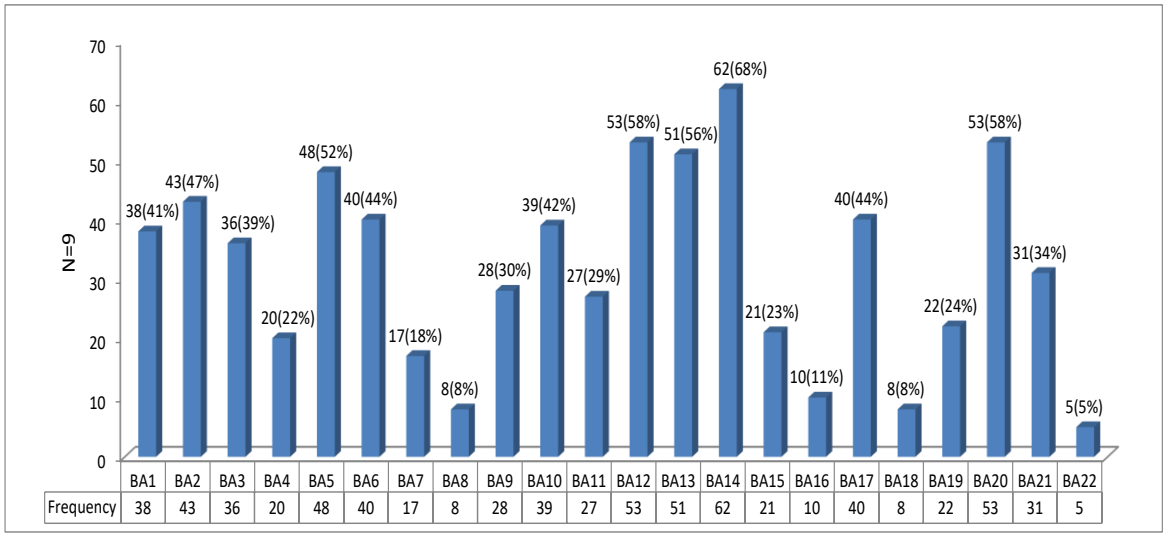


Figure 4.4 Frequency distribution of barriers identified using SLR

In Figure 4.4, (N = 91) is the total number of the articles selected during SLR study and these articles are cited in Appendix B. Total twenty two barriers were extracted from the selected SLR studies as revealed in Tables 4.7 and Figure 4.4.

Table 4.7 Identified barriers using SLR

S. No	Identified barriers	Rank	S. No	Identified barriers	Rank
BA1	Inexperienced staff	8	BA12	Lack of resources	2
BA2	Staff turnover	5	BA13	Lack of communication	3
BA3	Cultural difference	9	BA14	Lack of organizational support	1
BA4	Lack of trust	15	BA15	Temporal distance	14
BA5	Lack of process improvement knowledge	4	BA16	Poor organizational infrastructure	17
BA6	Lack of training	6	BA17	Budget constraints	6
BA7	Lack of feedback	16	BA18	Organizational changes	18
BA8	Personality clashes	18	BA19	Lack of sponsorship	13
BA9	Workload	11	BA20	Lack of formal SPI implementation methodology	2
BA10	Organizational politics	7	BA21	Lack of implementation tools and standards	10
BA11	Time pressure	12	BA22	Stalling on action Plan implementation	19

Among the 22 identified barriers, 'BA14: lack of organizational support (68%)' was found to be the most common barrier for SPI implementation as shown in Figure 4.4. According to (Sulyman et al., LT2) organizational support is the extent to which the higher and lower level management in an organization support, finance, realize and participate in SPI activities. Ramasubbu [LT5] stressed that organizational commitment and participation is crucial for SPI implementation activities. He mentioned that due to the lack of proper support, the GSD organization would not be able to actualize the SPI program. Herbsleb, & Dennis [LT3] conducted a survey with fifty-six software companies. They argued that some organizations were not so successful and respondents from these organizations shed light that organizational management did not allocate sufficient resources for SPI implementation. Niazi [LT32] tried to explain the insufficient support of the management to SPI activities. He highlighted that one of the key causes of lack of organizational support is that management staff is not aware of the significance of SPI.

The SLR results show that (58%) of the SLR studies cited 'BA12: lack of resources' as a critical barrier for SPI implementation. An empirical study conducted by (Niazi,

Wilson, & Zowghi, LT27) reported that almost three-quarters (72%) respondents believed that SPI implementation has often suffered due to lack of sufficient resources. In another article, (Niazi, Babar, & Verner, LT16) discussed the cross cultural barriers in distributed development and made it essential to assess and deliver adequate resources for SPI activities or else the organization would not be able to accomplish the desired outputs of the process improvement program. An empirical study conducted by (Kautz, & Nielsen, LT8) pointed out the fact that the team managers were uncertain to allocate resources for SPI activities using their own project budget. The organizations should have more open-minded and positive attitude towards the SPI programs and provide all the estimated resources (Niazi, Wilson, & Zowghi, LT23).

Similarly 'BA20: lack of formal SPI implementation methodology' is mentioned in (58%) of the SLR articles as a barrier that could negatively impact SPI activities. The necessity to have an SPI implementation methodology in GSD was brought forward by (Niazi, Babar, & Verner, LT16). They mentioned that formal SPI implementation methodology should consist of complete process deployment strategy, process improvement activities, tasks, and measures. Majority of the SPI practitioners working beyond the geographical boundaries believes that the lack of formal SPI implementation strategies impeded the effective execution of process improvement program (Niazi, Babar, & Verner, LT16). The reason behind is the lack of attention given to construct a proper SPI implementation methodology (Niazi, LT32; Shah, Harrold, & Sinha, LT33).

Third most cited barrier was 'BA13: lack of communication (56%)'. Agerfalk et al. [LT34] highlighted that in GSD, the distribution of development teams over various geographical boundaries made communication a vital issue. Team members working in a distributed environment are scattered and could hardly meet each other which hinder the building of trust and confidence. Various studies have addressed the lack of

communication as a critical issue in GSD. Lack of communication can lead to misinterpretation, lack of control and even communication breakdown (Taweel et al., LT35). Conchúir et al. [LT36] further claimed that the lack of face to face communication could easily lead to other barriers, such as lack of trust and lack of feedback.

The SLR results show that 'BA5: lack of process improvement knowledge' was cited in 52% of the articles as shown in Figure 4.4. Kautz and Nielsen [LT8] carried out an industrial empirical study and tried to seek the underlying reason for unsuccessful SPI implementation in that particular company: "the technical director and staff had no expertise and knowledge regarding process improvement and they have experienced various hurdles during the SPI implementation". Bayona, Manzano and Feliu [LT24] emphasized on the experience of the stakeholders and motivate the team members to have sufficient knowledge to perform SPI activities. Emam and Koru [LT6] discussed that one of the reasons for SPI failure is the lack of knowledge in the team members regarding process improvement activities.

'BA2: staff turnover' was mentioned by 47% of the selected primary studies. Due to frequent staff turnover, the cost of SPI implementation could be remarkably increased (Rainer, & Hall, LT4). Apart from the direct cost of employing a replacement, indirect cost related to the loss of core individuals, knowledge and experience also existed. Hall et al. [LT30] analysed the data collected from 89 practitioners to examine the impact of high staff turnover concerning the success of process improvement projects. They suggested that boosting motivation levels of practitioners can decrease staff turnover.

Another major barrier for SPI implementation is 'BA17: budget constraints'. This was evidenced in this study when 44% of the articles cited it as a barrier for SPI implementation. Owing to budget constraints, it would be difficult to hire process

improvement consultants; still the organizational management striving to successfully implement the process improvement program (D. Mishra, & A. Mishra, LT40). Niazi, Babar and Katugampola [LT42] highlighted that the implementation of SPI program increased pressure on small vendor organizations due to budget constraints. Small organizations might not be able to set aside a big budget for SPI activities, as they have to retain low cost in order to compete with in the market.

More than 40% of SLR articles identified 'BA10: organizational politics' as a major barrier for process improvement implementation as shown in Figure 4.4. SPI is often regarded as a change in the company and usually the team members resist this change. Niazi, Babar and Verner [LT16] discussed that team members consist of geographically distributed individuals and groups who might have opposing ideas, aims, and objectives. Hence, the SPI implementation possibly fit into goals of one group but not into another's. Moitra [LT29] brought attention to the pitfalls and complications of change management for SPI and suggested that organizational politics is probably one of the main causes that can destroy the change management attempts for SPI implementation. Iversen, Mathiassen and Nielsen [LT13] identified other aspects of organizational politics that might be decisive to SPI implementation, for example promotion opportunities, reallocation of resources, role, ambiguity and low trust.

Around 41% of the articles referred 'BA1: inexperienced staff' as a barrier for SPI implementation. Rainer and Hall [LT4] described the challenges of managing change for SPI and discussed that process and quality improvement people are mostly theoretical. They do not have deep knowledge regarding software development processes and the domain in which they are employed. Niazi, Babar and Verner [LT16] claimed in their empirical study that GSD organizations that involved in SPI activities

could only be successful if the team members have skills in the process improvement implementation.

'BA3: cultural difference' was quoted by 39% of the selected SLR studies. In GSD, team members scattered around the globe and may belong to various cultural backgrounds. In GSD environment, it is arduous for both client and vendor organizations to use their native languages because they might be from different countries (Khan et al., T43). Due to the diverse cultural backgrounds, misunderstanding in the exchange of messages may take place and this situation could create confusion between different teams (Shih, & Huang, LT44).

In this SLR study, 'BA21: lack of implementation tools and standards' was discussed in 34% of the selected articles. Mohd, Ahmad and Hassan [LT38] underlined the adaptation of proper tools for SPI implementation and motivate the team members to have sufficient knowledge about those tools. Besides, (Dutra, & Santos, LT39) also agreed that one of the reasons for SPI failure is the lack of tools and standards for process improvement activities. He postulated that without any other barriers, lack of tools might be the superseding problem for SPI success.

'BA9: workload', 'BA11: time pressure', 'BA19: lack of sponsorship', 'BA15: temporal distance', 'BA4: lack of trust', 'BA7: lack of feedback', 'BA16: poor organizational infrastructure', 'BA18: organizational changes' and 'BA22: stalling on action plan implementation' were also cited as barriers for implementation of SPI activities in GSD.

4.3.2 Barriers identified using survey questionnaire

In order to address RQ4, a list of identified barriers is presented in Table 4.8. The results show that majority of the respondents agreed with the identified barriers that can

have negative impact on process improvement implementation in GSD environment. This is obvious from the results in the 'Positive (+Ve)' category where most of the values are above 70% except for a few barriers.

In the identified barriers 'BA11: time pressure (91%)' was considered the major barrier for SPI implementation in GSD. This is because operational management feels time pressure as a preeminent hurdle to process improvement execution (Niazi, LT32; Niazi, Babar, & Verner, LT16; Niazi, Wilson, & Zowghi, LT27). In another study, (Richardson et al., LT18) discussed case studies for SPI implementation and illuminate time constraint as a vital barrier for SPI implementation. As a result of time pressure the decisions of team members may not be in the interest of the process improvement program. According to (Mantyla et al., LT22), under the time pressure, team members made quick decisions in order to stay on schedule. However, those decisions may not be for the benefit of the process improvement program. An industrial study conducted by (Baddoo, Hall, & Wilson, LT26) found that all groups of practitioners have quoted time pressure as a de-motivator for SPI, i.e. 58% of senior managers, 44% of project managers and 62% of developers.

The results shown in Table 4.8 highlighted that 'BA12: lack of resources (90%) ' is the second most common factor for SPI implementation in GSD. In the absence of sufficient resources, the organization will not be able to achieve the goals and objectives of SPI program (Boddoo, & Hall, LT25). It is important to estimate and provide sufficient resources to achieve the key objectives of SPI. Otherwise, frustration will end the organization's readiness to adopt the SPI program (Niazi, LT32).

Similarly 'BA20: lack of formal SPI implementation methodology (89%)' got the attention of the respondents. They cited it as the third most significant barrier. I believe

this is due to the unavailability of proper process improvement implementation approach that can assist the distributed SPI team members.

Table 4.8 Barriers identified using survey questionnaire

S. No	Barriers	Experts Opinion (N=111)									
		+Ve				-Ve				Neutral	
		EA	MA	SA	%	ED	MD	SD	%	NU	%
B1	Inexperienced Staff	30	34	29	84	0	2	7	8	9	8
B2	Staff turnover	23	43	19	77	1	7	9	15	9	8
B3	Cultural difference	22	29	24	68	6	8	10	22	12	11
B4	Lack of trust	32	38	21	82	3	2	5	9	10	9
B5	Lack of process improvement knowledge	27	41	21	80	2	4	8	13	8	7
B6	Lack of training	30	47	21	88	0	4	3	6	6	5
B7	Lack of feedback	31	38	28	87	2	2	5	8	5	4
B8	Personality clashes	19	29	25	66	6	12	7	23	13	12
B9	Workload	36	29	25	81	0	5	10	14	6	5
B10	Organizational politics	53	30	13	86	1	8	2	10	4	3
B11	Time pressure	38	48	16	91	3	1	3	6	2	1
B12	Lack of resources	59	32	9	90	2	3	2	6	4	3
B13	Lack of communication	74	17	4	85	3	4	3	9	6	5
B14	Lack of organizational support	53	34	10	87	2	4	3	8	5	4
B15	Temporal distance	17	28	25	63	4	4	18	23	15	14
B16	Poor organizational infrastructure	25	40	24	80	3	2	4	8	13	12
B17	Budget constraints	25	50	21	86	2	1	4	6	8	7
B18	Organizational changes	30	36	19	76	2	4	10	14	10	9
B19	Lack of sponsorship	36	27	19	73	3	10	8	19	8	7
B20	Lack of formal SPI implementation methodology	52	35	12	89	1	3	3	6	5	4
B21	Lack of implementation tools and standards	32	52	12	86	2	1	5	7	7	6
B22	Stalling on action plan implementation	24	39	25	79	2	3	5	9	13	12

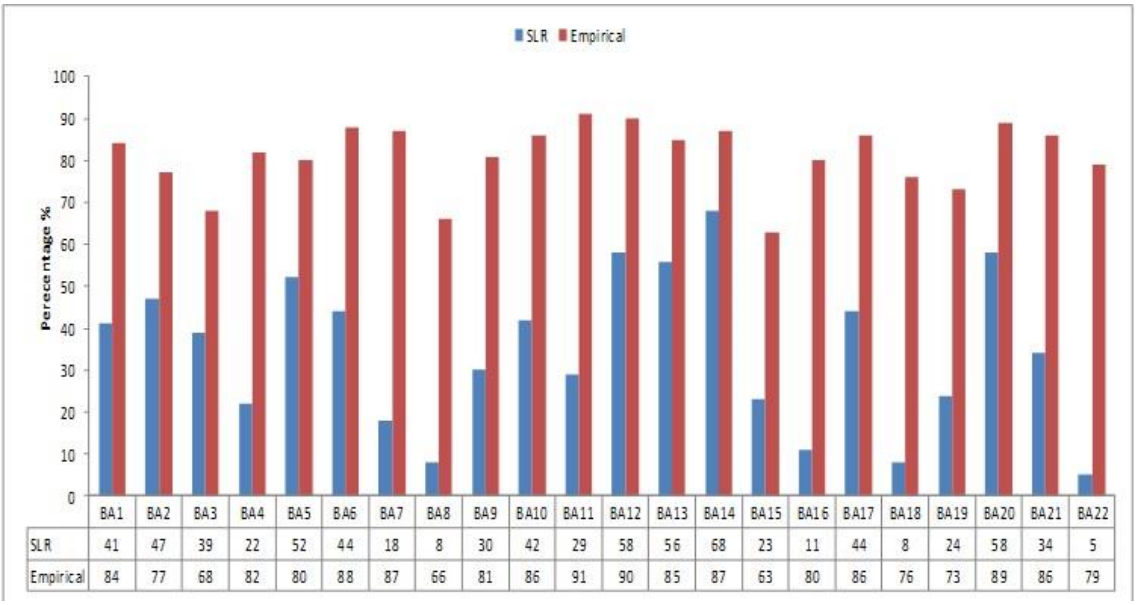
The other important barriers (>70%) are ‘BA1: inexperienced staff’, ‘BA2: staff turnover, ‘BA4: lack of trust’, ‘BA5: lack of process improvement knowledge’, ‘BA6: lack of training’, ‘BA7: lack of feedback’, ‘BA9: workload’, ‘BA10: organizational politics’, ‘BA13: lack of communication’, ‘BA14: lack of organizational support’, ‘BA17: budget constraints’, ‘BA16: poor organizational infrastructure’, ‘BA18: organizational changes’, ‘BA19: lack of sponsorship’, ‘BA21: lack of Implementation

tools and standards' and 'BA22: stalling on action plan implementation' as shown in Table 4.8.

4.3.3 Comparison of barriers identified using SLR and survey questionnaire

To answer RQ6, I have compared the results of both SLR and empirical study in order to find the similarities and differences among the identified barriers as shown in Figure 4.5.

I have compared the ranks of the identified barriers in both types of the studies (SLR and empirical study) as shown in Table 4.9. I have also evaluated the mean differences of SLR and survey data using independent t-test as shown in Table 4.10 and Table 4.11. The calculated results of t-test are (t=0.47, p=0.34> 0.05), which shows that there is no significant difference between the findings of SLR and questionnaire.



	BA1	BA2	BA3	BA4	BA5	BA6	BA7	BA8	BA9	BA10	BA11	BA12	BA13	BA14	BA15	BA16	BA17	BA18	BA19	BA20	BA21	BA22
SLR	41	47	39	22	52	44	18	8	30	42	29	58	56	68	23	11	44	8	24	58	34	5
Empirical	84	77	68	82	80	88	87	66	81	86	91	90	85	87	63	80	86	76	73	89	86	79

Figure 4.5 Percentage wise comparisons of barriers identified using SLR and survey questionnaire

Table 4.9 Comparison of barriers identified using SLR and a survey questionnaire

S. No	Barriers	Occurrence in SLR (n=91)		Positive occurrence in survey (n=111)		Average Rank
		%	Rank	%	Rank	
BA1	Inexperienced Staff	41	8	84	8	8
BA2	Staff turnover	47	5	77	13	9
BA3	Cultural difference	39	9	68	16	13
BA4	Lack of trust	22	15	82	9	12
BA5	Lack of process improvement knowledge	52	4	80	11	7
BA6	Lack of training	44	6	88	4	5
BA7	Lack of feedback	18	16	87	5	11
BA8	Personality clashes	8	18	66	17	18
BA9	Workload	30	11	81	10	11
BA10	Organizational politics	42	7	86	6	6
BA11	Time pressure	29	12	91	1	6
BA12	Lack of resources	58	2	90	2	2
BA13	Lack of communication	56	3	85	7	5
BA14	Lack of organizational support	68	1	87	5	3
BA15	Temporal distance	23	14	63	18	16
BA16	Poor organizational infrastructure	11	17	80	11	14
BA17	Budget constraints	44	6	86	6	6
BA18	Organizational changes	8	18	76	14	16
BA19	Lack of sponsorship	24	13	73	15	14
BA20	Lack of formal SPI implementation methodology	58	2	89	3	2
BA21	Lack of implementation tools and standards	34	10	86	6	8
BA22	Stalling on action plan implementation	5	19	79	12	15

Table 4.10 Group Statistics for barriers

	Group	N	Mean	Std. Deviation	Std. Error Mean
Rank	SLR	22	9.818	5.827	1.242
	Survey	22	9.045	5.009	1.067

Table 4.11 Independent Sample t-test for barriers

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	MD	SD	95% Confidence Interval of the Difference	
									LW	UP
Rank	Equal variances assumed	.92	.34	.47	42	.64	.77	1.63	-2.53	4.07
	Equal variances not assumed			.47	41	.64	.77	1.63	-2.53	4.08
UP=Upper, LW=Lower, MD=Mean Difference, SD= Std. Error Difference										

It is worth to note that ranks of both the studies are not same. Therefore, I assessed the significant difference between the ranks of identified barriers using Spearman's rank-order correlation as shown in Table 4.12.

Table 4.12 Barriers identified using survey questionnaire

			SLR_Rank	Empr_Rank
Spearman's rho	SLR_Rank	Correlation Coefficient	1.000	.495*
		Sig. (2-tailed)	.	.019
		N	22	22
	Empr_Rank	Correlation Coefficient	.495*	1.000
		Sig. (2-tailed)	.019	.
		N	22	22
*. Correlation is significant at the 0.05 level (2-tailed).				

The calculated Spearman's correlation coefficient is (0.495) whereas p=0.019, which is showing positive and statistically significant correlation between the ranks of barriers identified in SLR and empirical study. The results are also depicted in Figure 4.6.

For example barrier (BA12: time pressure) ranked 12 in SLR and ranked 1 in the data collected using the survey questionnaire. It means that (BA12: time pressure) got more attention in the industry as compared to the existing literature. The practitioners gave more importance to the barrier 'time pressure'.

Different other barriers i.e., (BA7: lack of feedback, BA2: staff turnover, BA3: cultural difference) have much variation in their ranks for both SLR and empirical study. They got high ranking in one type of study, but low consideration in the other type.

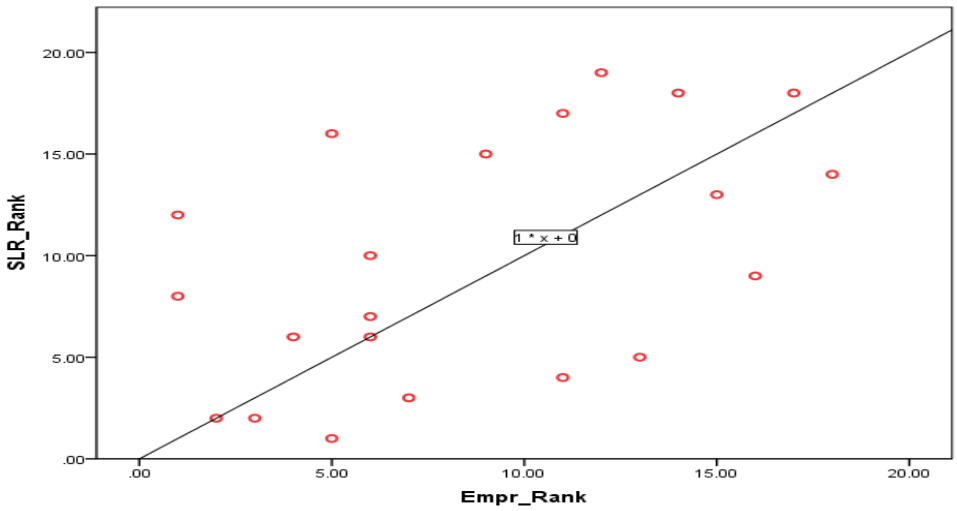


Figure 4.6 Scatter plot of the barriers ranks obtained from SLR and the survey questionnaire

4.3.4 Critical barriers identified using both SLR and survey questionnaire

In order to find the critical barriers, I have followed the criteria discussed in section 4.2.4. In the identified barriers, five barriers were ranked as CBs. The identified CBs are: lack of process improvement knowledge, lack of resources, lack of communication, lack of organizational support and lack of formal SPI implementation methodology.

4.4 Practices to address the identified critical success factors (CSFs) and critical barriers (CBs)

In order to address RQ7 and RQ8, I have used SLR and survey questionnaire approaches to explore different practices in order to address the identified CSFs and CBs. The identified practices using SLR were evaluated by SPI experts using the survey questionnaire. I have also provided an open ended text box in order to find additional practices.

4.4.1 Practices identified using SLR

Using SLR, total 56 practices were identified to address the CSFs and CBs. In these practices, 31 practices were suggested for CSFs and 25 for CBs.

4.4.1.1 Practices identified using SLR for CSFs

The identified practices along the CFs are shown in Figure 4.7 and Table 4.13.

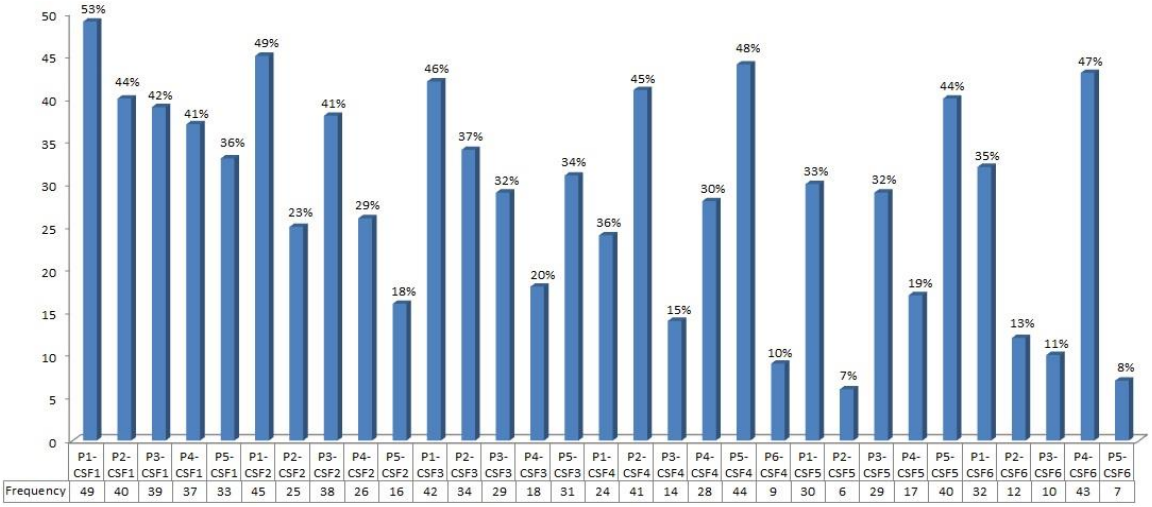


Figure 4.7 Frequency distribution of practices identified to address CSFs using SLR

In Table 4.13 total five practices are discussed for 'CSF1: management commitment'. In the identified practices 'P1-CSF1' is the most common practice and is cited by 53% of the selected studies. The main focus of practice 'P1-CSF1' is to encourage the organizational management to provide strong support for SPI activities and implementation. The second most common practice to address 'CSF1: management commitment' is 'P2-CSF1 (44%)'. The aim of 'P2-CSF1' is to provide and sustain adequate resources for the implementation of process improvement programs. 'CSF1: management commitment' can be best addressed by following the above two practices as they show high frequencies.

Table 4.13 Identified practices for CSFs

Practice No	CSF1: Management Commitment
P1-CSF1	Strong support and commitment of organizational management for software process improvement program.
P2-CSF1	Management provides and sustain resources for process improvement program.
P3-CSF1	Continuously monitor the process improvement activities
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.
P5-CSF1	Continuously encourage the efforts of process improvement team members.
CSF2: Staff Involvement	
P1-CSF2	Employees must adopt process innovations in their day-to-day activities.
P2-CSF2	Staff members should participate in process improvement because they have detailed knowledge of the strengths and weaknesses of current processes.
P3-CSF2	Facilitate process improvement team members.
P4-CSF2	Properly monitor the staff members so that every member feels the sense of responsibility.
P5-CSF2	Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.
CSF3: Allocation of Resources	
P1-CSF3	There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.
P2-CSF3	Management should have a broader picture of the resources and time required in order to conduct the process improvement program.
P3-CSF3	Provide all the required technological resources including hardware and software.
P4-CSF3	Process improvement team members have been allocated sufficient time for process improvement program.
P5-CSF3	Provide adequate budget and human resources from the very start of the process improvement project implementation.
CSF4: 3C's (Communication, Coordination, Control)	
P1-CSF4	The team members should frequently visit the geographically distributed sites in order to develop group cohesiveness.
P2-CSF4	Encourage the use of effective communication, coordination and control tools and techniques.
P3-CSF4	Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.
P4-CSF4	Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.
P5-CSF4	Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.
P6-CSF4	Organization should appoint liaison among the geographically distributed teams.
CSF5: Project Pilot Implementation	
P1-CSF5	Implement process improvement for testing on a small scale.
P2-CSF5	Develop criteria for pilot implementation of process improvement.
P3-CSF5	Capture the feedback from the pilot implementation and use for future process improvement activities.
P4-CSF5	Continuously monitor the results of pilot process improvement implementation.
P5-CSF5	Provide adequate resources for pilot implementation.
CSF6: Process Improvement Expertise	
P1-CSF6	Process improvement team members have a deep understanding of software quality and software processes.
P2-CSF6	Expertise needs continuous improvement by means of training.
P3-CSF6	The team consists of individuals having previous process improvement experience, knowledge and necessary skills.
P4-CSF6	Use the previous experience of process improvement projects in global software development.
P5-CSF6	Draw on the expertise of external assessors/consultants as mentors.

To address ‘CSF2: staff involvement’, the SLR results find out total five practices. The results exhibit that ‘P1-CSF2’ is the most significant practice and is mentioned by 49% of the studies. ‘P1-CSF2’ is towards the motivation of the team members to adopt an innovative process in their everyday activities. It will assist the team members to adopt the new process improvement techniques and technologies. The second most common practice is ‘P3-CSF2’ and it yielded 41% occurrence from the articles.

Table 4.13 presents 5 practices for addressing ‘CSF3: allocation of resources’. Among these practices, ‘P1-CSF3’ and ‘P2-CSF3’ shows high frequencies and got more attention in the selected studies for SLR. ‘P1-CSF3’ is the most significant practice and is highlighted by 46% of the selected studies. ‘P1-CSF3’ is about the planning and estimation of required resources for SPI implementation. The second important practice is ‘P2-CSF3’ and is discussed in 37% of the studies as shown in Figure 4.7.

For addressing the ‘CSF4: 3C's (communication, coordination, control)’, I have extracted 6 practices and the most common practices is ‘P5-CSF4’. The SLR results show that ‘P5-CSF4’ was cited by 48% of the articles. ‘P5-CSF4’ encourages the staff members to conduct frequent meetings using different sources in order to mitigate the communication gap between the distributed teams. The other common practice is ‘P2-CSF4’ (45%) and it focus on the use of effective communication tools and techniques in order to overcome the communication, coordination and control issues.

The SLR results revealed five practices to address ‘CSF5: project pilot implementation’. Among the identified practices, ‘P5-CSF5’ (44%) is the most common quoted practice and it focus to provide adequate resources for the pilot implementation of SPI activities prior to the implementation of SPI program in the entire organization.

The last critical success factor is ‘CSF6: process improvement expertise’ and five practices are identified in order to address it. ‘P4-CSF6’ found to be the most significant

factor as it was mentioned by 47% of the articles. The key objective of practice 'P4-CSF6' is to motivate the SPI teams to use the experiences of previous projects implemented in the context of GSD and SPI. The second most common practice is 'P1-CSF6' (35%) and it suggests that SPI team members should have complete knowledge of software quality and software processes.

4.4.1.2 Practices identified using SLR for CBs

Total five barriers were identified as the most critical barriers. The identified CBs and their practices are given in presented in Figure 4.8 and Table 4.14.

The critical barrier 'CB1: lack of organizational support' is addressed with five practices and practice 'P4- CB1' (53%) is cited to be the most significant practice of all the identified practices. 'P4- CB1' focused on the provision of training and allocation of resources to perform SPI related activities. The second most important practice is 'P1-CB1' and is considered by 47% of the selected articles. The aim of this practice is about the commitment of organizational management to support the staff involved in the implementation of SPI program.

Results presented in Figure 4.8 described that 'P1- CB2' is considered by 51% of the articles to address the critical barrier 'CB2: lack of communication'. In 'P1- CB2', it is recommended for SPI staff to frequently visit the distributed sites in order to promote social cohesion among the team members. The other important practice is 'P3- CB2' which highlighted the significance of using advanced communication techniques and tools in order to mitigate the communication issues.

The third most critical barrier is 'CB3: lack of process improvement knowledge'. Total five practices are identified to address CB3 and practice 'P5- CB3' is mentioned by 48% of the selected studies. Practice 'P5- CB3' recommend to promote the awareness of the SPI program among the team members in order to provide them sufficient

knowledge about the significance of process improvement. In SLR study, 'P4- CB3' (45%) is reported to be the second most important practice in order to address barrier 'CB3: lack of process improvement knowledge'.

In table 4.14, five practices are discussed to address barrier 'CB4: lack of formal process improvement implementation methodology'. In the identified practices, 'P5-CB4' (43%) is highlighted as the most significant practice. It encourages the team members to use the licensed tools and models to perform the implementation of SPI program.

The last significant barrier is 'CB5: lack of resources' and in this study five practices are suggested to address it. In 'P1-CB5' (52%), it is suggested to plan the complete SPI program in advance and estimate all the required resources. The project manager should estimate the cost and time to perform the process improvement activities. Second important practice is 'P3-CB5' (34%), which emphasized on the development of techniques that could lessen the time pressure of the team members involved in process improvement program.

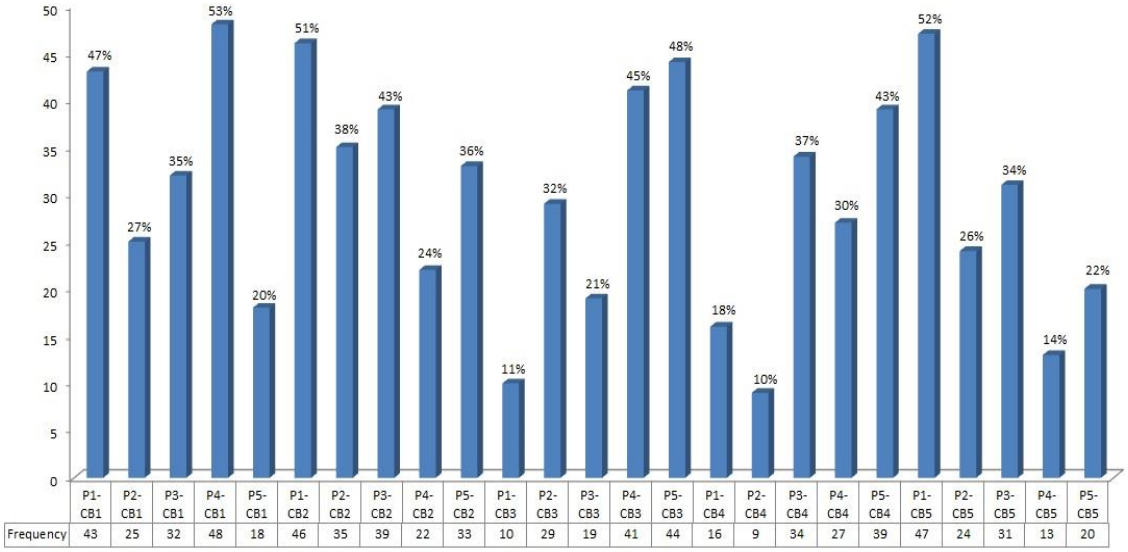


Figure 4.8 Frequency distribution of practices identified to address CBs using SLR

Table 4.14 Identified practices for CBs

Practice No	CB1: Lack of organizational support
P1- CB1	Management committed to support SPI team members.
P2- CB1	Top level management should make software process improvement practices as the fundamental part of the software development cycle.
P3- CB1	Develop criteria to continuously monitor the progress of the process improvement team.
P4- CB1	Management commit to provide adequate resources and training for process improvement activities.
P5- CB1	Management is willing to participate in assessment meetings and improvement workshops.
CB2: Lack of Communication	
P1- CB2	Regular travel to distributed sites creates group cohesiveness among the team members.
P2- CB2	Promote efficient offshore relationship.
P3- CB2	Promote the use of advance communication and information technology tools and practices.
P4- CB2	Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.
P5- CB2	Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.
CB3: Lack of Process Improvement Knowledge	
P1- CB3	Detail process improvement knowledge.
P2- CB3	Conduct regular training session for team members.
P3- CB3	Establish a mechanism to continuously monitor the progress of each SPI team member.
P4- CB3	Encourage team building activities
P5- CB3	Promote process improvement awareness among process improvement team members.
CB4: Lack of formal process improvement implementation methodology	
P1-CB4	Establish technical infrastructure to implement the process improvement program.
P2- CB4	Use applications of process, implementation or product indicators as an effective management tool for process improvement.
P3-CB4	Promote the awareness of process improvement application tools and standards among team members.
P4-CB4	Adopt standards for the assessment of processes.
P5-CB4	Use of licensed software tools.
CB5: Lack of Resources	
P1-CB5	Project planning done in order to estimate all the required resources.
P2-CB5	Management commits to allocate sufficient time for SPI activities.
P3-CB5	A mechanism developed to avoid time pressure.
P4-CB5	Team members agree to allocate time for SPI activities.
P5-CB5	Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.

4.4.2 Practices identified using survey questionnaire

In order to answer RQ8, an online survey was conducted with SPI experts based on the practices identified using SLR approach. The ranking of the practices identified for CSFs and CBs using a survey approach is shown in Table 4.15 and Table 4.17 respectively. The tables are divided into three main categories of 'Positive' (Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA)), 'Negative' (Extremely

Disagree (ED), Moderately Disagree (MD), Slightly Disagree (SD)) and 'Neutral' (NS). The positive category presents the percentage of the respondents who agree with the practices identified using SLR technique. The negative category shows the percentage of those respondents who considered that the identified practices might not be effective to address the identified CSFs and CBs. In the neutral category, I have mentioned the percentage of those respondents who were not sure about the ranking of the identified practices.

4.4.2.1 Practices identified using survey questionnaire for CSFs

The results presented in Table 4.15 demonstrate that most of the experts were positively agreed with the practices identified using SLR approach. This is obvious from the 'Positive' category of the Table 4.15 where most of the values are above 80% except few practices.

To address CSF1, 97% of the experts agreed with the significance of practice 'P1-CSF1'. This is because the experts feel the importance of organizational commitment and support (Niazi, Babar, & Verner, LT16; Niazi, Wilson, & Zowghi, LT27; Niazi, LT32; Khan, & Keung, 2016). In another study, (Richardson et al., LT18) discussed case studies for SPI implementation and illuminate the importance of commitment and support of organizational management.

The results reveal that 93% of the respondents cited practice 'P3-CSF2' as the most common practice for CSF2. Practice 'P3-CSF2' is to facilitate the team members in various aspects and the necessity of facilities provided to SPI team members is underlined by (Mohd, Ahmad, & Hassan, LT38). They mentioned the provision of facilities in the form of tools, training and financial packages.

Practice ‘P2-CSF3’ was revealed by 96% of the survey respondents. Practice ‘P2-CSF3’ focus on preplanning of all the available resources for SPI initiation. Before the initiation of SPI program, the organisation should assess all the available resources and should allocate sufficient resources to execute the SPI activities.

Table 4.15 Identified practices for CSFs using survey questionnaire

S. No	Experts Opinion (N=111)									
	+Ve				-Ve				Neutral	
	EA	MA	SA	%	ED	MD	SD	%	NU	%
P1-CSF1	59	41	8	97	0	0	0	0	3	3
P2-CSF1	41	46	19	95	1	0	1	2	3	3
P3-CSF1	35	43	22	90	1	0	5	5	5	4
P4-CSF1	39	37	28	94	1	0	0	1	6	5
P5-CSF1	35	46	25	95	0	0	0	0	5	4
P1-CSF2	41	39	18	88	1	1	6	7	5	4
P2-CSF2	41	43	16	90	0	1	2	3	8	7
P3-CSF2	38	42	24	93	0	2	1	3	4	4
P4-CSF2	27	32	29	79	1	0	12	11	10	9
P5-CSF2	25	40	30	86	2	0	6	7	8	7
P1-CSF3	54	35	16	95	0	1	1	2	4	4
P2-CSF3	41	56	10	96	0	0	1	2	3	3
P3-CSF3	41	46	19	95	0	0	1	2	4	4
P4-CSF3	51	34	17	92	0	1	2	3	6	5
P5-CSF3	39	41	20	90	0	1	6	6	4	4
P1-CSF4	24	38	22	76	1	5	12	16	9	8
P2-CSF4	55	37	12	94	0	1	3	3	3	3
P3-CSF4	43	45	13	91	1	2	3	5	4	4
P4-CSF4	35	48	14	87	0	2	2	4	10	9
P5-CSF4	45	40	16	91	1	2	1	4	7	6
P6-CSF4	32	30	17	71	0	4	14	16	14	13
P1-CSF5	44	39	18	91	1	1	3	4	5	4
P2-CSF5	37	47	17	91	1	1	0	2	8	7
P3-CSF5	57	32	16	89	0	1	2	3	3	3
P4-CSF5	43	41	16	90	0	1	3	4	7	6
P5-CSF5	46	38	17	91	0	1	3	4	6	5
P1-CSF6	37	47	17	91	1	1	2	4	6	5
P2-CSF6	35	50	19	94	0	1	3	4	3	3
P3-CSF6	28	51	22	91	2	1	3	5	4	4
P4-CSF6	42	40	20	92	1	1	1	3	6	5
P5-CSF6	25	38	24	79	2	1	3	5	18	16

In the survey study, 94% of the SPI experts shed light the significance of practice ‘P2-CSF4’ to address CSF4. Practice ‘P2-CSF4’ address CSF4 in the way to provide all the available advanced communication tools and techniques for SPI program. As in GSD

the team member's work beyond the geographical boundaries and it is vital to provide all the advance communication facilities to the team members (Agerfalk et al., SL34).

In order to address CSF5, 91% of the survey respondents quoted 'P1-CSF5', 'P2-CSF5' and 'P5-CSF5' as the most common practices. These practices address CSF5 in the way to develop criteria for the small scale (pilot) implementation of SPI program. (Niazi, Wilson, Zowghi, LT11) discussed that organization should implement an SPI program in a specific department before adopting in the entire organization. They argued that pilot implementation of SPI program can assist the process improvement teams to estimate resources and workforce required for high level adaptation of SPI program.

Practice 'P2-CSF6' (94%) is recognised the most important practice to address CSF6. The aim of practice 'P2-CSF6' is to increase the expertise level of the SPI team members by means of proper training and awareness. (Niazi, Wilson, & Zowghi, LT9) give a detailed overview of the importance of training and awareness to SPI team members. They mentioned that it is important to provide them adequate training regarding SPI as the deployment of the SPI program is the practice of implementation of new processes in an organization.

In this empirical study 15 new practices are also identified in order to address the reported CSFs. Those practices have not been identified during the SLR study. The additional practices with their respective CSFs are presented in Table 4.16 and their serial numbers are keep continuous with the practices identified using SLR as discussed in Table 4.13.

Table 4.16 Additional identified practices for CSFs

Additional Practices	CSF1: Management Commitment
P6-CSF1	Top level management should lead the initiation and implementation of SPI program.
P7-CSF1	Management encourages and drive the bottom-up staff in SPI activities.
P8-CSF1	Organizational management motivates SPI team members as well the non SPI staff members to accept the changes of process improvement.
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.
P10-CSF1	Tope level management should show long time commitment.
CSF2: Staff Involvement	
P6-CSF2	Each distributed site should have technical leader that could lead the development process, coordinate with the team members and schedule the process improvement activities.
P7-CSF2	Regularly discuss the rationale for process improvement efforts with staff.
P8-CSF2	Explicitly describe the benefits of SPI to both the team members and the organization.
CSF3: Allocation of Resources	
P6-CSF3	The organization sets the priorities of what they choose to implement based on resources and budget - they don't have to do everything at once.
CSF4: 3C's (Communication, Coordination, Control)	
P7-CSF4	Frequent planning of interactions between distributed sites: daily stand-up/call improves this largely.
CSF5: Project Pilot Implementation	
P6-CSF5	Publicise and communicate widely pilot implementation success story.
P7-CSF5	Test earlier, provide examples and reiterate fast.
P8-CSF5	Explicitly discuss the results of the pilot implementation
CSF6: Process Improvement Expertise	
P6-CSF6	Use consultants to facilitate and guide.
P7-CSF6	The users of the system as well as the implementation team need to understand the basics of a quality process.

4.4.2.2 Practices identified using survey questionnaire for CBs

In table 4.17 the results of empirical study revealed that more than 80% of the respondents agreed with the practices identified in the literature

Practice ‘P1-CB1’ (95%) was found to be the most common practice to address CB1. Practice ‘P1-CB1’ motivates the management to support the team members during implementation of SPI activities. (Ramasubbu, LT5) discussed that organizational support and motivation is significant to successfully initiate the SPI program.

The empirical results demonstrate that the practice ‘P3-CB2’ quoted by 95% of the respondents in order to mitigate the critical barrier ‘CB2’. The key objective of practice ‘P3-CB2’ is to motivate the team members to adopt the most advance techniques in order to mitigate the communication gap among the distributed SPI teams. Effective

communication channels are claimed to assist process improvement activities (Beecham, Hall, & Rainer, LT81). Effective communication alleviates any noise, persuades team members of the necessity of process change and lessens their resistance to change (Bayona et al., LT21).

Practices 'P1-CB3' and 'P5-CB3' were highlighted as the most significant practices by 94% of the survey respondents in order to alleviate the critical barrier 'CB3'. Both of these practices encourage the SPI practitioners to have in depth knowledge and awareness of process improvement programs. The managers of SPI teams should promote the awareness of the change bring by the software process improvement. Without proper awareness, the SPI team members may not have in-depth understanding of how to evaluate the need for change (Wiegers, LT37).

Table 4.17 Identified practices for CBs using survey questionnaire

S. No	Experts Opinion (N=111)									
	+Ve				-Ve				Neutral	
	EA	MA	SA	%	ED	MD	SD	%	NU	%
P1-CB1	57	39	9	95	0	0	1	1	5	4
P2-CB1	38	42	20	90	0	1	1	2	9	9
P3-CB1	30	49	24	93	1	2	2	5	3	3
P4-CB1	47	36	20	93	1	0	2	3	5	4
P5-CB1	32	45	26	92	0	0	4	4	4	4
P1-CB2	31	35	23	80	2	6	6	13	8	7
P2-CB2	31	41	31	93	0	0	1	1	7	6
P3-CB2	56	40	10	95	1	0	1	2	3	3
P4-CB2	37	49	18	94	1	0	1	2	5	4
P5-CB2	54	38	11	93	1	0	0	1	7	6
P1-CB3	28	57	19	94	1	1	2	4	3	3
P2-CB3	40	44	17	91	0	0	3	3	7	6
P3-CB3	32	32	24	79	1	3	8	11	11	10
P4-CB3	41	44	20	95	0	1	0	1	5	4
P5-CB3	48	39	17	94	0	0	0	0	7	6
P1-CB4	33	46	22	91	1	0	1	2	8	7
P2-CB4	29	44	24	87	1	0	3	4	10	9
P3-CB4	33	48	20	91	1	0	3	4	6	5
P4-CB4	42	49	9	90	0	0	6	5	5	4
P5-CB4	32	32	17	73	5	3	6	13	16	14
P1-CB5	53	34	16	93	0	2	2	4	4	4
P2-CB5	49	26	23	88	1	4	3	7	5	4
P3-CB5	45	20	30	86	3	6	4	12	3	3
P4-CB5	34	39	28	91	0	4	2	5	4	4
P5-CB5	36	41	16	84	2	2	5	9	9	9

Analysis of the survey results exhibit that (91%) of the survey respondents cited ‘P1-CB4’ and ‘P4-CB4’ as the most common practices to address CB4. Practice ‘P1-CB4’ is about the establishment and provision of technical infrastructure to achieve the successful implementation of process improvement programs. Similarly, practice ‘P4-CB4’ encourages the process improvement teams to adopt the standards and models in order to assess the SPI program.

The last critical barrier is CB5 and practice ‘P1-CB5’ (93%) was considered the most significant practice which is based on the aim of advanced estimation and planning of all the available resources. (Niazi, Babar, & Verner, LT16) encourage estimating and the provision of all the available resources for process improvement implementation. They mentioned that inadequate resources can undermine the desired results of SPI program.

I have identified one new practice during the survey questionnaire study in order to address CB2 (i.e. team members should have plan for frequent daily meetings). This practice was not acknowledged during the literature review.

4.5 Additional analysis of identified success factors and barriers

I have performed additional analysis of the data collected for success factors and barriers. Various statistical tests were performed and the brief results and analysis are discussed in the following sections. The main reason behind this statistical analysis was to determine the significant differences among the success factors and barriers in different domains. Different other researchers have followed the same pattern of statistical analysis (Khan, 2011; Khan, 2016). These statistical investigations of significant difference are described in the following sections.

4.5.1 Continent based comparison of success factors identified using SLR

All the articles selected using SLR approach were categorised based on the continents where the empirical study conducted in order to find the significant difference between the success factors in the domain of different continents. The main reason behind this classification is to investigate any difference in these continents with respect to identified success factors (Khan, & Khan; LT7; Khan, Niazi, & Ahmad, LT1). This is because the success factors that have an impact on SPI implementation in any continent should be taken seriously by the organisations in that particular country (Khan, & Khan; LT7; Khan, Niazi, & Ahmad, LT1). I have used linear-by-linear association X^2 test to calculate the significant difference between the identified success factors found in different continents. Linear-by-linear association X^2 test is considered ideal for ordinal type of variables and it is more influential than Pearson X^2 test (Khan, & Khan; LT7; Khan, Niazi, & Ahmad, LT1; Khan, Niazi, & Ahmad, LT28). To check any significant difference, the following hypotheses have been developed:

- Null hypothesis (H0): There is no significant difference among the continents which are used to discuss the identified success factors.
- Alternate hypothesis (H1): There are significant differences among the continents which are used to discuss the identified success factors.

If the significance value 'P' for any success factor is >0.05, then the null hypothesis (H0) will be supported, otherwise the alternate hypothesis (H1) will be considered. If there is no significant difference for specific success factor, then there is no substantial difference in articles reported in different continents. Similarly, if there is a significant difference for any success factor, it means that this specific success factor is not equally reported in different continents.

Using the selected test for comparison among the success factors based on continents, Table 4.18 shows the significant difference for only two success factors, i.e. SF17 (joint management infrastructure) and SF19 (strong relationship between team members) as the value of 'P' is <0.05. SF17 (joint management infrastructure) have a high percentage of occurrence in NA (North America) and have less in other categories of continents. Therefore, we reject the null hypotheses (H0) and accept the alternate hypotheses (H1) for success factor SF17 (joint management infrastructure).

Based on the above discussion, it can be highlighted that as majority of the client organizations in GSD are from North America (USA, Canada etc.), and they consider the importance of joint management infrastructure among the teams working in distributed environment in order to avoid possible risks related to SPI implementation. The second most significant difference found for factor SF19 (strong relationship between team members) and 78% of the studies conducted in Australia highlighted the significance of strong relationship among the distributed teams. As most of the Australian based organizations are client and they outsource development activities to vendor organizations in different other countries (e.g. India, China etc.). Therefore, they considered the significance of the relationship among the team members as they belong to various cultural backgrounds. Strong positive relationship can assist the GSD organizations to successfully execute the process improvement activities beyond the geographical and cultural boundaries.

Table 4.18 Continental based classification of success factors identified using SLR

SF	Total number of SLR studies (N=91)												$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$, df=1	
	AS (N=28)		EU (N=33)		AUS (N=9)		NA (N=9)		SA (N=5)		MX (N=7)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	X^2	P
SF1	18	64	24	73	8	89	6	67	3	60	3	43	0.868	0.351
SF2	18	64	20	61	6	67	8	89	3	60	2	29	0.383	0.536
SF3	15	54	18	55	6	67	2	22	3	60	2	29	1.982	0.159
SF4	12	43	15	45	4	44	4	44	3	60	1	14	0.441	0.506
SF5	16	57	18	55	7	78	4	44	2	40	5	71	0.135	0.713
SF6	18	64	24	73	6	67	6	67	3	60	4	57	0.243	0.622
SF7	11	39	13	39	7	78	4	44	3	60	3	43	0.531	0.466
SF8	9	32	12	36	3	33	4	44	2	40	2	29	0.345	0.557
SF9	19	68	24	73	4	44	6	67	1	20	3	43	1.549	0.213
SF10	8	29	12	36	3	33	3	33	3	60	0	0	0.230	0.632
SF11	9	32	13	39	5	56	5	56	2	40	2	29	0.209	0.648
SF12	13	46	18	55	6	67	4	44	1	20	1	14	2.996	0.083
SF13	12	43	14	42	0	0	3	33	0	0	3	43	1.358	0.244
SF14	11	39	10	30	1	11	3	33	0	0	1	14	2.884	0.089
SF15	9	32	14	42	1	11	1	11	2	40	2	29	0.693	0.405
SF16	3	11	5	15	4	44	1	11	1	20	1	14	0.149	0.699
SF17	**2**	**7**	**4**	**12**	**1**	**11**	**4**	**44**	**1**	**20**	**2**	**29**	**5.405**	**0.020**
SF18	6	21	11	33	5	56	4	44	1	20	3	43	1.158	0.282
SF19	**5**	**18**	**11**	**33**	**7**	**78**	**6**	**67**	**3**	**60**	**3**	**43**	**6.577**	**0.010**
SF20	0	0	3	9	1	11	2	22	0	0	0	0	0.395	0.530
SF21	4	14	8	24	4	44	5	56	1	20	2	29	2.372	0.124

SF= Success Factors, Freq=Frequency, AS= Asia, EU= Europe, AUS= Australia, NA= North America, SA= South America , MX=Mixed, N= Number of studies

4.5.2 Temporal classification of success factors identified using SLR

Table 4.19 provides the complete summary of the selected studies and shows their frequencies based on the publication decade.

The articles identified using SLR were classified into two decades from year 1996-2005 and 2006-2015. In this research work the SLR study was finished at the end of year 2015. To check any significant difference for the success factors among the two decades, the following hypotheses have been developed:

- Null hypothesis (H0): There is no significant difference among the decades used to discuss the identified success factors.

- Alternate hypothesis (H1): There are significant differences among the decades used to discuss the identified success factors.

It is shown in the Table 4.19 that there is no significant difference between the success factors discussed in the quoted decades. Therefore the null hypothesis (H0) is accepted and rejected the alternate hypothesis (H1).

The results show that the identified success factors are cited in both decades. In the first decade, nine success factors have been quoted in more than 50% of the articles selected during SLR. The most common cited success factors in first decade is SF9 (3C (communication, coordination and control), 73%). It shows that 3C was a most significant factor for GSD organizations as GSD was a novel phenomenon during the first decade. Most of the organizations had critical issues to communicate with the geographically distributed development teams (Khan et al., LT43). However the significance of SF9 has been decreased to 61% in the second decade because in this modern technology age most of the organizations get control over communication challenges. Other frequently cited factors of first decade are SF6 (allocation of resources, 70%), SF1 (management commitment, 67%), SF5 (process improvement expertise, 63%) and SF2 (staff involvement, 60%).

In the second decade five success factors have been cited in more than 50% of the papers selected during SLR. The most common factor during the second decade is SF1 (management commitment, 69%). As currently most of the organizations are globalizing their development activities around the globe and the commitment of top management is vital in order to achieve the objectives of GSD (Wilson, Hall, & Baddoo, LT79). Other important factors during second decade are SF2 (staff involvement, 64%) and SF6 (allocation of resources, 62%).

Table 4.19 Temporal distribution of success factors identified using SLR

SF	Total number of SLR studies (N=91)				$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	First decade (1996-2005) N=30		Second decade (2006-2015) N=61				
	Freq	%	Freq	%	X^2	Df	P
SF1	20	67	42	69	0.044	1	0.834
SF2	18	60	39	64	0.132	1	0.717
SF3	16	53	30	49	0.137	1	0.711
SF4	16	53	23	38	1.984	1	0.159
SF5	19	63	33	54	1.292	1	0.256
SF6	21	70	38	62	0.795	1	0.373
SF7	17	57	24	39	2.411	1	0.121
SF8	10	33	23	38	0.164	1	0.685
SF9	22	73	37	61	1.402	1	0.236
SF10	10	33	19	31	0.044	1	0.834
SF11	13	43	23	38	0.264	1	0.608
SF12	17	57	25	41	2.886	1	0.089
SF13	12	40	20	33	0.454	1	0.500
SF14	8	27	18	30	0.079	1	0.779
SF15	9	30	20	33	0.071	1	0.790
SF16	5	17	10	16	0.001	1	0.974
SF17	5	17	9	15	0.056	1	0.813
SF18	14	47	16	26	3.759	1	0.053
SF19	15	50	20	33	2.490	1	0.115
SF20	3	10	3	5	0.834	1	0.361
SF21	8	27	16	26	0.002	1	0.965
N= Number of studies, Freq=Frequency, SF= Success Factors							

4.5.3 Classification of success factors identified using SLR, based on organization size

In this this research work the sample size of the SLR study is 91 articles, however only 33 articles have mentioned the size of the organizations where those studies were conducted. I have followed the definition of the organization size provided by the Australian Bureau of Statistics (Trewin, 2002). According to this definition, those companies which have less <=19 employees are considered to be small organization. Similarly, those organizations which have a number of employees (20 to <= 200) are medium size. Large organizations are defined to be those which have >= 200+ employees. The following hypotheses have been developed in order to check the significant difference for the success factors among the sizes of the organizations:

- Null hypothesis (H0): There is no significant difference between the sizes of the organizations used to discuss the identified success factors.
- Alternate hypothesis (H1): There are significant differences among the sizes of the organizations used to discuss the identified success factors.

It is shown in the results that there is no significant difference among the sizes of the organizations which are used to discuss the identified success factor (Table 4.20). In this case the null hypothesis (H0) is accepted and rejected the alternate hypothesis (H1).

The results presented in Table 4.20 shows that all the identified factors are cited in small size organizations. The most common success factor mentioned in the domain of small organizations is SF9 ((3C (communication, coordination and control), 59%). This means that due to lack of sufficient resources the small organizations are not able to establish a technical infrastructure that could make easy the job of communication, coordination and control (Basri, & O'Connor, LT89). Most of the small size organizations follow informal techniques to communicate and the main reasons behind the informal adoption of various techniques are the unavailability of sufficient resources. They give higher priority to the product rather than process (Basri, & O'Connor, LT89). Different other significant factors mentioned for small organizations are SF1 (management commitment, 53%) and SF3 (project pilot implementation, 53%).

I have found 19 success factors that were quoted in the context of medium sized organizations. Total 4 articles were in the context of medium sized organization and seven factors were discussed in 75% of the identified four articles i.e. SF1 (management commitment, 75%), SF3 (project pilot implementation, 75%), SF8 (skilled human resources, 75%), SF10 (mutual understanding between team members, 75%), SF11 (continuous organizational support, 75%), SF12 (process improvement leadership, 75%) and SF18 (setting process improvement goals, 75%).

Table 4.20 Classification of success factors identified using SLR, based on the organization size

SF	Organization Size						$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	Small (N=17)		Medium (N=4)		Large (N=12)				
	Freq	%	Freq	%	Freq	%	X^2	Df	P
SF1	9	53	3	75	9	75	0.593	1	0.441
SF2	8	47	2	50	8	67	1.030	1	0.310
SF3	9	53	3	75	8	67	0.593	1	0.441
SF4	8	47	2	50	6	50	0.25	1	0.875
SF5	7	41	0	0	4	33	0.275	1	0.600
SF6	8	47	1	25	4	33	1.165	1	0.280
SF7	6	35	2	50	3	25	0.275	1	0.600
SF8	6	35	3	75	4	33	0.07	1	0.791
SF9	10	59	2	50	7	58	0.224	1	0.636
SF10	3	18	3	75	5	42	2.077	1	0.150
SF11	6	35	3	75	3	25	0.153	1	0.696
SF12	7	41	3	75	6	50	0.279	1	0.597
SF13	4	24	2	50	5	42	1.099	1	0.295
SF14	4	24	2	50	3	25	0.023	1	0.880
SF15	4	24	1	25	5	42	2.637	1	0.104
SF16	3	18	0	0	3	25	0.001	1	0.978
SF17	3	18	1	25	2	17	0.002	1	0.965
SF18	5	29	3	75	3	25	0.005	1	0.944
SF19	6	35	2	50	3	25	0.275	1	0.600
SF20	2	12	1	25	0	0	0.992	1	0.319
SF21	5	29	2	50	4	33	0.069	1	0.793
SF= Success Factors, N= Number of studies, Freq=Frequency									

For large organizations, total six success factors have been identified in >=50% of the articles. The factor SF1 (management commitment, 75%) has been quoted as the most common success factor in the large organizations. (Ramasubbu, LT5; Khan, & Keung, LT10) shed light that the commitment and involvement of the organizational management are vital in order to drive the successful execution of SPI program. It is significant that management team finance, realise, participate, and contribute in process improvement activities (Sulyman et al. LT2; Khan, & Keung, LT10). The second most common factors identified in the domain of large organizations are SF2 (staff involvement, 67%) and SF3 (project pilot implementation, 67%).

4.5.4 Comparison of success factors identified using SLR, based on the study type

I have classified the identified articles into seven core study strategies used in the empirical software engineering. The identified strategies are (QS= Questionnaire Survey, INT= Interview, SLR= Systematic literature review, ILR= Informal literature review, CS= Case Study, MM=Mixed Method and AR=Action Research) as shown in Table 4.21. The identified strategies were evaluated through secondary reviewers using inter-rater reliability analysis discussed in section 3.5.2.2.

The results presented in Table 4.21 highlighted that the identified 21 success factors have been discussed across the mentioned study strategies. QS (Questionnaire Survey) is the most common research approach as 25 articles have adopted this approach to conduct their empirical studies. All of the identified 21 success factors are discussed in the domain of QS approach. Success factor SF1 (management commitment, 60%) has been mentioned as the most common and significant factor in those studies which have adopted the QS methodology.

The second most common research approach is CS (Case Study), which has been used by 21 studies. The results revealed that twenty success factors have been cited in the articles that followed the case study research approach. Among those twenty success factors, the most frequently mentioned factor is SF6 (process improvement leadership, 81%).

The third most common adopted research technique is INT (Interview). Total 17 articles have used the interview technique in order to collect the data. The results indicate that all of the identified success factors are mentioned in the articles related to interviews. SF1 (management commitment, 82%) was specified as the most significant success factor by those studies who had performed interviews in order to collect the data.

MM (Mixed Method) technique has been used by 14 primary studies selected during the SLR study. Two success factors, i.e. SF6 (allocation of resources, 79%) and SF9 (3C (communication, coordination and control), 79%) were most commonly discussed by the mixed method approach articles (Table 4.21).

Table 4.21 Classification of success factors identified using SLR, based on study types

SF	Study Types								
	QS N=25)	**INT (N=17)**	**SLR (N=5)**	**ILR (N=7)**	**CS (N=21)**	**MM (N=14)**	**AR (N=2)**	$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$, df=1	
	Freq	Freq	Freq	Freq	Freq	Freq	Freq	X^2	P
SF1	15	14	2	5	13	12	1	0.347	0.556
SF2	14	11	3	4	10	13	2	1.703	0.192
SF3	12	8	1	3	12	9	1	1.076	0.299
SF4	8	8	2	4	8	8	1	1.204	0.272
SF5	11	11	1	4	15	10	1	3.069	0.080
SF6	**14**	**11**	**2**	**4**	**17**	**11**	**2**	**4.341**	**0.037**
SF7	11	11	2	3	8	6	0	1.222	0.269
SF8	10	6	2	3	6	5	1	0.157	0.692
SF9	15	10	4	4	14	11	1	0.833	0.361
SF10	6	6	1	1	8	6	1	1.498	0.221
SF11	**5**	**6**	**3**	**3**	**12**	**6**	**1**	**4.824**	**0.028**
SF12	8	8	2	5	11	9	0	2.476	0.116
SF13	**6**	**3**	**1**	**2**	**11**	**8**	**1**	**8.106**	**0.004**
SF14	7	2	1	3	8	5	0	1.072	0.301
SF15	7	4	0	2	9	6	1	2.446	0.118
SF16	2	4	0	2	2	5	0	1.209	0.272
SF17	6	2	0	1	1	4	0	0.330	0.566
SF18	6	5	0	3	10	6	0	2.282	0.131
SF19	7	10	2	5	6	5	0	0.219	0.640
SF20	1	2	0	2	0	1	0	0.056	0.813
SF21	**4**	**4**	**0**	**1**	**7**	**7**	**1**	**5.493**	**0.019**

SF= Success Factors, Freq=Frequency, Number of studies, QS= Questionnaire Survey, INT= Interview, SLR= Systematic literature review, ILR= Informal literature review, CS= Case Study , MM=Mixed Method, AR=Action Research

I have applied linear by linear chi-square test in order to find the significant differences between the studies strategies used to discuss the identified success factors. The following hypotheses were developed in order to calculate the significant difference.

- Null hypothesis (H0): There is no significant difference among the study strategies used to discuss the identified success factors.
- Alternate hypothesis (H1): There are significant differences among the study strategies used to discuss the identified success factors.

I have identified significant differences for total four success factors i.e. SF6 (allocation of resources), SF11 (continuous organizational support), SF13 (organizational culture) and SF21 (process improvement standards and procedures). In this case the null hypothesis is rejected for the above four factors and accepted the alternate hypothesis.

4.5.5 Continent based comparison of barriers identified using SLR

I have classified all the selected barriers based on different continents as shown in Table 4.22.

The selected primary study articles were categorised according to the location where the empirical studies took place. The linear by linear association x^2 test was used in order to check any statistical difference between the barriers per continent. Other researchers (Khan, & Keung, LT10; Khan, & Khan, LT7; Khan, Niazi, & Ahmad, LT1; Khan, Niazi, & Ahmad, LT28) considered linear by linear association x^2 test ideal for ordinal variables because it is more influential than Pearson x^2 test.

The following hypotheses have been developed in order to measure the significant difference among the identified barriers based on different continents.

- Null hypothesis (H0): there is no statistical difference between continents regarding the identified barriers.
- Alternate hypothesis (H1): there are statistical differences between continents regarding the identified barriers.

Table 4.22 Continental based classification of barriers identified using SLR

BA	Total number of SLR studies (N=91)												$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$, df=1	
	AS (N=28)		**EU (N=33)**		**AUS (N=9)**		**NA (N=9)**		**SA (N=5)**		**MX (N=7)**			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	X^2	P
BA1	11	39	14	42	5	56	5	56	1	20	2	29	0.135	0.713
BA2	13	46	12	36	7	78	5	56	2	40	4	57	0.630	0.427
BA3	10	36	16	49	2	22	3	33	1	20	4	57	0.001	0.103
BA4	7	25	5	15	1	11	2	22	2	40	3	43	1.467	0.226
BA5	13	46	15	45	8	89	6	67	3	60	3	43	0.552	0.457
BA6	9	32	16	49	6	67	2	22	2	40	5	71	0.841	0.359
BA7	5	18	7	21	0	0	3	33	1	20	1	14	0.030	0.863
BA8	2	7	2	6	1	11	0	0	1	20	2	29	2.085	0.149
BA9	6	21	12	36	3	33	4	44	1	20	2	29	0.184	0.668
BA10	13	46	12	36	6	67	3	33	2	40	3	43	0.049	0.825
BA11	10	36	11	33	2	22	3	33	0	0	1	14	2.318	0.128
BA12	18	64	20	61	6	67	5	56	1	20	3	43	2.665	0.103
BA13	17	61	17	52	5	56	5	56	2	40	5	71	0.006	0.939
BA14	20	71	21	64	7	78	6	67	3	60	5	71	0.012	0.914
BA15	5	18	8	24	1	11	3	33	0	0	4	57	1.851	0.174
BA16	2	7	3	9	3	33	0	0	1	20	1	14	0.291	0.590
BA17	8	29	14	42	8	89	4	44	2	40	4	57	1.846	0.174
BA18	1	4	3	9	2	22	1	11	0	0	1	14	0.449	0.503
BA19	5	18	10	30	4	44	2	22	0	0	1	14	0.448	0.503
BA20	12	43	23	70	8	89	5	56	1	20	4	57	0.035	0.851
BA21	7	25	9	27	8	89	2	22	2	40	3	43	0.975	0.324
BA22	**0**	**0**	**1**	**3**	**1**	**11**	**1**	**11**	**1**	**20**	**1**	**14**	**5.261**	**0.022**
BA= Barriers, Freq=Frequency, AS= Asia, EU= Europe, AUS= Australia, NA= North America, SA= South America , MX=Mixed, N= Number of studies														

BA10 (organizational politics) was considered by most of the studies conducted in Asian based organizations. As most of the Asian firms are small to medium sized organizations and the implementation of SPI might be in interest of one group but not in another (Niazi, Babar, & Verner, LT16). The issues of promotion opportunities, limited resources, roles and ambiguity could cause the organizational politics (Iversen, Mathiassen, & Nielsen, LT13).

BA20 (lack of formal SPI implementation methodology) was considered by most of the studies conducted in Europe based software development firms. Majority of the European organizations are client in nature and they follow formal techniques and approaches to conduct software development activities. It might be the reason that they

quoted the need of formal SPI implementation methodology which consists of comprehensive process implementation strategy, activities, tasks, and measures to be used throughout the SPI implementation (Niazi, Babar, & Verner, LT16).

BA14 (lack of organizational support) was considered to be the most common barrier among all the continents. As SPI is a long standing approach and it is vital for the top level management to support the process improvement activities by providing adequate resources, participating in SPI activities and promoting the awareness of SPI implementation (Dyba, LT15). The lack of organizational support can undermine the effectiveness of the SPI program (Baddoo, & Hall, LT25).

Using the selected test for comparison among the barriers based on the continents, Table 4.22 shows that all the reported continents have more similarities than differences regarding the identified barriers. I have found only one significant difference for the barrier BA22 (stalling on action plan implementation). Therefore the null hypothesis is rejected for BA22 and accepted the alternate hypothesis.

4.5.6 Temporal classification of barriers identified using SLR

Table 4.23 highlighted the results of barriers based on the decades.

The articles selected using SLR were categorised into two decades from year 1996-2005 and 2006-2015. In this research work the SLR study was finished at the end of year 2015.

- Null hypothesis (H0): There is no significant difference among the decades used to discuss the identified barriers.
- Alternate hypothesis (H1): There are significant differences among the decades used to discuss the identified barriers.

Table 4.23 Temporal distribution of barriers identified using SLR

BA	Total number of SLR studies (N=91)				$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ ($\alpha = 0.05$)		
	First decade (1996-2005) N=30		Second decade (2006-2015) N=61				
	Freq	%	Freq	%	X^2	Df	P
BA1	11	37	27	44	0.472	1	0.492
BA2	11	37	32	52	1.990	1	0.158
BA3	8	27	28	46	3.078	1	0.079
BA4	3	10	17	28	3.703	1	0.054
BA5	19	63	29	48	1.990	1	0.158
BA6	15	50	25	41	0.656	1	0.418
BA7	5	17	12	20	0.118	1	0.731
BA8	2	7	6	10	0.249	1	0.618
BA9	8	27	20	33	0.350	1	0.554
BA10	14	47	25	41	0.262	1	0.609
BA11	**4**	**13**	**23**	**38**	**5.661**	**1**	**0.017**
BA12	19	63	34	56	0.472	1	0.492
BA13	16	53	35	57	0.132	1	0.716
BA14	23	77	39	64	1.485	1	0.223
BA15	7	23	14	23	0.002	1	0.968
BA16	2	7	8	13	0.845	1	0.358
BA17	14	47	26	43	0.132	1	0.716
BA18	2	7	6	10	0.249	1	0.618
BA19	4	13	18	29	2.839	1	0.092
BA20	19	63	34	56	0.472	1	0.492
BA21	11	37	20	33	0.133	1	0.715
N= Number of studies, Freq=Frequency, BA= Barriers							

I have identified the significant difference for only single barrier i.e. BA11 (time pressure) as shown in Table 4.23. Therefore, the null hypothesis is rejected for barrier BA11and accepted the alternate hypothesis. BA11 is cited by most of the studies conducted in the second decade (2006-2015). As GSD is the novel phenomenon of software development and most of the organizations are globalizing their work in order to attain the numerous competitive advantages (Herbsleb et al., LT61). Therefore, most of the teams working on SPI program feel time pressure in order to complete the project within time and budget (Mantyla et al., LT22). In order to stay on schedule, the team members made quick decisions which might not be in the favor of process improvement program (Mantyla et al., LT22).

The results indicate that six barriers have been cited in >=50% of the articles published in the first decade. These barriers are BA5 (lack of process improvement knowledge,

63%), BA6 (lack of training, 50%), BA12 (lack of resources, 63%), BA13 (lack of communication, 53%), BA14 (lack of organizational support, 77%) and BA20 (lack of formal SPI implementation methodology, 63%).

In the second decade (2006-2015), five barriers have been mentioned in >=50% of the articles selected using SLR. The identified barriers are BA2 (staff turnover, 52%), BA12 (lack of resources, 56%), BA13 (lack of communication, 57%), BA14 (lack of organizational support, 64%) and BA20 (lack of formal SPI implementation methodology, 56%).

4.5.7 Classification of barriers identified using SLR, based on the organization size

The sample size of articles selected using SLR is 91, however only 33 articles have mentioned the size of the organizations. I have adopted the definition of the organizational size defined by the Australian Bureau of Statistics (Trewin, 2002). According to this definition, those companies which have less <=19 employees are considered to be small organizations. Similarly, those organizations which have no of employees (20 to <= 200) are medium size. Large organizations are defined to be those which have >= 200+ employees.

The following hypotheses have been developed in order to measure the significance of the barriers among different organization sizes:

- Null hypothesis (H0): There is no significant difference between the sizes of the organizations used to discuss the identified barriers.
- Alternate hypothesis (H1): There are significant differences among the sizes of the organizations used to discuss the identified barriers.

The analysis presented in Table 4.24 shows that there are more similarities than differences among the identified barriers discussed in the context of organizational size.

I have not found any significant difference between the sizes of the organizations which have discussed the identified barriers. Therefore null hypothesis is accepted for all the barriers and rejected the alternate hypothesis.

All the identified 22 barriers are discussed in the articles conducted in small size organizations. Total three barriers were cited by more than >=50% of the articles conducted in small organizations. These three barriers are BA11 (time pressure, 53%), BA12 (lack of resources, 59%), and BA21 (lack of implementation tools and standards, 53%). Table 4.24 illustrate that BA12 (lack of resources, 59%) is mentioned to be the most important barrier for small scale organizations. (Babar, & Niazi, LT75) conducted a cross cultural study in Vietnamese small and medium sized GSD organizations. They discussed that for effective process improvement implementation, it is mandatory to assess and provide all the available resources to execute the SPI activities otherwise the organization will not be able to accomplish the desired results of process improvement.

The analysis shown in Table 4.24 shed light that all the identified 22 barriers are considered for medium sized organizations. Nine barriers are cited in 75% of the articles categorised in medium sized organizations. These 9 barriers are BA1 (inexperienced staff), BA2 (staff turnover), BA3 (cultural difference), BA5 (lack of process improvement knowledge), BA10 (organizational politics), BA12 (lack of resources), BA13 (lack of communication), BA14 (lack of organizational support), BA17 (budget constraints) and BA20 (lack of formal SPI implementation methodology).

The analysis indicates that 19 barriers out of 22 have been cited in large size organizations. Seven barriers have been quoted in >=50% of the articles. These seven barriers are BA1 (inexperienced staff, 50%), BA3 (cultural difference, 58%), BA12 (lack of resources, 50%), BA13 (lack of communication, 67%), BA14 (lack of organizational support, 75%), BA17 (budget constraints, 50%) and BA20 (lack of

formal SPI implementation methodology, 58%). It is worth noting that BA14 (lack of organizational support, 75%) is the most common barrier in the articles discussed in the context of large sized organizations. BA13 (lack of communication, 67%) has the second highest percentage for large sized GSD organizations.

Table 4.24 Classification of barriers identified using SLR, based on organization size

BS	Organization Size						$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	Small (N=17)		Medium (N=4)		Large (N=12)				
	Freq	%	Freq	%	Freq	%	X^2	Df	P
BA1	8	47	3	75	6	50	0.046	1	0.831
BA2	6	35	3	75	5	42	0.177	1	0.674
BA3	5	29	3	75	7	58	2.528	1	0.112
BA4	6	35	2	50	5	42	0.177	1	0.674
BA5	8	47	3	75	4	33	0.912	1	0.340
BA6	8	47	2	50	5	42	0.073	1	0.787
BA7	5	29	2	50	5	42	0.490	1	0.484
BA8	4	24	1	25	1	8	0.773	1	0.379
BA9	6	35	2	50	1	8	2.289	1	0.130
BA10	8	47	3	75	5	42	0.025	1	0.875
BA11	9	53	2	50	2	17	3.639	1	0.056
BA12	10	59	3	75	6	50	0.010	1	0.919
BA13	7	41	3	75	8	67	0.593	1	0.441
BA14	6	35	3	75	9	75	2.878	1	0.090
BA15	4	24	2	50	4	33	0.373	1	0.541
BA16	4	24	1	25	0	0	2.808	1	0.094
BA17	7	41	3	75	6	50	0.279	1	0.597
BA18	1	6	2	50	0	0	0.124	1	0.725
BA19	6	35	2	50	3	18	0.275	1	0.600
BA20	7	41	3	75	7	58	0.020	1	0.854
BA21	9	53	1	25	5	42	0.413	1	0.520
BA22	1	6	1	25	0	0	0.293	1	0.588
BA= Barriers, N= Number of studies, Freq=Frequency									

4.5.8 Comparison of the barriers identified using SLR, based on the study type

All of the selected 91 primary studies are categorized into seven core study strategies used in software engineering. The reported strategies are (QS= Questionnaire Survey, INT= Interview, SLR= Systematic literature review, ILR= Informal literature review, CS= Case Study, MM=Mixed Method and AR=Action Research) as shown in Table

4.25. The identified strategies were evaluated through secondary reviewers using inter rater reliability analysis discussed in section 3.5.2.2.

The following two hypotheses were developed in order to measure the significant difference among the various study strategies for the identified barriers:

- Null hypothesis (H0): There is no significant difference among the study strategies discussed the identified barriers.
- Alternate hypothesis (H1): There are significant differences among the study strategies discussed the identified barriers.

BA14 (lack of organizational support, 80%) is the most common barrier in the questionnaire surveys (QS), BA2 (staff turnover, 64%) and BA6 (lack of training, 64%) are found to be the most significant factors in interviews and three barriers BA12 (lack of resources, 80%), BA13 (lack of communication, 80%) and BA14 (temporal distance, 80%) are cited to be the most critical barriers in the SLR studies. Relating to informal literature reviews (ILR), total 17 barriers are identified. Among the identified 17 barriers, BA5 (lack of process improvement knowledge, 86%) is highlighted to the most important barrier.

In the selected case studies, 18 barriers have been identified and BA14 (lack of organizational support, 76%) is mentioned to be the most cited barrier. The second most quoted barrier is BA13 (lack of communication, 62%).

In relating to studies conducted mixed methods (MM), 21 barriers have been reported. Among these 21 barriers, seven barriers have been cited >=50% of the articles as shown in Table 4.25. BA20 (lack of formal SPI implementation methodology) has the highest percentage (71%) of the occurrence for mixed method studies.

I have identified the significant differences for two barriers i.e. BA6 (lack of training) and BA8 (personality clashes). Therefore the alternate hypothesis is accepted for these

barriers and rejected the null hypothesis. Both of these barriers have been highly cited in those studies that have collected the data using the questionnaire surveys.

Table 4.25 Classification of barriers identified using SLR, based on study types

BA	Study Types								
	QS N=25)	**INT (N=17)**	**SLR (N=5)**	**ILR (N=7)**	**CS (N=21)**	**MM (N=14)**	**AR (N=2)**	$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$, df=1	
	Freq	Freq	Freq	Freq	Freq	Freq	Freq	X^2	P
BA1	10	8	0	4	8	7	1	0.152	0.697
BA2	13	11	2	1	7	8	1	0.931	0.335
BA3	10	5	1	1	10	8	1	1.500	0.221
BA4	7	3	1	0	4	5	0	0.017	0.895
BA5	14	12	2	6	7	6	1	2.476	0.116
BA6	**13**	**11**	**2**	**2**	**8**	**4**	**0**	**5.022**	**0.025**
BA7	4	3	0	0	4	4	2	2.229	0.135
BA8	**5**	**2**	**0**	**0**	**0**	**1**	**0**	**4.852**	**0.028**
BA9	8	6	0	2	5	5	2	0.130	0.718
BA10	11	7	2	2	11	6	0	0.006	0.939
BA11	11	2	1	1	7	5	0	0.163	0.686
BA12	15	7	4	4	12	9	2	0.621	0.431
BA13	13	9	4	5	13	7	0	0.010	0.921
BA14	20	8	4	5	16	7	1	0.186	0.667
BA15	7	4	0	0	5	4	1	0.006	0.939
BA16	3	4	1	0	0	2	0	1.610	0.204
BA17	11	8	3	3	9	6	0	0.290	0.590
BA18	2	2	1	2	0	1	0	0.506	0.477
BA19	7	5	0	2	2	6	0	0.114	0.736
BA20	12	10	3	4	12	10	2	2.047	0.153
BA21	9	9	1	2	7	3	0	2.066	0.151
BA22	2	1	0	2	0	0	0	1.216	0.270

BA= Barriers, Freq=Frequency, N=Number of studies, QS= Questionnaire Survey, INT= Interview, SLR= Systematic literature review, ILR= Informal literature review, CS= Case Study , MM=Mixed Method, AR=Action Research

4.5.9 Comparison of success factors identified using empirical study, based on experience levels of survey participants

I have conducted an empirical study with SPI experts and collected total from 111 respondents. The experience level of those experts has been classified into three categories i.e. junior, intermediate and senior level experts. Those experts were considered in junior level, which has experience ranged from 1-5 years, intermediate level experts having experience ranged from 6-10 and experts having experience 11

years or above have been measured as senior level. The same criteria have been used by different other researchers (Khan, 2011; Khan, 2015).

For junior level, all the identified 21 success factors were positively cited and 56% of the junior level experts were extremely agreed to consider SF9 (3C (communication, coordination and control)) as the most significant positive success factor as shown in Table 4.26. It shows that proper communication, coordination and control infrastructure is a strong demand of junior experts working in GSD environment. Effective communication and coordination tools and techniques are claimed to assist the SPI process in a more formal way (Christiansen, LT58). SF12 (process improvement leadership) was considered to be the second most significant factor and 50% of the junior level respondents were extremely agree to mention it as a success factor. Other frequently cited factors, by junior level experts were SF1 (management commitment, 46%) and SF3 (project pilot implementation, 40%).

The results shown in Table 4.26 revealed that 57% of the intermediate level experts were extremely agreed to quote two factors i.e. SF3 (project pilot implementation) and SF9 (3C (communication, coordination and control)) as the most common success factors. As process improvement is expensive and long standing approach, therefore the pilot level implementation of the SPI program in significant to evaluate its effectiveness (Moe, & Smite, LT47). SF1 (management commitment) was indicated by 52% of the intermediate level experts as the second most important factor. Other frequently cited factors are SF7 (process improvement awareness), SF12 (process improvement leadership) and SF18 (setting process improvement goals) which have been mentioned by 48% of the experts as the extremely positive success factors for SPI implementation.

All the 21 success factors were positively acknowledged by the senior level experts participated in the survey. Table 4.26 indicates that 79% of the senior level experts were

extremely agreed to contemplate SF1 (management commitment) as the most influential success factors. This analysis shed light the significance of management commitment to SPI activities and implementation. Organization will not be able to achieve long term benefits of SPI implementation without the proper commitment of top level management (Bunditwongrat, Mathupayas, & Atcharawan, LT76). SF6 (allocation of resources) and SF18 (setting process improvement goals) were ranked as the second most success factors and positively mentioned by 64% of the senior experts.

As the nature of the collected data is ordinal, therefore I have used liner by linear Chi square test in order to measure the significant difference among different levels of experts for the success factors. Liner-by-linear Chi square test is better than Pearson Chi square test when the data is of ordinal nature (Khan, & Keung, LT10; Khan, & Khan, LT7). For this purpose, the following two hypotheses have been developed.

- Null hypothesis (H0): There is no significant difference between the different expert levels for the identified success factors identified using the survey questionnaire.
- Alternate hypothesis (H1): There is a significant difference between the different expert levels for the success factors identified using survey questionnaire

Table 4.26 present that there are more similarities than differences among the different expert levels and I have noted significant differences ($p < 0.05$) for only five factors i.e. SF1 (management commitment), SF6 (allocation of resources), SF7 (process improvement awareness), SF9 (3C's (Communication, coordination and control)) and SF13 (organizational culture). Therefore the alternate hypothesis is accepted for these five success factors and rejected the null hypothesis.

Table 4.26 Categorization of empirically identified success factors based on the experience levels of the experts

Success Factors	Respondents Experience level																					$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	Junior (N=48)							Intermediate (N=21)							Senior (N=42)									
	EA	MA	SA	ED	MD	SD	NU	EA	MA	SA	ED	MD	SD	NU	EA	MA	SA	ED	MD	SD	NU	X^2	df	P
SF1	**22**	**21**	**3**	**0**	**0**	**1**	**1**	**11**	**8**	**0**	**0**	**0**	**0**	**1**	**33**	**7**	**2**	**0**	**0**	**0**	**0**	**5.773**	**1**	**0.016**
SF2	16	18	11	0	1	2	0	8	9	3	0	0	0	0	16	16	6	1	0	0	3	0.014	1	0.906
SF3	19	14	7	0	2	3	3	12	5	2	0	0	0	1	12	24	5	0	0	0	1	2.441	1	0.118
SF4	14	22	10	0	0	1	1	9	8	0	0	0	0	3	12	21	6	1	0	0	2	0.021	1	0.886
SF5	9	24	12	1	1	0	1	9	6	4	0	0	0	1	16	18	1	0	0	0	7	0.337	1	0.561
SF6	**10**	**24**	**11**	**1**	**0**	**0**	**2**	**8**	**9**	**2**	**0**	**0**	**0**	**1**	**27**	**9**	**5**	**0**	**0**	**0**	**1**	**6.680**	**1**	**0.010**
SF7	**12**	**21**	**9**	**0**	**0**	**2**	**4**	**10**	**5**	**3**	**0**	**0**	**0**	**2**	**18**	**18**	**5**	**0**	**0**	**0**	**1**	**4.754**	**1**	**0.029**
SF8	14	23	7	1	0	1	2	5	7	7	0	0	0	4	9	19	10	0	0	0	4	1.018	1	0.313
SF9	**27**	**13**	**5**	**0**	**1**	**1**	**1**	**12**	**3**	**4**	**0**	**0**	**0**	**1**	**15**	**15**	**6**	**0**	**0**	**0**	**6**	**4.094**	**1**	**0.043**
SF10	15	16	8	0	2	4	3	7	8	4	0	0	1	0	11	18	5	0	0	0	8	0.180	1	0.671
SF11	17	21	6	0	1	2	1	8	8	3	0	0	0	3	27	9	3	0	0	0	3	0.122	1	0.290
SF12	24	18	3	0	0	0	3	10	2	7	0	0	0	1	18	18	3	0	0	1	2	0.118	1	0.732
SF13	**8**	**20**	**7**	**1**	**2**	**6**	**4**	**7**	**5**	**4**	**1**	**0**	**1**	**2**	**16**	**19**	**4**	**1**	**1**	**0**	**1**	**8.879**	**1**	**0.003**
SF14	7	19	13	1	1	2	5	6	5	6	0	0	2	1	6	19	11	0	0	1	5	0.090	1	0.764
SF15	9	15	14	1	1	0	8	4	5	6	0	1	0	4	7	11	14	0	1	0	9	0.389	1	0.533
SF16	6	21	9	0	1	5	6	2	10	2	0	0	0	6	8	13	8	0	0	1	12	0.594	1	0.441
SF17	7	15	7	2	8	3	6	7	5	4	0	0	0	4	5	16	10	0	2	0	9	0.098	1	0.754
SF18	18	23	6	0	0	1	0	10	5	2	0	0	0	3	27	12	3	0	0	0	0	2.422	1	0.120
SF19	15	18	12	0	1	0	2	7	7	3	2	0	0	1	19	18	4	0	0	0	1	2.676	1	0.102
SF20	11	19	15	1	0	0	2	9	9	1	0	0	1	0	14	20	7	0	0	0	1	2.451	1	0.117
SF21	17	16	8	1	0	0	6	8	7	3	1	0	0	1	11	11	10	1	0	2	7	1.828	1	0.176

Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA), (Extremely Disagree (ED), Moderately Disagree (MD), Slightly Disagree (SD), 'Neutral' (NS), N (No of respondents)

4.5.10 Classification of success factors identified using empirical study, based on the size of the organization

The questionnaire survey data were collected from three types of organizations i.e. small, medium and large. Table 4.27 presents the results of the classification of success factors across the reported three types of organizations. It is shown that all of the experts in small size organizations were extremely agreed with the identified 21 success factors. The respondents from small organizations cited four factors having frequency >=50%. These four factors are SF1 (management commitment, 64%), SF11 (continuous organizational support, 50%), SF12 (process improvement leadership, 53%) and SF18 (setting process improvement Goals, 56%). The most common factor is SF1 (management commitment) and 64% of the experts were extremely agreed to consider it as the most significant success factor for small size organizations. It determines that the commitment of organizational management is vital for the successful execution of process improvement activities. Management should promote awareness related to SPI, participate, finance, and acknowledge the efforts of process improvement team members (Sulyman et al., LT17).

The results presented in Table 4.27 exhibit that >=50% of the experts in medium size organizations were extremely agreed to consider success factors SF1 (management commitment, 55%) and SF9 (3C (communication, coordination and control), 50%) as the highly influential success factors. It is worth noting that SF1 (management commitment, 55%) was considered as the most significant success factor by the experts in both small and medium size organizations. The reason might be that small and medium size organizations are not much stable in various aspects and they highlighted the significance of the commitment and support of the organizational management.

For large size organizations, three success factors were found that have been quoted by more than >=50% of the respondents. The identified three factors are SF2 (staff involvement, 68%), SF11 (continuous organizational support, 52%) and SF18 (setting process improvement goals, 55%). They proclaimed SF2 (staff involvement, 68%) as the most common success factor. The implementation of process improvement program is impractical without the interest of staff members (Hall et al., LT30).

The following hypotheses have been developed in order to measure the significant differences among different sizes of organizations for the identified success factors.

- Null hypothesis (H0): There is no significant difference among the different organization sizes for the success factors identified using survey questionnaire.

- Alternate hypothesis (H1): There are significant differences among the different organization sizes for the success factors identified using survey questionnaire.

I have identified the significant difference for only single success factor i.e. SF10 (mutual understanding between team members) as shown in Table 4.27. SF10 (mutual understanding between team members) have high frequency in medium and large, but less in small size organizations. The reason might be that medium and large sized organizations have participated in various GSD projects and their team members are culturally mature. On the other hand, small organizations are typically newly developed and have not much experience to work with different other teams in offshore development.

Table 4.27 Classification of success factors based on organization size

SF	Respondents Organization Size																					$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	Small (N=36)							Medium (N=44)							Large (N=31)									
	EA	MA	SA	ED	MD	SD	NU	EA	MA	SA	ED	MD	SD	NU	EA	MA	SA	ED	MD	SD	NU	X^2	df	P
SF1	23	10	3	0	0	0	0	24	19	2	0	0	0	1	15	7	1	0	0		1	0.973	1	0.324
SF2	13	14	5	1	1	0	2	14	17	9	0	0	2	2	21	12	6	0	0	0	0	0.700	1	0.403
SF3	13	14	3	0	1	1	4	17	15	8	0	1	2	1	13	14	3	0	0	0	1	1.828	1	0.176
SF4	12	15	7	1	0	0	1	11	25	5	0	0	0	3	12	11	4	0	0	1	3	1.620	1	0.203
SF5	12	16	6	0	0	0	2	10	21	7	1	0	0	5	12	11	4	0	1	0	3	0.883	1	0.347
SF6	17	14	4	0	0	1	0	13	18	9	0	0	0	4	15	10	5	1	0	0	0	0.230	1	0.631
SF7	16	14	4	0	0	1	1	15	17	7	0	0	0	5	9	13	6	0	0	1	2	2.474	1	0.116
SF8	11	15	5	0	0	2	3	8	23	11	0	0	0	2	9	11	8	1	0	0	2	0.003	1	0.956
SF9	17	10	3	0	0	1	5	22	11	7	0	0	1	1	13	10	5	0	1	0	2	0.184	1	0.668
SF10	**10**	**12**	**5**	**0**	**1**	**2**	**6**	**12**	**17**	**7**	**0**	**0**	**3**	**5**	**12**	**13**	**5**	**0**	**1**	**0**	**0**	**6.424**	**1**	**0.011**
SF11	18	12	5	0	0	0	1	18	17	4	0	0	2	3	16	9	3	0	1	1	1	1.047	1	0.306
SF12	19	11	4	0	0	1	1	20	17	3	0	0	0	4	13	10	6	0	0	1	1	1.002	1	0.317
SF13	8	19	3	1	2	1	2	11	16	6	1	1	5	4	12	9	6	1	0	1	2	0.000	1	0.986
SF14	8	12	7	0	0	3	6	4	18	14	0	1	1	6	7	13	9	1	0	1	0	2.953	1	0.086
SF15	6	11	12	0	0	1	6	8	12	14	0	1	0	9	6	8	8	1	2	0	6	0.276	1	0.599
SF16	8	14	4	0	0	5	5	4	21	9	0	0	1	9	4	9	6	0	1	1	10	2.330	1	0.127
SF17	5	13	7	1	3	3	4	6	16	6	1	5	1	9	8	7	8	0	2	0	6	0.000	1	0.991
SF18	20	13	2	0	0	0	1	18	17	6	0	0	0	3	17	10	3	0	0	1	0	0.550	1	0.458
SF19	14	12	9	0	0	1	0	12	21	6	2	0	0	3	15	10	4	0	1	0	1	0.045	1	0.833
SF20	13	14	6	0	0	0	3	12	20	10	0	0	1	1	9	14	7	1	0	0	0	0.076	1	0.783
SF21	11	16	6	0	0	0	3	16	13	4	1	0	1	9	10	5	11	2	0	1	2	0.448	1	0.503

Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA), (Extremely Disagree (ED), Moderately Disagree (MD), Slightly Disagree (SD), 'Neutral' (NS), SF (Success Factors), N (No of respondents)

4.5.11 Classification of success factors identified using empirical study, based on the experts position

The positions of the survey respondents are classified into the groups of developers, SPI consultants, researchers, CEO and others. Others in this study mean the experts that have academic knowledge about the process improvement and GSD. The same categorization has been done in other research studies of SPI (Niazi, Wilson, & Zowghi, LT23; Niazi, & Babar, LT74; Babar, & Niazi, LT75).

The responses of the experts are divided into three main categories of 'Positive' (Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA)), 'Negative' (Extremely Disagree (ED), Moderately Disagree (MD), Slightly Disagree (SD)) and 'Neutral' (NS) as shown in Table 4.28

The positive category presents the percentage of the experts who agree with the identified success factors. The negative category shows the percentage of those respondents who consider that the identified success factors are least significant for SPI implementation. Neutral category mentioned the percentage of those experts who were not sure about the ranking of the factors.

The results reported in Table 4.28 shed light that the developers were positively agreed with the identified success factors and it's obvious from the results in the 'Positive (+Ve) category where most of the values are above 80% except for a few factors. Four success factors have been positively cited by 100% of the developers i.e. SF4 (information Sharing), SF8 (skilled human resources), SF9 (3C's (communication, coordination and control)) and SF18 (setting process improvement goals). Developers

considered these factors as the most significant success factors for SPI implementation in GSD environment.

Two factors have been positively quoted by 100% of the SPI consultants. These success factors are SF1 (management commitment) and SF6 (allocation of resources). It highlighted the importance of the management commitment and the need of adequate resources for SPI program. The management should have the ability to direct and encourage the team members to achieve the specific SPI goals and objectives otherwise the SPI program will end with failure and frustration (Bayona et al., LT21).

SF2 (staff involvement) has been positively mentioned by 100% of the researchers working in the domain of SPI and GSD. They also indicated three success factors as least significant (-Ve category). The mentioned three factors are SF15 (overseas site's response, 22%), SF16 (SPI consultancy, 27%) and SF17 (joint management infrastructure, 18%). According to the researchers, the most common least significant factor is SF16 (SPI consultancy, 27%). It shows that 27% of the researchers have rejected the importance of hiring SPI consultants for process improvement activities.

I have collected data from eight CEOs of different organizations and 100% of them positively reported the importance of 13 success factors for SPI implementation. These success factors are SF1 (management commitment), SF4 (information sharing), SF5 (process improvement expertise), SF6 (allocation of resources), SF8 (skilled human resources), SF9 (3C's (Communication, coordination and control)), SF11 (continuous organizational support), SF12 (process improvement leadership), SF14 (organizational infrastructure), SF18 (setting process improvement goals), SF19 (project pilot implementation), SF20 (process improvement evaluation) and SF21 (process improvement standards and procedures). The analysis presented in Table 4.28 revealed

that 38% of the CEOs indicated factor SF17 (joint management infrastructure) as the most least significant success factor. They were not agreed to have single management infrastructure for all the distributed teams working across geographical boundaries.

Success factor SF1 (management commitment) has been declared as the most common success factor by 100% of the experts from the "others" category. They mentioned SF16 (SPI consultancy) as the most common neutral factor. The results and analysis presented in Table 4.28 demonstrates that 60% of the respondents were not sure about the significance of success factor SF16 (SPI consultancy).

I have developed two hypotheses in order to assess the significant differences among the different positions of the experts for the reported 21 success factors.

- Null hypothesis (H0): There is no significant difference between the experts position for the factors identified using empirical study.

- Alternate hypothesis (H1): There are significant differences between the experts position for the factors identified using empirical study.

Chi square analysis test was performed in order to test the above hypotheses. The results reported in Table 4.28 mentioned that the significant difference was found for single success factor i.e. SF16 (SPI consultancy). Therefore, I have accepted the alternate hypothesis for SF16 and rejected the null hypothesis. Majority of the SPI consultants considered the SPI consultancy as the important factor to achieve the goals and objectives of successful SPI program. But factor SF16 (SPI consultancy) have low frequency of occurrence in the "others" category. The results shown in Table 4.28 demonstrates that 47% of the experts in the "others" category declined the positive impact of SPI consultancy on process improvement program.

4.5.12 Continental based comparison of success factors identified using survey questionnaire

The survey data collected from 111 experts were classified based on their respective continents. I have collected data from total five continents i.e. Asia, Europe, Australia, Africa, America (North America, South America) as shown in Table 4.29. The main reason behind the categorization of American based organizations is that most of the firms in North American countries (US, Canada etc.) are client. On the other hand the majority of organizations working in South American countries (Brazil, Argentina etc.) are vendor in nature. They might have different views and perceptions about the identified barriers.

The aim of the continent based categorization is to investigate any differences between the continents with respect to the identified success factors (Khan, & Keung, LT10; Khan, & Khan, LT7; Khan, Niazi, & Ahmad, LT1; Khan, Niazi, & Ahmad, LT28). This is because the proposed model of this research work is generic in nature that could assist any GSD organization implementing SPI program. Similarly the success factors that have an impact on SPI implementation in any continent should be taken seriously by the organizations in that particular continent.

The results presented in Table 4.29 highlighted that majority of the responses are collected from Asia and most of the success factors are positively cited by >80% of the respondents. The most positively significant factor indicated by the experts from Asian based organizations is SF1 (management commitment, 98%). It can be highlighted that the majority of the Asian organizations (India, China etc.) are vendor organizations and they consider the commitment of the organization management as the most vital success factor in order to avoid any risks related to SPI implementation in GSD. They also

indicated SF17 (joint management infrastructure) as the least significant success factor for SPI implementation in distributed software development. They rejected to consider SF17 (joint management infrastructure) as the positive success factor, because 21% of the Asian respondents were not agreed to establish joint management infrastructure with other distributed team.

In the context of European based organizations, 100% of the respondents acknowledged SF18 (setting process improvement goals) as the most effective success factor. Most of the European based organizations are well established and they adopted the formal techniques and methodologies for software development processes. Therefore the respondents of this survey focused to set all the goals and objectives of process improvement prior to SPI initiation. They have considered SF15 (overseas site's response, 46%) as the most common neutral factor. It shows that 46% of the experts were not aware of the significance of factor SF15 (overseas site's response).

Total four responses were collected from Australian based organizations and majority of them were positively agreed with the identified 21 success factors. They have highlighted SF21 (process improvement standards and procedures, 75%) as the most neutral success factors. They were not sure about the criticality of adopting formal process improvement standards and techniques. It might be due to the reason that most of the organizations prefer to use their own standards and methodologies or follow the informal ways to implement process improvement activities.

The experts positioned in African based organizations have highlighted eleven factors as the most common success factors for the deployment of process improvement activities. The reported eleven factors are SF2 (staff involvement), SF3 (project pilot implementation), SF5 (process improvement expertise), SF6 (allocation of resources),

SF7 (process Improvement awareness), SF10 (mutual understanding between team members), SF12 (process improvement leadership), SF14 (organizational infrastructure), SF18 (setting process improvement goals), SF20 (process improvement evaluation) and SF21 (process improvement standards and procedures). These factors were positively reported by 100% of the responses collected from Africa.

It was identified that most of the success factors were positively cited by ≥ 90% of the experts employed in North America. They have acknowledged SF13 (organizational culture, 60%) as the least significant factor. The main reason behind this consideration might be that most of the North American countries (USA, Canada etc.) are multi-cultural and they are inhabited by the people from diverse cultural backgrounds. Therefore the respondents of the survey have not quoted the organizational culture as the most significant success factor. They have deep understanding and knowledge of various cultural norms and values.

Similarly twelve success factors were mentioned by 100% of the feedbacks collected from South America as shown in Table 4.29. A single factor SF16 (SPI consultancy, 75%) was classified as the most neutral success factor. They were not sure about that in which extent the SPI consultancy can assist the implementation of process improvement activities.

Linear-by-linear association test was used in order to calculate the significant differences among the different continents for the success factors identified in the survey questionnaire. To check any significant difference, the following hypotheses have been developed:

Null hypothesis (H0): There is no significant difference among the continents which are used to discuss the identified success factors.

Alternate hypothesis (H1): There are significant differences among the continents which are used to discuss the identified success.

Using the selected test for comparison among the success factors based on the continents, Table 4.29 shows the significant differences for three success factor, i.e. SF6 (allocation of resources), SF9 (3C's (communication, coordination and control)) and SF13 (organizational culture) as the value of 'P' is <0.05. Therefore the null hypothesis is rejected and alternate hypothesis is accepted for these three factors. SF6 (allocation of resources) has been shed light as the most significant positive factor by 100% of the respondents in Australia, Africa and America (North, South). Similarly SF9 (3C's (communication, coordination and control)) has a high positive percentage in Africa (100%) and Asia (97%). It might be due to the reason that majority of organizations working in Asia and Africa are vendor organizations and they have not mature infrastructure that could assist to overcome communication and coordination issues. The third most significant factor SF13 (organizational culture) has high positive percentage in all the continents except North America (30%). The major cause of this result might be the diverse cultural environment of North American (USA, Canada etc.) countries. They might not face cultural issues as their societies consist of people having diverse cultural backgrounds.

Table 4.28 Classification of success factors based on respondent's position

SF	Respondents Position															$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	Developers (N=27)			**SPI Consultants (N=14)**			**Researchers (N=45)**			**CEO (N=8)**			**Others (N=17)**					
	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	X^2	df	P
SF1	96	0	4	100	0	0	96	2	2	100	0	0	100	0	0	1.210	1	0.271
SF2	93	4	4	79	7	14	100	0	0	87	0	13	88	12	0	0.484	1	0.487
SF3	89	11	0	93	0	7	98	0	2	75	0	25	76	12	12	2.728	1	0.099
SF4	100	0	0	85	0	14	89	2	9	100	0	0	88	6	6	2.781	1	0.095
SF5	96	0	4	93	7	0	87	2	11	100	0	0	76	6	18	3.617	1	0.057
SF6	96	0	4	100	0	0	96	2	2	100	0	0	88	0	12	0.571	1	0.450
SF7	93	0	7	93	7	0	89	2	9	87	12	0	94	0	6	0.240	1	0.624
SF8	100	0	0	79	7	14	91	2	7	100	0	0	82	6	12	1.797	1	0.180
SF9	100	0	0	79	0	21	87	4	9	100	0	0	88	0	12	2.652	1	0.103
SF10	85	11	4	71	7	14	96	2	2	63	12	25	65	12	24	3.110	1	0.078
SF11	96	0	4	86	0	14	91	7	2	100	0	0	88	6	6	0.538	1	0.463
SF12	96	0	4	86	0	14	96	0	4	100	0	0	83	6	12	1.282	1	0.258
SF13	74	15	11	93	7	0	87	7	7	75	12	12	71	24	6	0.531	1	0.466
SF14	85	4	11	79	0	21	84	7	9	100	0	0	71	18	12	0.058	1	0.810
SF15	81	0	19	85	14	0	71	7	22	88	0	12	71	0	29	1.782	1	0.182
SF16	**78**	**15**	**7**	**86**	**0**	**14**	**71**	**2**	**27**	**75**	**25**	**0**	**47**	**0**	**60**	**6.701**	**1**	**0.010**
SF17	59	22	25	79	0	21	76	7	18	38	38	25	71	18	12	0.381	1	0.537
SF18	100	0	0	93	7	0	96	2	2	100	0	0	88	0	12	1.490	1	0.222
SF19	96	0	4	86	0	14	93	4	4	100	0	0	88	6	6	0.017	1	0.896
SF20	93	0	7	93	7	0	98	2	0	100	0	0	88	6	6	1.712	1	0.191
SF21	89	0	11	57	14	29	84	7	9	100	0	0	76	6	18	0.004	1	0.950

Positive category of responses (+VE), Negative category of responses (-VE %), Neutral category of responses (NU), Success Factors (SF), N (No of respondents)

Table 4.29 Classification of success factors based on continents

SF	Continent																				
	Asia (N=68)			Europe (19)			Australia (N=4)			Africa (N=6)			North America (N=10)			South America (N=4)			$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	X^2	df	P
SF1	98	1	1	79	11	11	100	0	0	83	0	17	100	0	0	100	0	0	0.183	1	0.669
SF2	94	4	1	95	0	5	50	0	50	100	0	0	100	0	0	100	0	0	0.513	1	0.474
SF3	87	7	6	95	0	5	100	0	0	100	0	0	100	0	0	100	0	0	3.787	1	0.052
SF4	93	1	6	89	0	11	100	0	0	83	17	0	90	0	10	100	0	0	0.447	1	0.504
SF5	93	2	4	79	0	21	50	0	50	100	0	0	90	0	10	50	50	0	0.223	1	0.637
SF6	**94**	**1**	**5**	**95**	**0**	**5**	**100**	**0**	**0**	**100**	**0**	**0**	**100**	**0**	**0**	**100**	**0**	**0**	**4.934**	**1**	**0.026**
SF7	90	3	7	89	0	11	100	0	0	100	0	0	100	0	0	100	0	0	2.794	1	0.065
SF8	93	3	4	89	0	11	50	0	50	50	50	0	70	0	30	75	0	25	0.130	1	0.718
SF9	**97**	**3**	**0**	**79**	**0**	**21**	**75**	**0**	**25**	**100**	**0**	**0**	**83**	**0**	**17**	**50**	**0**	**50**	**7.430**	**1**	**0.006**
SF10	84	10	6	79	0	21	50	0	50	100	0	0	90	0	10	75	0	25	0.071	1	0.791
SF11	93	4	3	89	0	11	100	0	0	83	17	0	100	0	0	100	0	0	0.301	1	0.583
SF12	94	0	6	89	5	5	100	0	0	100	0	0	100	0	0	75	0	25	0.893	1	0.345
SF13	**84**	**10**	**9**	**89**	**5**	**5**	**100**	**0**	**0**	**83**	**17**	**0**	**30**	**60**	**10**	**100**	**0**	**0**	**7.329**	**1**	**0.007**
SF14	82	7	11	79	5	16	50	0	50	100	0	0	100	0	0	75	0	25	1.331	1	0.249
SF15	79	4	16	68	0	46	100	0	0	50	17	33	90	0	10	75	0	25	0.000	1	0.993
SF16	74	9	18	63	0	37	50	0	50	83	0	17	80	10	10	25	0	75	0.060	1	0.807
SF17	66	21	13	68	0	32	75	0	25	83	0	17	80	10	10	100	0	0	0.484	1	0.487
SF18	94	1	5	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	1.112	1	0.292
SF19	93	4	3	95	0	5	100	0	0	83	0	17	100	0	0	100	0	0	0.464	1	0.496
SF20	94	3	3	95	0	5	100	0	0	100	0	0	100	0	0	100	0	0	1.325	1	0.250
SF21	84	4	12	74	5	21	25	0	75	100	0	0	70	0	30	75	0	25	0.047	1	0.828
Positive category of responses (+VE), Negative category of responses (-VE %), Neutral category of responses (NU), Success Factors (SF), N (No of respondents)																					

4.5.13 Comparison of barrier identified using empirical study, based on experience levels of survey respondents

In this research work, the empirical study was conducted with SPI experts and total of 111 survey responses were collected. The experience levels of those experts have been classified into three categories i.e. junior, intermediate and senior level experts. Those experts were considered in junior level which have experience ranged from 1-5 years, intermediate level experts having experience ranged from 6-10 and experts having experience 11 years or above have been reported as senior level. The same criteria have been used by other researchers (Khan, 2011; Khan, 2015).

In Table 4.30 the results indicate that ≥ 50% of the junior level experts were extremely agreed to mention four barriers as the most significant. These barriers are BA10 (organizational politics, 50%), BA12 (lack of resources, 60%), BA13 (lack of communication, 73%) and BA20 (lack of formal SPI implementation methodology, 54%). It is worth noting that BA13 (lack of communication, 73%) has the highest percentage in junior level category. It is argued that strong communication is the root factor to accomplish the projects performed under various geographical boundaries. Because a proper interaction is required to solve the issues of SPI, to notice the progress, build team coordination, negotiation between the team members and organization (Taweel et al., LT35; Christiansen, LT58; Anandasiyam, Mukhopadhyay, & Krishnan, LT67). I have also noticed that 8% of the junior level experts were extremely disagree to consider BA8 (personality clashes) as the barrier for SPI implementation. It means that few respondents were not agreed to classify (personality clashes) as the barrier for the SPI program.

Two barriers BA20 (lack of formal SPI implementation methodology, 52%) and BA21 (lack of implementation tools and standards, 52%) were cited by ≥ 50% of the

intermediate level experts as the extremely critical barriers. The formal SPI implementation methodology included complete process deployment strategy, process improvement activities, tasks, and measures to be used throughout the process improvement implementation (Niazi, Babar, & Verner, LT16). (Dutra, & Santos, LT39) also postulated that without any other barriers, lack of tools might be the superseding problem for SPI success. The intermediate level experts mentioned BA10 (organizational politics, 48%) as the second most common barrier that could negatively impact the SPI process.

It is indicated in Table 4.30 that ≥ 50% of the senior level respondents were extremely agreed to consider four barriers as the most significant barriers. The barrier BA13 (lack of communication, 62%) was mentioned as the most common barrier having high percentage of occurrence. Second, most significant barriers are BA14 (lack of organizational support) and BA19 (lack of sponsorship) which were mentioned by the 55% of the experts. BA12 (lack of resources, 50%) has been quoted as the third most barrier in the views of the senior level experts.

The following hypotheses have been developed and tested by the selected chi-square test in order to measure the significant differences among the different groups of experts based on their experience level.

Null hypothesis (H0): There is no significant difference between the different expert levels for the barriers identified using survey questionnaire.

Alternate hypothesis (H1): There are significant differences among the different expert levels for the barriers identified using survey questionnaire.

Significant differences were found for four barriers between the different groups of experts. Therefore the alternate hypothesis is accepted for these four barriers and rejected the null hypothesis. These barriers are BA2 (staff turnover), BA11 (time

pressure), BA19 (lack of sponsorship) and BA22 (stalling on action plan implementation). It shows that there are more similarities than differences among the expert's levels related to the identified barriers. BA2 (staff turnover) has the highest percentage of occurrence in senior level experts and lower in the other two categories as shown in Table 4.30. Similarly BA11 (time pressure) and BA19 (lack of sponsorship) were also highly cited by the senior level experts, but low attention has been given by the junior and intermediate level experts. BA22 (stalling on action plan implementation) has a high frequency in the responses collected from junior level experts but lower in the category of senior experts.

Table 4.30 Classification of empirically identified barriers based on the experience levels of the experts

Barriers	Respondents Experience level																					$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	Junior (N=48)							Intermediate (N=21)							Senior (N=42)									
	EA	MA	SA	ED	MD	SD	NU	EA	MA	SA	ED	MD	SD	NU	EA	MA	SA	ED	MD	SD	NU	X^2	df	P
BA1	10	21	13	1	1	1	1	7	7	4	0	1	0	2	16	9	9	0	1	2	5	0.884	1	0.347
BA2	**7**	**19**	**7**	**2**	**2**	**7**	**4**	**3**	**10**	**6**	**0**	**1**	**1**	**0**	**13**	**15**	**8**	**0**	**2**	**1**	**3**	**4.042**	**1**	**0.044**
BA3	9	10	12	2	4	6	5	5	5	7	2	0	1	1	9	31	25	4	5	9	13	0.822	1	0.365
BA4	7	15	18	1	2	2	3	7	7	3	1	0	0	3	17	15	4	0	0	2	4	1.866	1	0.172
BA5	11	18	11	1	2	4	1	6	7	1	1	2	1	3	11	18	8	0	1	2	2	0.219	1	0.640
BA6	9	27	7	0	2	0	3	5	9	3	1	0	2	1	14	14	9	0	1	1	3	0.001	1	0.976
BA7	10	19	12	0	2	4	1	6	7	6	1	1	0	0	17	12	8	0	0	2	3	0.740	1	0.390
BA8	7	15	7	4	7	4	4	5	2	8	0	1	2	3	11	13	12	0	0	0	6	2.156	1	0.142
BA9	14	10	13	0	2	7	2	6	7	6	0	0	1	1	16	12	8	1	0	2	3	1.716	1	0.190
BA10	24	17	3	1	2	1	0	10	6	2	1	0	1	1	18	15	7	0	0	1	1	0.287	1	0.592
BA11	**13**	**23**	**7**	**2**	**0**	**1**	**2**	**7**	**5**	**7**	**1**	**1**	**0**	**0**	**19**	**18**	**5**	**0**	**0**	**0**	**0**	**6.042**	**1**	**0.014**
BA12	29	13	0	1	1	1	3	9	6	4	1	0	1	0	21	12	7	1	0	0	1	0.039	1	0.844
BA13	35	6	1	2	1	1	2	9	8	1	2	0	0	1	26	11	2	0	0	0	3	0.036	1	0.850
BA14	22	14	6	1	3	0	2	9	6	3	1	0	0	2	23	12	3	0	0	1	3	0.127	1	0.721
BA15	8	11	9	2	2	12	4	6	5	5	1	2	0	2	3	16	11	0	1	5	6	0.242	1	0.623
BA16	11	18	8	2	1	1	7	8	4	6	0	0	1	2	12	17	5	0	0	2	6	0.147	1	0.702
BA17	10	21	10	1	2	0	4	5	9	5	0	0	1	1	11	19	5	1	0	2	4	0.002	1	0.966
BA18	10	20	5	1	2	7	3	6	9	4	0	0	0	2	18	11	6	0	0	4	3	1.618	1	0.203
BA19	**8**	**15**	**9**	**2**	**3**	**6**	**5**	**7**	**6**	**6**	**0**	**0**	**0**	**2**	**23**	**10**	**6**	**0**	**0**	**0**	**3**	**1.506**	**1**	**0.001**
BA20	26	12	6	1	1	1	1	11	6	4	0	0	0	0	16	16	5	0	0	2	3	1.727	1	0.189
BA21	12	29	2	1	1	1	2	11	6	4	0	0	0	0	11	18	6	0	0	3	4	1.777	1	0.183
BA22	**10**	**12**	**12**	**2**	**2**	**3**	**7**	**8**	**5**	**4**	**0**	**0**	**2**	**2**	**9**	**22**	**8**	**0**	**0**	**0**	**3**	**5.094**	**1**	**0.024**

Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA), (Extremely Disagree (ED), Moderately Disagree (MD), Slightly Disagree (SD), Neutral (NS), N (No of respondents)

4.5.14 Categorization of barriers identified using empirical study, based on the size of organization

The survey questionnaire of this research work was distributed among the SPI experts in different small, medium and large sized organizations. The key objective for collecting the data from multi sized organizations is to present the proposed software process improvement implementation and management model as a generic GSD model.

The analyses discussed in Table 4.31 indicate that all the identified 22 barriers have been extremely agreed by the experts responded from small organizations. Among these 22 barriers, three barriers i.e. BA5 (lack of process improvement knowledge, 62%), BA12 (lack of resources, 58) and BA14 (lack of organizational support, 56%) have been cited by ≥ 50% of the experts answered from small size organizations. BA5 (lack of process improvement knowledge, 62%) was mentioned to be the highest ranked barrier by the responses collected from small sized organizations. It shows that small sized organizations have more concern about the deep understanding and knowledge of the SPI activities. They reported BA12 (lack of resources, 58) as the second most significant barrier for SPI implementation.

Three barriers, i.e. BA10 (organizational politics, 55%), BA12 (lack of resources, 52%) and BA20 (lack of formal SPI implementation methodology, 55%) have been extremely cited by ≥ 50% of the experts responded from the medium sized organizations. BA13 (lack of communication, 7%) was categorised as the highest rank least significant barrier in the domain of medium sized organizations.

It was found that barrier BA12 (lack of resources, 55%) has been extremely cited by ≥ 50% of the experts of large organizations. The same fact has been shed light by

(Kautz, & Nielsen; LT8) in an empirical study. They pointed out that team managers were uncertain to allocate resources for SPI activities using their own project budget. They suggested that organizations might adopt a more open-minded and positive attitude towards SPI programs and provide all the estimated resources.

It is worth noting that barrier BA12 (lack of resources) is the most common barrier among all the three types (small, medium, large) of the organizations. This demonstrates that the respondents consider barrier BA12 (lack of resources) as the most important barrier that need to be properly addressed by all types of organizations during SPI implementation.

I have developed the following two hypotheses in order to evaluate the significant differences for the identified barriers based on the size of the organizations.

- Null hypothesis (H0): There is no significant difference among the different organizations size for the barriers identified using survey questionnaire.

- Alternate hypothesis (H1): There are significant differences among the organizations size for the barriers identified using survey questionnaire.

I have calculated the significant difference for single barrier i.e. BA21 (lack of implementation tools and standards). BA21 (lack of implementation tools and standards) has the highest percentage of occurrence in small sized organizations but low percentage in medium and large sized organizations. It may be due to the fact that medium and large sized organizations are much more stable and mature as compared to small organizations. They usually adopt the formal SPI implementation tools and techniques.

Table 4.31 Classification of empirically identified barriers based on the size of the organizations

BA	Organization Size																					$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	Small (N=36)							Medium (N=44)							Large (N=31)									
	EA	MA	SA	ED	MD	SD	NU	EA	MA	SA	ED	MD	SD	NU	EA	MA	SA	ED	MD	SD	NU	X^2	df	P
BA1	15	8	7	0	1	2	3	12	15	13	1	1	0	2	6	14	5	0	1	1	4	1.203	1	0.273
BA2	8	12	7	0	3	5	1	6	21	9	2	0	3	3	9	11	6	0	2	0	3	0.590	1	0.442
BA3	6	10	5	0	3	5	7	13	13	8	2	2	3	3	4	8	12	2	0	1	4	1.158	1	0.282
BA4	8	14	8	0	0	2	4	13	12	11	2	1	1	4	10	11	6	0	1	1	2	0.621	1	0.431
BA5	22	8	2	0	1	2	1	19	8	8	1	2	3	3	12	6	6	1	2	1	3	2.683	1	0.101
BA6	9	16	8	0	1	1	0	9	23	5	1	1	0	5	10	11	6	0	1	1	2	0.463	1	0.496
BA7	8	14	9	0	1	2	2	13	16	8	1	1	4	1	12	8	9	0	1	0	1	0.978	1	0.323
BA8	8	9	5	2	3	1	8	11	13	10	2	3	3	2	4	8	11	0	2	2	4	0.048	1	0.826
BA9	13	6	8	0	1	5	3	13	13	12	0	1	4	1	10	10	6	1	1	1	2	0.738	1	0.390
BA10	15	13	4	0	1	1	1	24	16	1	2	0	1	0	13	9	7	0	1	0	1	0.003	1	0.956
BA11	11	16	6	0	0	0	3	16	19	6	2	0	1	0	12	11	7	1	0	0	0	0.779	1	0.377
BA12	21	11	3	0	0	0	0	23	10	3	2	1	1	4	17	8	4	1	0	1	0	1.184	1	0.277
BA13	17	17	1	0	0	0	1	18	16	1	3	1	1	4	14	13	2	0	0	0	2	0.332	1	0.565
BA14	20	13	0	0	0	1	2	20	9	7	2	2	0	4	14	10	4	0	1	1	1	0.867	1	0.352
BA15	5	9	9	0	1	5	7	9	15	6	2	3	6	3	3	7	10	0	2	6	3	0.002	1	0.966
BA16	9	15	8	0	0	0	4	13	13	6	1	1	2	8	8	11	5	1	0	2	4	0.991	1	0.319
BA17	9	17	6	0	0	2	2	9	18	8	1	2	1	5	8	13	6	1	0	1	2	0.145	1	0.704
BA18	11	14	4	0	1	4	2	11	16	8	1	1	2	5	11	10	3	0	0	5	2	0.247	1	0.619
BA19	16	10	4	0	2	3	1	12	11	9	1	1	3	7	10	9	9	1	0	0	2	0.053	1	0.819
BA20	16	13	6	0	0	0	1	24	12	3	1	1	2	1	12	9	6	0	0	1	3	3.840	1	0.050
BA21	**12**	**18**	**5**	**0**	**0**	**0**	**1**	**13**	**24**	**1**	**1**	**1**	**1**	**3**	**8**	**11**	**6**	**0**	**0**	**3**	**3**	**6.870**	**1**	**0.009**
BA22	9	15	7	0	1	1	3	10	11	10	1	1	4	7	7	13	7	1	0	0	3	0.116	1	0.733

Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA), (Extremely Disagree (ED), Moderately Disagree (MD), Slightly Disagree (SD), 'Neutral' (NS), BA (Barriers), N (No of respondents)

4.5.15 Categorization of the barriers identified using empirical study, based on the position of the survey respondents

I have categorised the position of the respondents into the groups of developers, SPI consultants, researchers, CEO and others. The experts who are reported in the "other" category have academic knowledge about the process improvement and GSD. The same categorization has been done by different other researchers for the same nature of studies (Niazi, Wilson, & Zowghi, LT23; Niazi, & Babar, LT74; Babar, & Niazi, LT75).

The responses of the experts are divided into three main categories of 'Positive' (Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA)), 'Negative' (Extremely Disagree (ED), Moderately Disagree (MD), Slightly Disagree (SD)) and 'Neutral' (NS) as shown in Table 4.32

All those responses are considered in positive category who agreed with the identified barriers. The negative category shows the percentage of those respondents who consider that the identified barriers are less significant for SPI implementation. Neutral category indicates the percentage of those experts who were not sure about the positive or negative categorization of the barriers.

The analysis presented in Table 4.32 highlighted that all the identified barriers have been positively cited by the developers. Most of the barriers are positively cited by ≥ 80% of the developers. Three barriers, i.e. BA1 (inexperienced staff), BA11 (time pressure) and BA20 (lack of formal SPI implementation methodology) are reported by 96% of the developers as the most significant barriers. Two barriers were quoted as the least significant barriers (negative category) by the developers. The reported least

significant barriers are BA3 (cultural difference, 26%) and BA15 (temporal distance, 26%). It means that 26% of the developers were not agreed to consider BA3 (cultural difference) and BA15 (temporal distance) as the barriers for SPI implementation in the domain of GSD.

Two barriers have been mentioned by 100% of the SPI consultants as the most important barriers. These barriers are BA11 (time pressure) and BA12 (lack of resources). SP consultants were more concern about the lack of resources and the time pressure that team members face during the execution of SPI activities. It might be due to the fact that SPI is a long standing approach and need adequate resources to achieve its core objectives.

The results discussed in Table 4.32 shows that all the 22 identified barriers are positively cited by the researchers working in the domain of SPI and GSD. The barrier BA11 (time pressure) has been specified by 93% of the researchers as the most significant barrier for implementing process improvement program. They also mentioned BA15 (temporal distance, 20%) as the least significant barrier. Twenty percent of the researchers rejected to consider the temporal distance as the barrier for SPI implementation in GSD.

In this research survey, I have collected data from eight CEOs of different organizations. The analysis of their responses demonstrates that 100% of the CEOs mentioned nine barriers as the most important barriers. These barriers are BA4 (lack of trust), BA6 (lack of training), BA11 (time pressure), BA12 (lack of resources), BA13 (lack of communication), BA16 (poor organizational infrastructure), BA17 (budget constraints), BA20 (lack of formal SPI implementation methodology) and BA21 (lack of implementation tools and standards).

For other category, two barriers have been mentioned by 94% of the experts as the most common barriers. These barriers are BA7 (lack of feedback) and BA11 (time pressure). BA15 (temporal distance) was cited as the least significant barrier by the experts classified in the others category.

The observations and analysis discussed in the context of different types of experts clarify that BA11 (time pressure) was mentioned by all groups of experts as the most significant barrier (Table 4.32). Similarly BA15 (temporal distance) was specified as the least significant barrier by all groups of experts. The organizational management should consider these two barriers as the most significant and least significant barriers.

The following two hypotheses have been developed to evaluate the significant differences among the different groups of experts.

- Null hypothesis (H0): There is no significant difference between the experts position for the barriers identified using empirical study.

- Alternative hypothesis (H1): There are significant differences between the experts position for the barriers identified using empirical study.

The significant difference was found for single barrier i.e. BA10 (organizational politics). This is because it's have low positive percentage in the 'others' category but high positive occurrence in the category of 'SPI consultants'. Therefore, the null hypothesis has been rejected and accepted the alternate hypothesis for barrier BA10 (organizational politics).

Table 4.32 Classification of empirically identified barriers based on the different groups of experts

BA	Respondents Position															$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	Developers (N=27)			SPI Consultants (N=14)			Researchers (N=45)			CEO (N=8)			Others (N=17)					
	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	X^2	df	P
BA1	96	4	0	64	14	21	89	7	4	88	12	0	76	6	18	0.060	1	0.807
BA2	74	22	4	71	14	14	84	7	9	75	12	12	83	18	0	0.405	1	0.525
BA3	59	26	15	71	14	14	80	11	9	75	12	12	65	24	12	0.705	1	0.401
BA4	78	11	11	93	0	7	84	7	9	100	0	0	71	12	17	0.001	1	0.970
BA5	85	11	4	71	21	7	80	13	7	88	12	0	88	0	12	0.119	1	0.730
BA6	93	0	7	71	21	7	87	7	7	100	0	0	88	0	12	0.000	1	0.989
BA7	93	7	0	71	7	21	87	7	4	75	25	0	94	6	0	0.112	1	0.738
BA8	67	22	11	71	7	21	78	13	9	75	25	0	59	24	18	0.541	1	0.462
BA9	78	19	4	79	21	7	91	2	7	88	12	0	65	24	12	0.458	1	0.498
BA10	**78**	**11**	**11**	**93**	**0**	**7**	**91**	**2**	**7**	**88**	**12**	**0**	**65**	**24**	**12**	**4.976**	**1**	**0.026**
BA11	96	0	4	100	0	0	93	4	4	100	0	0	94	6	0	0.696	1	0.404
BA12	93	0	7	100	0	0	91	7	2	100	0	0	76	18	6	0.649	1	0.420
BA13	93	4	4	93	0	7	87	7	7	100	0	0	82	6	12	1.344	1	0.246
BA14	93	0	7	86	7	7	87	11	2	88	0	12	82	6	12	0.782	1	0.377
BA15	59	26	15	71	14	14	67	20	13	75	25	0	65	29	6	0.193	1	0.660
BA16	85	4	11	71	7	21	76	7	18	100	0	0	76	12	12	0.000	1	0.991
BA17	89	4	7	79	21	7	91	4	4	100	0	0	59	18	24	1.774	1	0.183
BA18	78	15	7	86	14	0	89	9	2	63	37	0	59	12	29	2.128	1	0.145
BA19	74	15	11	71	14	14	84	4	12	75	12	12	71	18	12	0.045	1	0.832
BA20	96	4	0	86	14	0	89	4	7	100	0	0	88	6	6	0.174	1	0.677
BA21	93	0	7	71	21	7	89	7	4	100	0	0	88	6	6	0.158	1	0.691
BA22	67	15	19	86	0	14	87	7	7	88	0	12	76	12	12	0.375	1	0.540

Positive category of responses (+VE), Negative category of responses (-VE %), Neutral category of responses (NU), Barriers (BA), N (No of respondents)

4.5.16 Continental based comparison of barriers identified using survey questionnaire

The survey questionnaire was distributed among the SPI experts working across different continents. The data collected from the experts were categorized into five continents i.e. Asia, Europe, Australia, Africa, America (North America, South America) as shown in Table 4.33. The aim of this categorization is to investigate any differences in these continents with respect to identified barriers (Khan, & Keung, LT10). This is because the proposed model of this research work is generic in nature that could assist any GSD organization implementing SPI program. Similarly the barriers that have an impact on SPI implementation in any continent should be taken seriously by the organizations in that particular continent (Khan, & Keung, LT10).

The analysis expert's respondents from Asian countries were positively agreed with the identified 22 barriers. Five barriers were mentioned as the most significant barriers which have been positively cited by 91% of the respondents. These barriers are BA1 (inexperienced staff), BA10 (organizational politics), BA11 (time pressure), BA17 (budget constraints) and BA20 (lack of formal SPI implementation methodology). BA15 (temporal distance) was mentioned by 29% of the respondents as the least significant barrier.

The barrier BA11 (time pressure) has been positively cited by 100% of the responses received from European based organizations. They also specified BA15 (temporal distance) as the least significant barrier which has been quoted by 21% of the respondents in the negative category.

I have collected data from four experts working in the Australian based organizations and 100% of the four experts have mentioned BA4 (lack of trust), BA8 (personality clashes), BA9 (workload), BA11 (time pressure), BA12 (lack of resources), BA13 (lack of communication), BA14 (lack of organizational support), BA17 (budget constraints) and BA18 (organizational changes) as the most significant barriers.

The experts responded from Africa were 100% agreed to consider eight barriers as the most common barriers for SPI implementation. These barriers are BA1 (inexperienced staff), BA7 (lack of feedback), BA9 (workload), BA11 (time pressure), BA12 (lack of resources), BA18 (organizational changes), BA20 (lack of formal SPI implementation methodology) and BA21 (lack of implementation tools and standards). Barriers BA14 (lack of organization support) and BA16 (poor organizational infrastructure) were specified by 33% of the respondents as the most neutral barrier. It means that experts responded from Africa were not sure about the significance of the support provided by the organizational management as well the poor organizational infrastructure.

The experts working in North American countries were 100% agreed to consider the barriers BA1 (inexperienced staff), BA2 (staff turnover), BA10 (organizational politics), BA11 (time pressure), BA12 (lack of resources), BA19 (lack of sponsorship) and BA20 (lack of formal SPI implementation methodology) as the most significant barriers. Similarly the responses received from the South American based organization were 100% agreed to consider thirteen barriers as the most important barriers. These barriers are BA1 (inexperienced staff), BA2 (staff turnover), BA3 (cultural difference), BA5 (lack of process improvement knowledge), BA11 (time pressure), BA12 (lack of resources), BA13 (lack of communication), BA15 (temporal distance), BA17 (budget constraints), BA18 (organizational changes), BA19 (lack of sponsorship) and BA20

(lack of formal SPI implementation methodology) and BA22 (stalling on action plan implementation).

The results demonstrate that the data collected from both North and South American experts have some similarities and differences. Total six barriers were found to be common in both North and South American countries. These common barriers are BA1 (inexperienced staff), BA2 (staff turnover), BA11 (time pressure), BA12 (lack of resources), BA19 (lack of sponsorship) and BA20 (lack of formal SPI implementation methodology).

The entire discussion of the barriers in the context of the various continents shed light that all the experts from the reported continents have indicated BA11 (time pressure) as the most significant barriers. It summaries that the SPI teams working in various continents have shown a need of enough time in order to successfully execute the activities related to process improvement implementation. It is due to the fact that SPI is a long term approach.

To calculate the significant difference among different continents for the identified barriers, linear-by-linear association test was used. To check any significant difference, the following hypotheses have been developed:

Null hypothesis (H0): There is no significant differences among the continents which are used to discuss the identified barriers.

Alternate hypothesis (H1): There are significant differences among the continents which are used to discuss the identified barriers.

Using the selected Chi square test for comparison among the different continents for the identified barriers, Table 4.33 shows the significant difference for three barriers, i.e. BA2 (staff turnover), BA18 (organizational changes) and BA19 (lack of sponsorship) as the value of 'P' is <0.05. Therefore the null hypothesis is rejected and alternate hypothesis is accepted for these three barriers.

Table 4.33 Classification of empirically identified barriers based on the continents

BA	Continent																		$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$ (linear-by-linear association) $\alpha = 0.05$		
	Asia (N=68)			Europe (19)			Australia (N=4)			Africa (N=6)			North America (N=10)			South America (N=4)					
	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	+VE %	-VE %	NU %	X^2	df	P
BA1	91	7	1	58	5	37	50	50	0	100	0	0	100	0	0	100	0	0	0.717	1	0.397
BA2	**74**	**18**	**9**	**89**	**5**	**5**	**50**	**50**	**0**	**83**	**17**	**0**	**100**	**0**	**0**	**100**	**0**	**0**	**5.977**	**1**	**0.014**
BA3	82	21	12	89	5	5	50	50	0	50	16	33	70	10	20	100	0	0	0.198	1	0.657
BA4	79	9	12	95	0	5	100	0	0	67	17	17	90	10	0	75	25	0	0.581	1	0.209
BA5	82	13	4	84	5	11	50	50	0	67	17	17	90	10	0	100	0	0	0.067	1	0.796
BA6	90	4	6	95	0	5	25	50	25	67	17	17	90	10	0	50	0	50	0.057	1	0.812
BA7	87	10	3	95	0	5	50	0	50	100	0	0	80	10	10	75	25	0	0.200	1	0.655
BA8	66	22	12	79	11	11	100	0	0	67	17	17	90	0	10	75	0	25	0.560	1	0.454
BA9	81	16	3	79	5	16	100	0	0	100	0	0	90	10	0	75	0	25	2.061	1	0.151
BA10	91	7	2	89	5	5	75	25	0	83	0	17	100	0	0	75	25	0	0.324	1	0.569
BA11	91	6	3	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	1.290	1	0.256
BA12	88	7	4	89	5	5	100	0	0	100	0	0	100	0	0	100	0	0	0.219	1	0.270
BA13	87	6	7	95	0	5	100	0	0	83	17	0	90	10	0	100	0	0	0.648	1	0.421
BA14	88	9	3	95	0	5	100	0	0	67	0	33	80	0	20	25	50	25	0.639	1	0.424
BA15	65	29	6	58	21	21	25	0	75	67	17	17	90	0	10	100	0	0	0.318	1	0.573
BA16	82	9	9	68	5	26	50	0	50	67	0	33	90	0	10	75	0	25	0.656	1	0.418
BA17	91	6	9	84	5	11	100	0	0	83	17	0	90	10	0	100	0	0	0.053	1	0.818
BA18	**72**	**18**	**10**	**89**	**5**	**5**	**100**	**0**	**0**	**100**	**0**	**0**	**90**	**10**	**0**	**100**	**0**	**0**	**0.959**	**1**	**0.008**
BA19	**72**	**16**	**12**	**95**	**0**	**5**	**75**	**25**	**0**	**83**	**0**	**17**	**100**	**0**	**0**	**100**	**0**	**0**	**7.556**	**1**	**0.006**
BA20	91	6	3	89	0	11	50	50	0	100	0	0	100	0	0	100	0	0	0.031	1	0.861
BA21	90	6	4	79	5	16	50	50	0	100	0	0	60	20	20	25	50	25	0.430	1	0.512
BA22	76	12	12	84	5	12	100	0	0	83	0	17	90	0	10	100	0	0	0.142	1	0.143
Positive category of responses (+VE), Negative category of responses (-VE %), Neutral category of responses (NU), Barriers (BA), N (No of respondents)																					

4.6 Summary

This chapter presents the results and analysis of SLR and empirical study conducted with SPI experts working in the context of GSD. The data collected using SLR and questionnaire survey was analysed in order to identify success factors that have a positive impact on SPI implementation and barriers that have a negative effect on process improvement activities. I have also analysed the most critical success factors (CSFs) and critical barriers (CBs) using the selected criterion discussed in section (4.2.4). Using this criterion six success factors have been ranked as the most critical for the implementation of the SPI program in the GSD organizations. The identified CSFs are: management commitment, staff involvement, project pilot implementation, process improvement expertise, allocation of resources and 3C (communication, coordination and control).

Using the same criteria for CBs, total five barriers have been identified as the most critical barriers. The selected CBs are: lack of process improvement knowledge, lack of resources, lack of communication, lack of organizational support and lack of formal SPI implementation methodology.

I have also identified various practices using SLR and the responses collected from the experts using the questionnaire survey. The reported practices will be used to address the identified CSFs and CBs.

I have comparatively discussed the identified success factors and barriers of SLR and survey in different other aspects i.e. continental, temporal, organizational size, study types, expert levels, and respondents positions. As the proposed Software Process Improvement Implementation and Management Model (SPIIMM) is generic for any type of organization, region and SPI experts, therefore the comparative study provides

in depth understanding of the reported success factors and the barriers which are the building blocks of the proposed model (SPIIMM).

This chapter contributes to the three components of the SPIIMM, i.e. reporting the CSFs, CBs and their practices. These three components provide the input to the other components of the SPIIMM discussed in the next chapter (chapter five).

CHAPTER 5: SOFTWARE PROCESS IMPROVEMENT IMPLEMENTATION AND MANAGEMENT MODEL FOR GSD ORGANIZATIONS

5.1 Introduction

In this research study a software process improvement implementation and management model (SPIIMM) has been developed that could assist GSD organizations in the assessment and improvement of SPI programs. SPIIMM is based on the SLR study conducted in the domain of SPI, GSD and also an empirical study carried with SPI experts. SPIIMM consist of core three components i.e. SPIIMM maturity level component, SPIIMM factors component and SPIIMM practices. In this chapter, each component of SPIIMM is briefly discussed and reported the results of three case studies conducted to evaluate the effectiveness SPIIMM.

This chapter is structured as follows:

- The structure of SPIIMM is discussed in section 5.2.
- The assessment dimension of SPIIMM is reported in section 5.3.
- The assessment of SPIIMM is presented in section 5.4.
- The introduction of the organizations selected for case studies is reported in section 5.5
- In Section 5.6, the analysis of the case studies is discussed

- Summary results of case studies are reported in section 5.7
- In Section 5.8, the feedback of the experts is presented
- Section 5.9 consists of chapter summary

5.2 Structure of SPIIMM

In this research study, SLR and survey questionnaire studies were conducted in order to identify the success factors and barriers that could have positive or negative impacts on SPI implementation in the context of GSD.

I have adopted the concepts of available models i.e. CMMI (Chrissis, Konrad, & Shrum, 2006), IMM (Niazi, Wilson, & Zowghi, 2005) and SOVRM (Khan, 2011) in order to develop SPIIMM as shown in Figure 5.1. Figure 5.1 shows the relationship between different components of SPIIMM. It demonstrates that how the findings of the SLR and empirical studies assist to develop the core three components of SPIIMM i.e.

- SPIIMM maturity level component
- SPIIMM factors (CSFs and CBs) component
- SPIIMM practices component

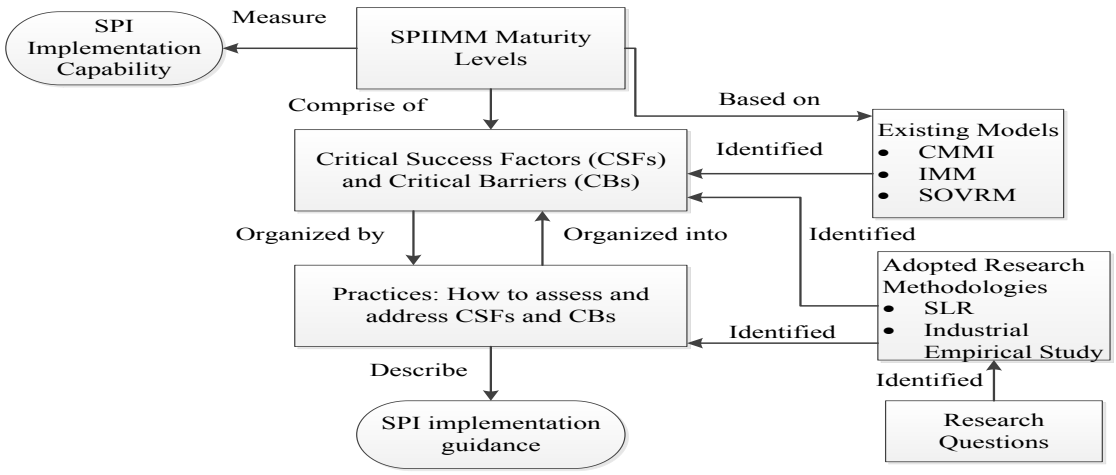


Figure 5.1 Structure of SPIIMM

These components are based on the existing models, i.e. CMMI (Chrissis, Konrad, & Shrum, 2003), IMM (Niazi, Wilson, & Zowghi, 2005) and SOVRM (Khan, 2011). CMMI consist of five maturity levels and each maturity level is based on different process areas (PAs). The process areas (PAs) of CMMI maturity levels contain various real world practices. The CMMI maturity levels and its categorization based on different PAs leads me to design SPIIMM maturity levels that composed of different CSFs and CBs. The CSFs and CBs of maturity levels are identified using SLR and survey questionnaire approaches. I have also identified the real world practices in order to address each CSF and CB of a specific maturity level.

5.2.1 SPIIMM maturity level component

In this research study, staged representation of CMMI has been followed in order to structure the maturity levels of SPIIMM. For SPIIMM, several alterations were made in the structure of CMMI to consider the characteristics of process improvement as illustrated in Figure 5.2:

- Level-1 (Initial): The level-1 of CMMI has been directly considered as the initial level of SPIIMM. In this level, the deployment process of SPI is chaotic and few processes are defined. This level has no CSF and CB.

- Level-2 (Commitment): Commitment has been identified as the most significant factor in the SLR study (68%) and survey questionnaire (96%). The implementation of SPI program is a long standing approach and need the commitment of organizational management in the sense of participating in SPI activities, providing the adequate resources, time, appropriate infrastructure and continuous support to successfully execute the SPI activates. Therefore, based

on the results obtained from SLR and industrial study, the level-2 of SPIIMM is considered as ‘commitment’. Therefore, for the successful execution of the SPI program, it is mandatory that organizational management commit to consider the SPI as a real world project. This level has one CSF and one CB as show in Figure 5.3.

- Level-3 (Communication): The focus of this level is that organization has appropriately addressed all the issues related to communication. Communication has been considered as the maturity level by (Khan, 2015) in order to develop communication and coordination challenges mitigation model for GSD vendor organizations. Therefore, in this research study the level-3 ‘communication’ is adopted from (Khan, 2015) as the domain of my work is also based on GSD. Similarly, 3C's (communication, coordination, control) has been found as one of the significant factors in SLR (64%) and empirical study (90%). Therefore, I have considered ‘communication’ as the maturity level because both coordination and control are dependent on communication (Khan et al., 2013). Level-3 consists of two CSFs and one CB as described in Figure 5.3.

- Level-4 (Defined): Level-4 has been adopted from CMMI as in this level all the processes of SPI implementation are reported, standardized and integrated into a standard implementation process for the organization (Niazi, Wilson, & Zowghi, 2005). This level has two CSFs and two barriers as shown in Figure 5.3.

- Level-5 (Optimizing): Optimizing is the final maturity level of SPIIMM and it is directly adopted from CMMI. At this level the organizations develop a structure

for continuous improvement (Niazi, Wilson, & Zowghi, 2005). This level consists of one CSF and one CB.

SPIIMM does not adopt CMMI level-2 (Managed) and level-4 (Quantitatively Managed). The focus of level-2 (Managed) is on project management and level-4 (Quantitatively Managed) on assessing the quantitative characteristics of the software process. In this research work, I didn't identify any success factor or barrier that has direct association with the level-2 and level-4 of CMMI.

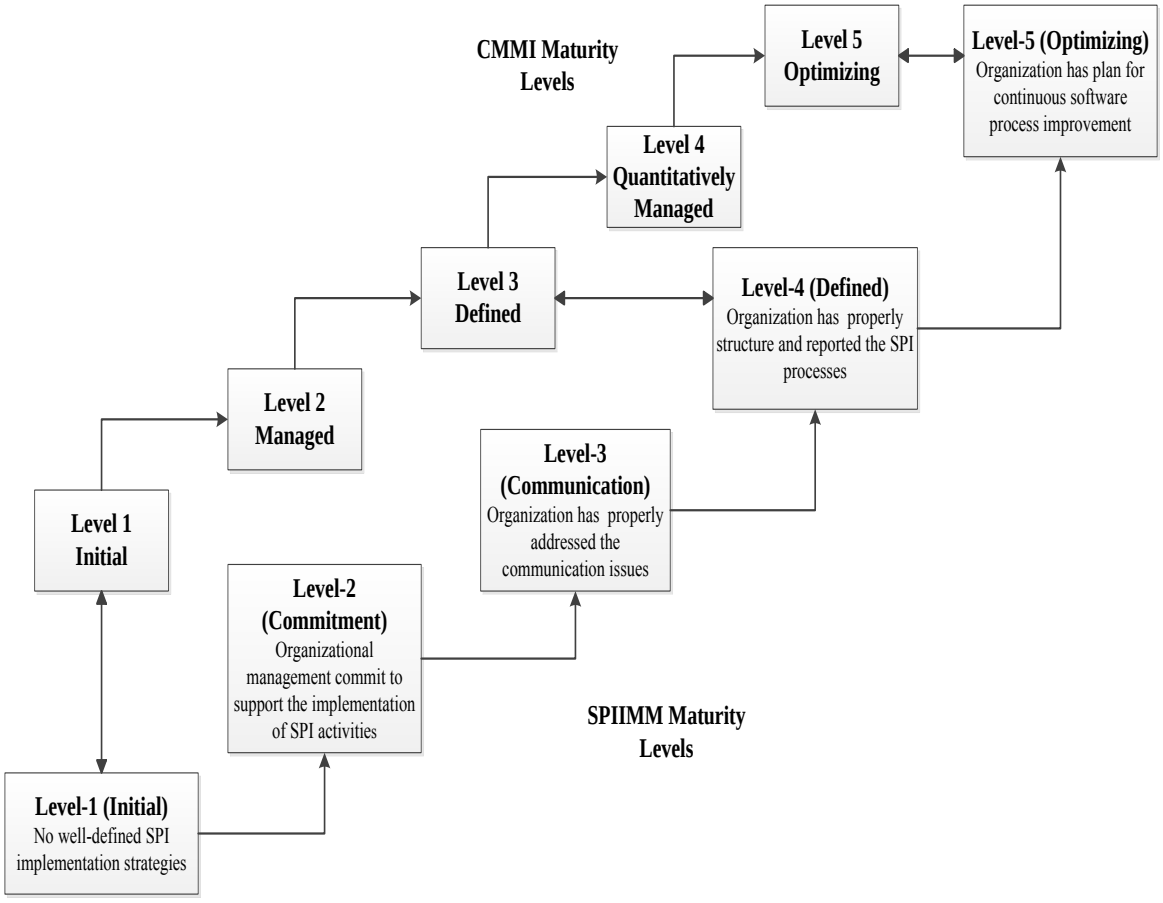


Figure 5.2 Comparison of SPIIMM and CMMI maturity levels

Different other researchers have also developed maturity models in different other domains of GSD based on CMM and CMMI.

(Khan, 2011) has developed software outsourcing vendors readiness model (SOVRM) based on CMMI. The structure of the model consists of four readiness levels and each level comprises of different CSFs and CBs.

(Khan, 2015) developed a communication and coordination challenges mitigation model (CCCMM) for GSD vendor organization by following the structure of CMMI. The aim of CCCMM is to assist GSD vendor organizations in identifying, analysing and mitigating the communication and coordination challenges by providing the real world practices. CCCMM consist of four maturity levels and each maturity level have specific CSFs and CBs. Different practices were defined in order to address the CSFs and CBs.

In another study, (Ali, & Khan, 2016) has developed a software outsourcing partnership model based on CMMI. The aim of this model is to assist GSD organizations to establish software outsourcing partnership with other organizations. This model could support GSD organizations to identify, analyse and implement the CSFs of software outsourcing partnership by providing the best practices. This model has five maturity levels that consist of CSFs and practices to address those CSFs.

5.2.2 SPIIMM factors (CSFs and CBs) component

CMMI is comprised of 25 process areas (PAs) classified into five maturity levels. In IMM (Niazi, Wilson, & Zowghi, 2005) and SOVRM (Khan, 2011), the authors has considered the maturity levels of SPI in terms of CSFs and CBs rather than process areas. The same concept of using CSFs and CBs has been adopted by different other researchers (Khan, 2015; Ali, & Khan, 2016). They have used CSFs and CBs rather than CMMI PAs. Different researchers have highlighted the significance of CSFs and CBs (Niazi, Wilson, & Zowghi, 2005; Khan, 2011, Huotari, & Wilson, 2001;

Khandelwal, & Ferguson, 1999; Khandelwal, & Natarajan, 2002; Pellow, & Wilson, 1993; Somers, & Nelson, 2001). Therefore we have adopted the concept of using CSFs and CBs to develop SPIIMM.

Critical factors (CSFs and CBs) represent some of the important areas where organizations should focus during the implementation of SPI program (Rockart, 1979). Number of CSFs and CBs are identified using the criterion developed in (section 4.2.4). The identified CSFs and CBs are listed in Table 5.1.

Table 5.1 CSFs and CBs identified using SLR and survey questionnaire

S. No	Identified CSFs	S. No	Identified CBs
CSF1	Management commitment	CB1	Lack of organizational support
CSF2	Staff involvement	CB2	Lack of communication
CSF3	Allocation of resources	CB3	Lack of process improvement knowledge
CSF4	3C's (communication, coordination, control)	CB4	Lack of resources
CSF5	Project pilot implementation	CB5	Lack of formal process improvement implementation methodology
CSF6	Process improvement expertise		

The process areas of CMMI could be classified into project management, engineering, process management, and support categories (Chrissis, Konrad, & Shrum, 2003). The same approach has been adopted in this research study and classified CSFs and CBs. This classification of CSFs and CBs has led me to design five maturity levels i.e. 'initial', 'commitment', 'communication', 'defined' and 'optimizing' as shown in Figure 5.3. The categorization of CSFs and CBs was based on the existing models in different other domains (Niazi, Wilson, & Zowghi, 2005; Khan, 2011; Khan, 2015; Ali and Khan, 2016), external reviews of my supervisors and case studies conducted in different GSD organizations (section 5.5).

The 'commitment' maturity level consists of those CSFs and CBs that support the activities related to commitment of organizational management for SPI implementation. Similarly the 'communication' maturity level comprises of CSFs and CBs related to communication, coordination and control activities of SPI staff members working

beyond geographical boundaries. The maturity level 'defined' covers the activities related to the formal documentation and reporting of the SPI implementation process. The last maturity level 'optimizing' based on the CSFs and CBs that could continuously improve the existing SPI implementation process.

The reported maturity levels with their respective CSFs and CBs are shown in Figure 5.3.

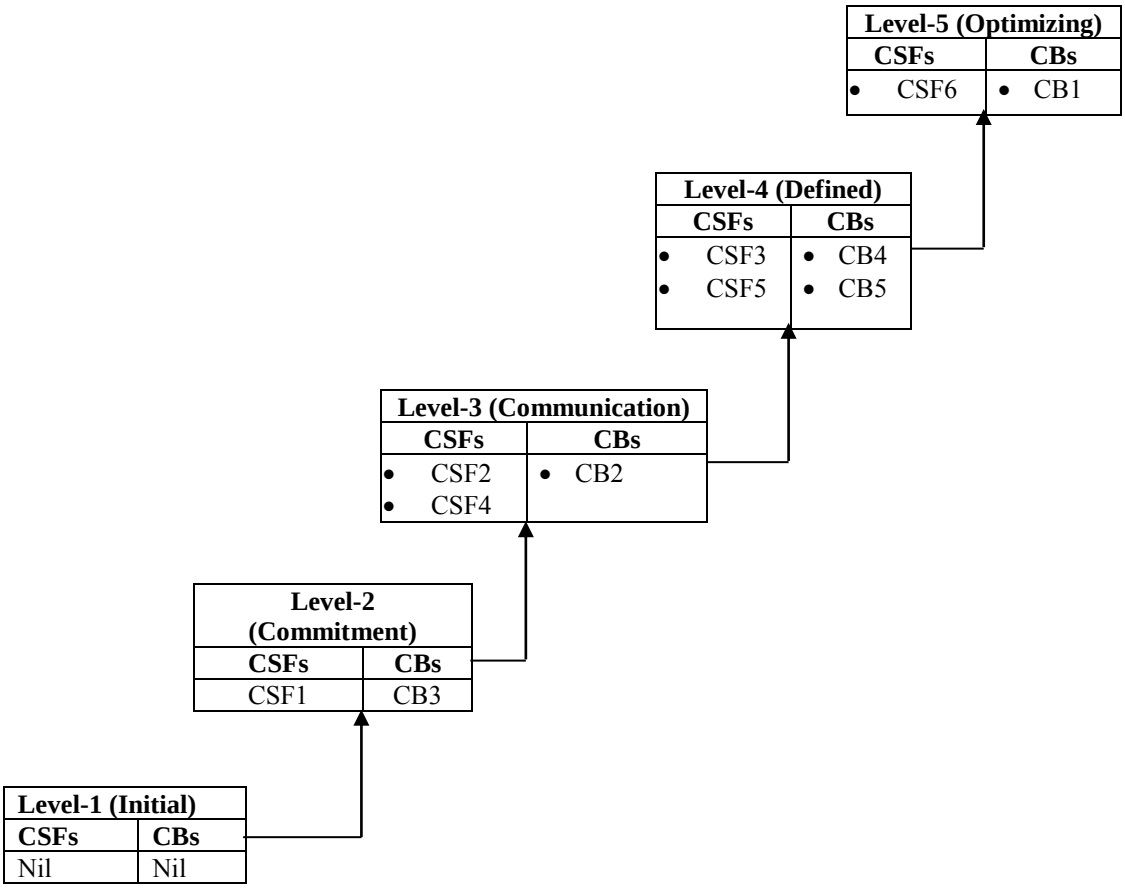


Figure 5.3 SPIIMM maturity levels with respective CSFs and CBs

5.2.3 SPIIMM practices component

In order to address the identified CSFs and CBs, I have identified a list of practices using SLR and a survey questionnaire as discussed in (section 4.4.1) and (section 4.4.2). All the identified practices along their respective CSFs are discussed in Table 5.2. Table

5.2 presents SPIIMM maturity levels with their respective CSFs and practices identified to address these CSFs. In Table 5.2, 'P-CSF' represents (practice for critical success factor). All the practices are briefly discussed in chapter 4 (Table 4.13, Table 4.16). Table 4.13 consists of those practices which were identified during the SLR study and Table 4.16 contains the additional new practices that were not found during SLR study but reported by the experts during the survey study. In total 46 practices were found that could address the identified CSFs as shown in Table 5.2.

Table 5.2 Identified practices for CSFs

Maturity Levels	**CSFs**	**Practices**
Level-1 (Initial)	Nil	Nil
Level-2 (Commitment)	CSF1:Management commitment	P1-CSF1 (Practice is given in Table 4.13) P2-CSF1 (Practice is given in Table 4.13) P3-CSF1 (Practice is given in Table 4.13) P4-CSF1 (Practice is given in Table 4.13) P5-CSF1 (Practice is given in Table 4.13) P6-CSF1 (Practice is given in Table 4.16) P7-CSF1 (Practice is given in Table 4.16) P8-CSF1 (Practice is given in Table 4.16) P9-CSF1 (Practice is given in Table 4.16) P10-CSF1 (Practice is given in Table 4.16)
Level-3 (Communication)	CSF2: Staff involvement	P1-CSF2 (Practice is given in Table 4.13) P2-CSF2 (Practice is given in Table 4.13) P3-CSF2 (Practice is given in Table 4.13) P4-CSF2 (Practice is given in Table 4.13) P5-CSF2 (Practice is given in Table 4.13) P6-CSF2 (Practice is given in Table 4.16) P7-CSF2 (Practice is given in Table 4.16) P8-CSF2 (Practice is given in Table 4.16)
	CSF4: 3C's (communication, coordination, control)	P1-CSF4 (Practice is given in Table 4.13) P2-CSF4 (Practice is given in Table 4.13) P3-CSF4 (Practice is given in Table 4.13) P4-CSF4 (Practice is given in Table 4.13) P5-CSF4 (Practice is given in Table 4.13) P6-CSF4 (Practice is given in Table 4.13) P7-CSF4 (Practice is given in Table 4.16)
Level-4 (Defined)	CSF3: Allocation of resources	P1-CSF3 (Practice is given in Table 4.13) P2-CSF3 (Practice is given in Table 4.13) P3-CSF3 (Practice is given in Table 4.13) P4-CSF3 (Practice is given in Table 4.13) P5-CSF3 (Practice is given in Table 4.13) P6-CSF3 (Practice is given in Table 4.16)
	CSF5: Project pilot implementation	P1-CSF5 (Practice is given in Table 4.13) P2-CSF5 (Practice is given in Table 4.13) P3-CSF5 (Practice is given in Table 4.13) P4-CSF5 (Practice is given in Table 4.13) P5-CSF5 (Practice is given in Table 4.13) P6-CSF5 (Practice is given in Table 4.16)

		P7-CSF5 (Practice is given in Table 4.16) P8-CSF5 (Practice is given in Table 4.16)
Level-5 (Optimizing)	CSF6: Process improvement expertise	P1-CSF6 (Practice is given in Table 4.13) P2-CSF6 (Practice is given in Table 4.13) P3-CSF6 (Practice is given in Table 4.13) P4-CSF6 (Practice is given in Table 4.13) P5-CSF6 (Practice is given in Table 4.13) P6-CSF6 (Practice is given in Table 4.16) P7-CSF6 (Practice is given in Table 4.16)

Similarly various practices were identified in order to address the identified CBs. The CBs along their respective practices are given in Table 5.3. In Table 5.3, 'P-CB' represents (practice for critical barrier).

Table 5.3 Identified practices for CBs

Maturity Levels	**CBs**	**Practices**
Level-1 (Initial)	Nil	Nil
Level-2 (Commitment)	CB3: Lack of process improvement knowledge	P1- CB3 (Practice is given in Table 4.14) P2- CB3 (Practice is given in Table 4.14) P3- CB3 (Practice is given in Table 4.14) P4- CB3 (Practice is given in Table 4.14) P5- CB3 (Practice is given in Table 4.14)
Level-3 (Communication)	CB2: Lack of communication	P1- CB2 (Practice is given in Table 4.14) P2- CB2 (Practice is given in Table 4.14) P3- CB2 (Practice is given in Table 4.14) P4- CB2 (Practice is given in Table 4.14) P5- CB2 (Practice is given in Table 4.14) P6-CB2 (Practice is given in section (4.4.2.2))
Level-4 (Defined)	CB4: Lack of resource	P1-CB4 (Practice is given in Table 4.14) P2-CB4 (Practice is given in Table 4.14) P3-CB4 (Practice is given in Table 4.14) P4-CB4 (Practice is given in Table 4.14) P5-CB4 (Practice is given in Table 4.14)
	CB5: Lack of formal process improvement implementation methodology	P1-CB5 (Practice is given in Table 4.14) P2-CB5 (Practice is given in Table 4.14) P3-CB5 (Practice is given in Table 4.14) P4-CB5 (Practice is given in Table 4.14) P5-CB5 (Practice is given in Table 4.14)
Level-5 (Optimizing)	CB1:Lack of organizational support	P1- CB1 (Practice is given in Table 4.14) P2- CB1 (Practice is given in Table 4.14) P3- CB1 (Practice is given in Table 4.14) P4- CB1 (Practice is given in Table 4.14) P5- CB1 (Practice is given in Table 4.14)

I have identified total 26 practices to address the reported CBs. In these 26 practices, one additional new practice (P6-CB2) was mentioned by the survey respondents. The remaining 25 barriers were extracted from the existing literature and validated for SPI

implementation in GSD organizations using the survey questionnaire approach. All these practices are briefly discussed in Table 4.14.

5.3 SPIIMM assessment dimensions

I have adopted Motorola assessment tool (Daskalantonakis, 1994) in order to evaluate SPIIMM as show in Table 5.4. The Motorola assessment tool has been used by different other researchers in order to evaluate their proposed maturity models (Niazi, Wilson, & Zowghi, 2005; Khan, 2011; Khan, 2015; Ali, & Khan, 2016). The Motorola assessment instrument has been adopted due to various compelling reasons. Motorola assessment instrument is normative and has been tried and tested at Motorola. This instrument is used to evaluate the existing status of an organization relative to CMM and CMMI. It could indicate the weak areas of an organization that need further consideration and improvement (Daskalantonakis, 1994). It consists of the following three evaluation dimensions (Daskalantonakis, 1994).

- **Approach:** The criterion of this dimension is the support and commitment of organizational management for the practice also the capability of an organization to implement the practice.
- **Deployment:** The criterion of this dimension is the consistent and uniform implementation of practice across all the project areas.
- **Results:** In this dimension the criterion is about the breadth and consistency of positive results over time and across the project areas.

Each dimension was assigned a score from 0-10 (Daskalantonakis, 1994). The scoring criterion for each dimension is discussed in Table 5.4.

Table 5.4 Motorola assessment Instrument (Daskalantonakis, 1994)

Score	Key Activity evaluation dimensions		
	Approach (Score Range: 0, 2, 4, 6, 8, 10)	**Deployment** (Score Range: 0, 2, 4, 6, 8, 10)	**Results** (Score Range: 0, 2, 4, 6, 8, 10)
Poor (0)	➢ No management recognition of need ➢ No organizational ability ➢ No organizational commitment ➢ Practice not evident	➢ No part of the organization uses the practice ➢ No part of the organization shows interest	➢ Ineffective
Weak (2)	➢ Management begins to recognize need ➢ Support items for the practice start to be created ➢ A few parts of organization are able to implement the practice	➢ Fragmented use ➢ Inconsistent use ➢ Deployed in some parts of the organization ➢ Limited to monitoring/verification of use	➢ Spotty results ➢ Inconsistent results ➢ Some evidence of effectiveness for some parts of the organization
Fair (4)	➢ Wide but not complete commitment by management ➢ Road map for practice implementation defined ➢ Several supporting items for the practice in place	➢ Less fragmented use ➢ Some consistency in use ➢ Deployed in some major parts of the organization ➢ Monitoring/verification of use for several parts of the organization	➢ Consistent and positive results for several parts of the organization ➢ Inconsistent results for other parts of the organization
Marginally qualified (6)	➢ Some management commitment; some management becomes proactive ➢ Practice implementation well under way across parts of the organization ➢ Supporting items in place	➢ Deployed in some parts of the organization ➢ Mostly consistent use across many parts of the organization ➢ Monitoring/verification of use for many parts of the organization	➢ Positive measurable results in most parts of the organization ➢ Consistently positive results over time across many parts of the organization
Qualified (8)	➢ Total management commitment ➢ Majority of management is proactive ➢ Practice established as an integral part of the process ➢ Supporting items encourage and facilitate the use of practice	➢ Deployed in almost all parts of the organization ➢ Consistent use across almost all parts of the organization ➢ Monitoring/verification of use for almost all parts of the organization	➢ Positive measurable results in almost all parts of the organization ➢ Consistently positive results over time across almost all parts of the organization
Outstanding (10)	➢ Management provides zealous leadership and commitment ➢ Organizational excellence in the practice recognized even outside the company	➢ Pervasive and consistent deployed across all parts of the organization ➢ Consistent use over time across all parts of the organization ➢ Monitoring/verification for all parts of the organization	➢ Requirements exceeded ➢ Consistently world-class results ➢ Counsel sought by others

The following steps of Motorola instrument have been adopted for the SPIIMM assessment component (Daskalantonakis, 1994).

- Step-1: The participant of the SPI implementation team should compute the three dimensional score of the Motorola instrument for each practice of critical success factors (CSFs) and critical barriers (CBs).
- Step-2: The calculated three dimensional scores of each practice are summed together and divided by three (3). The final calculated score is rounding the nearest whole number.
- Step-3: Step-2 should repeat for each practice of the identified CSFs and CBs. Add the scores of all the practices together in order to calculate the final score for specific CSF or CB.
- Step-4: Relating the assessment score to SPIIMM: a score of 7 or above for a specific CSF or CB will show that a particular CSF or CB has been effectively implemented (Daskalantonakis, 1994). If the score of any CSF or CB is lower than seven then the implementation of that particular CSF or CB considered weak (Daskalantonakis, 1994).
- Step-5: To achieve a specific maturity level of SPIIMM, it is vital to address all the CSFs and CBs of that particular maturity level. For example, if the organization wants to attain the maturity level-3 of SPIIMM it is must to address all the CSFs and CBs of level 3 i.e. (CSF2: staff Involvement), (CSF4: 3C's (communication, coordination, control)) and (CB2: lack of communication) and their average score should be seven or above.

In Table 5.5 the evaluation example of SPIIM is shown by following the above five steps of Motorola instrument.

Table 5.5 Assessment example of SPIIMM factors using Motorola assessment Instrument

CSF1:Management Commitment					
S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8, 10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6, 8,10)	
P1-CSF1	Strong support and commitment of organizational management for software process improvement program.	6	6	8	7
P2-CSF1	Management provides and sustain resources for process improvement program.	4	2	2	3
P3-CSF1	Continuously monitor the process improvement activities	6	4	4	5
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.	4	4	2	3
P5-CSF1	Continuously encourage the efforts of process improvement team members.	6	8	8	7
P6-CSF1	Top level management should lead the initiation and implementation of SPI program.	8	6	6	7
P7-CSF1	Management encourages and drive the bottom-up staff in SPI activities.	8	6	4	6
P8-CSF1	Organizational management motivates SPI team members as well the non SPI staff members to accept the changes of process improvement.	8	8	8	8
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.	4	2	6	4
P10-CSF1	Tope level management lead the initiation and implementation of SPI program	4	8	6	6
Total of 'average scores'= (add all the average score values at the right most column)					56
Overall score= Total of 'average score'/ total number of practices= (56/10=5.6)					6

The results presented in Table 5.5 demonstrate that the practices identified for (CSF1: management commitment) have overall average score 6. It reveal that the success factor (CSF1: management commitment) is not completely addressed because its score is less

than 7. To assess the SPI maturity level of an organization, it is vital to go through the evaluation of all the practices identified for CSFs and CBS.

5.4 Assessment of SPIIMM

Case study approach was followed in order to assess the proposed model SPIIMM as discussed in section 5.3. I have conducted three case studies in GSD organizations to evaluate the effectiveness of SPIIMM.

5.4.1 Assessment criteria

The following criteria have been adopted in order to assess the effectiveness of SPIIMM.

- **Ease of use:** The objective of this criterion is to evaluate that how easily experts can use and understand the implementation of SPIIMM.

- **User satisfaction:** The aim of this criterion is to analyse the user satisfaction level with the results of SPIIMM.

- **Structure of SPIIMM:** The objective of this criterion is to analyse different components of SPIIMM and also overview the distribution of critical success factors and critical barriers across the maturity levels of SPIIMM.

The criteria are based on existing literature and the same criteria have been adopted by different other researchers (Niazi, Wilson, & Zowghi, 2005; Ali, & S. U. Khan, 2016). The above criteria are followed in order to examine those areas where SPIIMM need further improvements. All the evaluation results of SPIIMM are used to modify the structure of SPIIMM and to use for future study.

5.4.2 Limitations of the assessment

The results discussed in this Chapter are based on the three case studies conducted in GSD organizations. The evaluation of SPIIMM on this small sample size might not be effective for all GSD organizations. Each case study was responded by a single representative and the feedback of that individual may not present the population of the entire SPI team. I have adopted Motorola instrument (Daskalantonakis, 1994) in order to assess the identified CSFs and CBs along their practices. The use of the single assessment instrument might not be enough to achieve more authentic results. Similarly, I have conducted all the case studies using email correspondence which did not provide any face to face interaction with the responded. Due to the lack of face to face communication, they might not have completely understood the documents provided for the case study.

5.4.3 SPIIMM assessment using case studies

In this research work the case study method was used in order to evaluate SPIIMM. Case study approach is considered to be more effective for assessment and could provide adequate information about the real world software industry experiences (Yin, 2013). As SPIIMM is designed to implement in the real world software industry, therefore the case study approach is considered to be more suitable and effective for this research study. The aim of real world case study was to examine that SPIIMM is fit in the GSD industry or not. It also assists to highlight those areas of SPIIMM which need further improvements. The case study approach helps to check the practicality and usability of SPIIMM.

Three separate case studies were conducted in different GSD organizations located in India, Uruguay and UK. Organizations were randomly selected for case studies by

visiting their profiles on social network LinkedIn. I have visited their websites for further information and detail about the SPI efforts and activities. Initially I contacted a few organizations by sending an invitation letter using email as shown in Appendix F. Total three organizations agreed to participate in this case study. The selected organizations give a rich description of their process improvement activities and they were agreed to issue the results of the case studies.

Each participant were contacted through email in order to provide complete information and understanding of the case study. I have sent the following three main documents to each participant.

- Guideline document for SPIIMM case study assessment process.
- Assessment of SPIIMM critical success factors (CSFs) and critical barriers (CBs) using the Motorola assessment Instrument
- Consent form

Guideline document consists of the brief description of the SPIIMM including introduction of the research project, structure of SPIIMM and assessment tool adopted for SPIIMM evaluation. The complete guideline document is shown in Appendix G.

The second document consists of the identified CSFs and CBs along their practices and each participant have to assess those CSFs and CBs for their respective organizations. The assessment is based on the Motorola evaluation instrument discussed in section 5.3. The assessment of SPIIMM critical success factors (CSFs) and critical barriers (CBs) document is presented in Appendix H.

The consent form was provided in order to conduct the feedback session with each participant regarding the SPIIMM. The questionnaire, as presented in Appendix I was used to structure the feedback session. The questionnaire consists of three sections i.e. Section-A, Section-B and Section-C. Section-A provides detailed demographic information about each participant. Section-B contains the evaluation of SPIIMM according to the assessment criterion discussed in section 5.4.1. In Section-C, the list of the identified practices for CSFs and CBs is provided to the participant for review and suggestions. Each questionnaire of the feedback section was qualitatively analysed due to the qualitative nature of the questionnaire questions.

5.5 Introduction of the organizations selected for case studies

The selected three companies are tagged as Company A, B and C. Due to privacy reasons the original names of the responding organizations are not disclosed.

5.5.1 Profile of Company A

Company A is an ISO 9001:2008 certified international company that provides consultancy and services related to information technology and electronics. Company A is a large organization employing 10000+employees and its network spans across 54 countries around the world. The participant of this case study is a product process consultant working in the branch of company A located in Delhi, India.

The aim of company A is to provide consultancy and technical services in the following major areas

- Electronics industry
- Machinery and heavy industry

- Chemical industry
- Finance services

5.5.2 Profile of Company B

Company B is a medium sized government organization located in Uruguay. Company B employing 200 employees and it provides consultancy services to software development organizations, in subject raging from standards adoption to organizational strategy. Company B assists software development organizations to transform their development lifecycle to agile in order to achieve ISO certifications, and to overall streamline their delivery process. The respondent from Company B is a quality and process improvement consultant.

Following are the major areas where company B provides consultancy services to software development organizations.

- Process improvement for software organizations
- Transition to Agile development
- Process evaluation
- Quality management system deployment
- ISO 9001 audits

5.5.3 Profile of Company C

Company C is a small size organization located in London, UK. Company C offers the consulting and training services of software process improvement in IT and telecommunication sectors. The participant of this case study is senior project manager

and business analyst. Company C help corporations in achieving their strategic business goals by providing consultancy and projects in the following areas.

- Business process redesign and alignment to strategic goals.
- Improving business controls to improve the effectiveness and efficiency of the management processes.
- Design and management of programs and projects to roll out the new processes and process controls across the organisation.
- Provided Consultancy on CMMI & Process Improvement strategies, methodology and Implementations.

5.6 Analysis of the case studies

The following analyses have been performed on the data collected during the case studies.

- Measure the maturity level of an organization for process improvement based on the assessment document provided to the respondents.
- According to the assessment document of SPIIMM a score of 7 or above for particular CSF or CB denotes that a specific factor has been successfully implemented. If the overall score is less than 7 then the implementation status of the factor will marked as weak.
- The data collected during the feedback session will be used to analyse the effectiveness of the SPIIMM.

- The analysis of the feedback session will clarify that whether SPIIMM is clear, easy to use and contributing to enhance the process improvement in the domain of GSD.
- The feedback session will analyse the ease of use and understanding of each practice design to address the CSFs and CBs.
- The results of the case study data will help to check the generalization and applicability of SPIIMM.

5.6.1 Results at Company A

Each participant of the case study was provided an assessment document of SPIIMM as shown in Appendix H. The assessment document was based on the Motorola assessment instrument (Daskalantonakis, 1994). The case study participant has used SPIIMM and measured the maturity level of the organization. The case study results obtained from company A are reported in Table 5.6 and shown in Appendix H1.

The results shown in Table 5.6 illustrate that company A stands at Level-3 of SPIIMM. Company A have addressed all CSFs and CBs of Level-2 and Level-3 because the average score of each CSF and CB is ≥ 7.

In order to achieve a specific maturity level, it is necessary that all the CSFs and CBs of that maturity level should be addressed by having average score ≥ 7. Therefore, to achieve maturity Level-4, it is important for company A to strongly address the critical success factor (CSF5: project pilot implementation) because its existing average score is 2. It means that Company A has given very less attention to conduct experimental based implementation of newly adopted standards and models.

In Level-3, it is shown that allocation of resources has a high score of 8.83 which clarify that company A have well established system to provide adequate resources for each

project. Company A also managed to use the formal process improvement implementation methodologies because they have strongly addressed the critical barrier (CB5: lack of formal process improvement implementation methodology) and it might be the reason that company A get ISO 9001:2008 certification.

Similarly to achieve Level-5 of SPIIMM, it is vital for company A to achieve all the previous levels and address the critical success factor (CSF6: process improvement expertise) which have an average score of 6. It highlighted that company A is lacking of experience individuals working in the domain of software process improvement. Company A also managed to address critical barrier (CB1: lack of organizational support).

Table 5.6 Assessment results for each CSF and CB in company A

Maturity Levels	**CSFs and CBs**	**Final Score**	**Status in Company A**
Level-1 (Initial)	-	-	-
Level-2 (Commitment)	CSF1: Management commitment	7.1	Strong
	CB3: Lack of process improvement knowledge	7	Strong
Level-3 (Communication)	CSF2: Staff involvement	7.37	Strong
	CSF4: 3C's (communication, coordination, control)	7.14	Strong
	CB2: Lack of communication	8	Strong
Level-4 (Defined)	CSF3: Allocation of resources	8.83	Strong
	CSF5: Project pilot implementation	2	Weak
	CB4: Lack of resources	7	Strong
	CB5: Lack of formal process improvement implementation methodology	9	Strong
Level-5 (Optimizing)	CSF6: Process improvement expertise	5.71	Weak
	CB1: Lack of organizational support	7.8	Strong

Summarising the picture from analysis discussed in Table 5.6, company A need to implement the weakly addressed factors at Level-4 and Level-5 in order to achieve the higher maturity i.e. Level-5 (Optimizing).

5.6.2 Results at Company B

The respondent of the company B is an SPI consultant and researcher, he evaluated the maturity level of his company using SPIIMM. The summary of the results are summarised in Table 5.7 and the detailed response is shown in Appendix H2.

Table 5.7 Assessment results for each CSF and CB in company B

Maturity Levels	CSFs and CBs	Final Score	Status in Company B
Level-1 (Initial)	-	-	-
Level-2 (Commitment)	CSF1: Management commitment	7.7	Strong
	CB3: Lack of process improvement knowledge	3.8	Weak
Level-3 (Communication)	CSF2: Staff involvement	5.08	Weak
	CSF4: 3C's (communication, coordination, control)	3.42	Weak
	CB2: Lack of communication	7	Strong
Level-4 (Defined)	CSF3: Allocation of resources	7	Strong
	CSF5: Project pilot implementation	10	Strong
	CB4: Lack of resources	6.8	Weak
	CB5: Lack of formal process improvement implementation methodology	10	Strong
Level-5 (Optimizing)	CSF6: Process improvement expertise	9	Strong
	CB1: Lack of organizational support	5.2	Weak

The results illustrate that company B is at Level-1 (Initial) of SPIIMM because one critical barrier i.e. (CB3: lack of process improvement knowledge) of Level-2 is not fully addressed as the average final score is <7. It is important for company B to completely address this barrier in order to achieve the maturity Level-2 (Commitment). Similarly, in order to achieve the maturity Level-3 and Level-4, the company B should address the critical success factors and barriers having an average final score lower than 7 i.e. (CSF2: staff involvement), CSF4: 3C's (communication, coordination, control) and (CB4: lack of resources). It is shown in Table 5.7 that the critical success factor (CSF5: project pilot implementation) and critical barrier (CB5: lack of formal process improvement implementation methodology) have the highest scores among all the factors. It means that company B is fully aware of the importance of testing based

implementation of models and standards. It is also clear that company B is following formal process improvement implementation methodologies.

5.6.3 Results at Company C

The participant of the case study used SPIIMM to assess and measured the SPI related maturity level of company C. The case study results of company C are discussed in Table 5.8 and shown in Appendix H3.

The results presented in Table 5.8 clarify that company C is at maturity level-2 of SPIIMM. CSFs and CBs of levels-2 (Commitment) are strongly addressed because their average evaluation scores are ≥ 7. It shows that management of company A are strongly committed towards the implementation of SPI activities.

Table 5.8 highlighted that in order to achieve level-3 (Communication) of SPIIMM, company C should address critical success factor (CSF4: 3C's (communication, coordination, control)) and critical barrier (CB2: lack of communication) because both of these factors have average assessment scores < 7.

To achieve the level-4 (Defined) of SPIIMM, the company C should attain all the previous maturity levels and, should address the factors of level-4 (Defined) which have average assessment scores < 7. Two factors, i.e. critical success factor (CSF5: project pilot implementation) and critical barrier (CB4: lack of resources) have assessment score 6.6 and 6.2 respectively. Therefore company C should strongly address these two factors in order to achieve the maturity level-4 (Defined) of SPIIMM. Critical success factor (CSF3: allocation of resources) of level-4 have average score 7.2, which illustrate that company C have sufficiently provided the available resources for SPI programs. They have also adopted the formal process improvement strategies because the critical

barrier (CB5: lack of formal process improvement implementation methodology) have average score ≥ 7.

Table 5.8 shows that in order to achieve the higher maturity level i.e. Level-5 (Optimizing) of SPIIMM, the company C should address the critical success factor (CSF6: process improvement expertise) and critical barrier (CB1: lack of organizational support). Both of these factors have average assessment scores < 7.

Table 5.8 Assessment results for each CSF and CB in company C

Maturity Levels	**CSFs and CBs**	**Final Score**	**Status in Company C**
Level-1 (Initial)	-	-	-
Level-2 (Commitment)	CSF1: Management commitment	7.1	Strong
	CB3: Lack of process improvement knowledge	7.4	Strong
Level-3 (Communication)	CSF2: Staff involvement	7.7	Strong
	CSF4: 3C's (communication, coordination, control)	5.8	Weak
	CB2: Lack of communication	6.8	Weak
Level-4 (Defined)	CSF3: Allocation of resources	7.2	Strong
	CSF5: Project pilot implementation	6.6	Weak
	CB4: Lack of resources	6.2	Weak
	CB5: Lack of formal process improvement implementation methodology	7.1	Strong
Level-5 (Optimizing)	CSF6: Process improvement expertise	5.6	Weak
	CB1: Lack of organizational support	5.7	Weak

5.7 Summary Results of case studies conducted at Company A, B, C

In this section the comparison of the three case studies is briefly discussed. It is clear from Table 5.9 that company A has only two weak factors, while company B and company C have 5 and 6 respectively. It shows that company A have addressed more critical success factors and barriers as compared to company B and C. Company A have no weak factors at maturity level-2 and level-3 which brings company A at the maturity level-3 of SPIIMM.

It is also significant to compare the results of company B and C, as both of them are in low maturity levels than company A. This will assist to identify the most common weak critical success factors and critical barriers of both company B and C. Table 5.9 highlighted that both companies have three common weak factors i.e. (CB4: lack of resources), (CSF4: 3C's (communication, coordination, control)), (CB1: lack of organizational support) at level-3, level-4 and level-5. The analyses indicate that there are some similarities and differences between the results of company A, B and C. It might be due to the reason that both company B and C are of small to medium size organizations, while company A is large size organization.

The comparative results suggest that companies B and C should address the barrier (CB4: lack of resources) in order to achieve the higher maturity levels of SPIIMM. For example, (Niazi, Wilson, & Zowghi, 2005) conducted an industrial empirical study and shed light that almost three-quarters (72%) of the practitioners believed that implementation of SPI program has often suffered due to the limited resources and time. In another article, (Niazi, Babar, & Verner 2010) reported the cross cultural barriers in GSD organizations and concluded that it is significant to provide all the required resources for the implementation of SPI activities. They further mentioned that without sufficient resources the organization might not be able to achieve the desired output of the SPI program. Similarly, they should have a strategy to address the weak factors (CSF4: 3C's (communication, coordination, control)) and (CB1: lack of organizational support) to achieve the advance maturity levels of SPIIMM.

Table 5.9 Summary of results of companies A, B and C

Assessment issue	Company A	Company B	Company C
Weak CSFs and CBs at maturity Level-2 (Commitment)	• Nil	• CB3: Lack of process improvement knowledge	• Nil
Weak CSFs and CBs at maturity Level-3 (Communication)	• Nil	• CSF2: Staff involvement • CSF4: 3C's (communication, coordination, control)	• CSF4: 3C's (communication, coordination, control) • CB2: Lack of communication
Weak CSFs and CBs at maturity Level-4 (Defined)	• CSF5: Project pilot implementation	• CB4: Lack of resources	• CSF5: Project pilot implementation • CB4: Lack of resources
Weak CSFs and CBs at maturity Level-5(Optimizing)	• CSF6: Process improvement expertise	• CB1: Lack of organizational support	• CSF6: Process improvement expertise • CB1: Lack of organizational support
Total Weak CSFs and CBs	**2**	**5**	**6**

5.8 Experts Feedback on SPIIMM

In addition to the case studies conducted with the experts, they were requested to evaluate the SPIIMM against the assessment criteria reported in section 5.4.1. Based on the years of industry experience, it was important to acknowledge and report the views and opinions of the case studies respondents. In order to seek the expert feedback about SPIIMM, a questionnaire was designed (Appendix I). The feedback questionnaire was reviewed by the student supervisors in order to evaluate the questions against the assessment criteria (section 5.4.1). Some questions of the questionnaire were rearranged based on the feedback collected from the supervisors.

Each participant was asked to assess the effectiveness of SPIIMM against the folliwng criteria.

- Ease of Use

- User Satisfaction
- Structure of SPIIMM

In the following sections the main insights derived from the collected data are presented.

5.8.1 Ease of Use

The detailed feedback data collected from the three participants are presented in Appendix I.1. The results show that the participants who evaluated SPIIMM were satisfied with respect to ease of use. The participants were asked different questions about the ease of use and their feedback regarding the ease of use was positive. They were positively agreed with the assessment results. The summarised results regarding ease of use are presented in Table 5.10.

Table 5.10 SPIIMM feedback results (Ease of Use) of companies A, B and C

Ease of Use	**No of Participants (n=3)**								
	Positive (+Ve)				Negative (-Ve)				NU
	EA	MA	A	EA+MA +A	ED	MD	D	ED+MD +D	
Representation of SPIIMM is simple.	2	1	0	3	0	0	0	0	0
SPIIMM need little SPI knowledge to understand.	2	0	1	3	0	0	0	0	0
It's simple to understand the practices of critical success factors and barriers.	1	0	2	3	0	0	0	0	0
It's simple to understand the Motorola assessment technique.	0	0	3	3					
It's simple to implement SPIIMM for process improvement activities.	0	3	0	3	0	0	0	0	0
It's simple to understand the maturity levels of SPIIMM along their critical success factors and critical barriers.	0	2	1	3	0	0	0	0	0
SPIIMM needs training to fully understand.	0	0	1	1	0	0	0	0	2
Extremely Agree (EA), Moderately Agree (MA), Agree (A), Neutral (NU), Extremely Disagree (ED), Moderately Disagree (MD), Disagree (D)									

It is evident from the results presented in Table 5.10 that the participants were positively agreed with the questions regarding the ease of use of SPIIMM. Two participants were neutral concerning the need of conducting training sessions to completely understand the use of SPIIMM.

5.8.2 User Satisfaction

Participants were asked different questions to rank SPIIMM regarding the 'user satisfaction' criterion. The summarised results of the collected data regarding the user satisfaction are presented in Table 5.11. The respondents were positively agreed with the assessment results of SPIIM related to the user satisfaction.

All the participants have positively responded and highlighted that it would be useful to employee SPIIMM in the software industry. It illustrates that the experts considered SPIIMM as useful and elegant for the GSD industry. They were also asked about the results of SPIIMM and all the participants have selected the positive category of the questionnaire. It shows that the organization should be confident with the assessment results of SPIIMM.

The experts were asked to rank the usefulness of SPIIMM for the GSD industry and 100% of the participants have positively responds as shown in Table 5.11. It demonstrates that any type of GSD organization could assess their SPI related activities using SPIIMM and also could employee to improve their process improvement program.

Similarly the other questions were also positively responded by the expert's i.e. generic nature of SPIIMM, report the weak and strong areas of organization related to SPI, and software tool of SPIIMM.

Table 5.11 SPIIMM feedback results (User Satisfaction) of companies A, B and C

User Satisfaction	No of Participants (n=3)								
	Positive (+Ve)				Negative (-Ve)				NU
	EA	MA	A	EA+MA +A	ED	MD	D	ED+MD +D	
SPIIMM is generic in nature and could be installed in different global software development organizations.	0	1	2	3	0	0	0	0	0
SPIIMM could help an on organization to understand weak and strong areas of process improvement	1	1	1	3	0	0	0	0	0
The use of SPIIMM could improve the software process of our organization.	0	0	2	2	0	0	0	0	1
I will prefer to use SPIIMM in my organization	0	0	3	3	0	0	0	0	0
I am confident with the results of SPIIMM.	1	1	1	3	0	0	0	0	0
The software tool of SPIIMM could facilitate the experts to implement SPI.	0	2	1	3	0	0	0	0	0
SPIIMM is a useful model for global software development organizations.	1	1	1	3	0	0	0	0	0
Extremely Agree (EA), Moderately Agree (MA), Agree (A), Neutral (NU), Extremely Disagree (ED), Moderately Disagree (MD), Disagree (D)									

5.8.3 Structure of SPIIMM

The feedback questionnaire consists of different close and open ended questions in order to identify any limitations with the structure of SPIIMM. The summarised results of the responses regarding the structure of SPIIMM are reported in Table 5.12.

The participants have positively considered the core components of SPIIMM as practical and robust for the GSD industry. The results presented in Table 5.12 highlighted that assessing an organization using SPIIMM could assist SPI practitioners to identify the limitations related to their existing SPI programs. The experts were also agreed with the five maturity levels of SPIIMM to assess the SPI maturity level of an organization. It shows that the maturity levels are enough and well defined.

In the open ended questions the participants were asked to report any further improvements related to SPIIMM, identify additional components for SPIIMM, evaluate the adopted Motorola assessment method and validate the distribution of critical success factors (CSFs), critical barriers (CBs) and their practices across different maturity levels.

One expert reported additional improvement by moving the critical barrier (CB3: lack of process improvement knowledge) from maturity level-2 (Commitment) to level-4 (Defined). He reported that the management might have complete understanding of process improvement knowledge but still not committed. Similarly, he suggested to move critical barrier (CB4: lack of resources) from level-4 (Defined) to level-2 (Commitment) because due to the lack of sufficient resources the higher management will not commit to an employee SPI program.

The experts were agreed to the distribution of practices for different CSFs and CBs. One expert recommended to move practice (P3-SF2: Facilitate process improvement team members) from factor (CSF2: staff involvement) to (CSF1: management commitment). He highlighted that providing the core facilities will show the strong commitment of higher management towards the implementation of SPI program. One expert suggested to rephrase the practice (P1- CB3: Detail process improvement knowledge) to meaningful sentence. Therefore, I have updated the mentioned practices as (P1-CB3: Team members should have deep and detailed knowledge related to process improvement).

One expert has criticized the adopted Motorola assessment method. He mentioned that this method is complex in the way that I have used in the case study. He suggested of using the Motorola assessment tool in the case when we conduct focus group studies.

Therefore, it could be a valuable suggestion for researchers, who are willing to use the Motorola assessment tool.

The detail feedback of all the participants is reported in Appendix I1.

Table 5.12 SPIIMM feedback results (SPIIMM structure) of companies A, B and C

Structure of SPIIMM	**No of Participants (n=3)**								
	Positive (+Ve)				Negative (-Ve)				NU
	EA	MA	A	EA+MA +A	ED	MD	D	ED+MD +D	
The core components of SPIIMM are self-exploratory and no need of further explanation to be used effectively.	0	0	2	2	0	0	1	1	0
The SPIIMM components are practical and could be used in GSD industry.	0	0	3	3	0	0	0	0	0
The implementation of SPIIMM could assist an organization to identify issues related to SPI.	2	1	0	3	0	0	0	0	0
The five maturity levels of SPIIMM are enough to assess the SPI maturity level of an organization.	2	0	1	3	0	0	0	0	0
Extremely Agree (EA), Moderately Agree (MA), Agree (A), Neutral (NU), Extremely Disagree (ED), Moderately Disagree (MD), Disagree (D)									

5.8.4 Revised SPIIMM

The structure of SPIIMM was revised based on the case studies conducted with the SPI expert. The feedback results of the experts revealed that minor changes in the structure of SPIIMM are necessary. As discussed in section 5.8.3, I have moved the critical barrier (CB3: lack of process improvement knowledge) from maturity level-2 (Commitment) to level-4 (Defined) as shown in Table 5.13. Similarly, one of the experts recommended to move the critical barrier (CB4: lack of resources) from level-4 (Defined) to level-2 (Commitment). This is because that it might be possible that organizational management have deep understanding and knowledge of SPI activities but still they are not committed to participate in the SPI program. On the other hand, lack of resources can be a strong barrier for the higher management to commit for the

SPI program. Therefore, the experts suggested to consider critical barrier (CB4: lack of resources) in the maturity level-2 (Commitment) of SPIIMM as shown in Table 5.13.

The other small changes were made in the practices of CSFs and CBs by moving practice (P3-SF2: Facilitate process improvement team members) from factor (CSF2: staff involvement) to (CSF1: management commitment). One expert suggested to rephrase the practice (P1- CB3: Detail process improvement knowledge) to meaningful sentence, which have been done by updating it to "P1- CB3: Team members should have deep and detailed knowledge related to process improvement".

Table 5.13 Modification of SPIIMM maturity levels CSFs and CBs

Maturity Levels	**CSFs**	**CBs**
Level-1 (Initial)	Nil	Nil
Level-2 (Commitment)	CSF1:Management commitment	CB4: Lack of resource
Level-3 (Communication)	CSF2: Staff involvement	CB2: Lack of communication
	CSF4: 3C's (communication, coordination, control)	
Level-4 (Defined)	CSF3: Allocation of resources	CB3: Lack of process improvement knowledge
	CSF5: Project pilot implementation	CB5: Lack of formal process improvement implementation methodology
Level-5 (Optimizing)	CSF6: Process improvement expertise	CB1:Lack of organizational support

SPIIMM have five maturity levels i.e. Level-1 (Initial), Level-2 (Commitment), Level-3 (Communication), Level-4 (Defined) and Level-5 (Optimizing). The level-1 does not contain any CSFs and CBs. It shows that the organization is in the beginning stage and did not achieve any maturity level. The Level-2 (Commitment) is based on the commitment and interest of the organizational management to support the SPI activities. This level consists of one critical success factor and one barrier i.e. (CSF1: management commitment) and (CB4: lack of resources) respectively. Organization can only achieve

the second level of SPIIMM if they have successfully addressed the CSF and CB of level-2.

The third level of SPIIMM is Level-3 (Communication), which consist of two CSFs and one CB. These CFSs are (CSF2: staff involvement) and (CSF4: 3C's (communication, coordination, control)) where the CB is (CB2: lack of communication) as shown in Table 5.13. In order to achieve the level-3, it is mandatory that organization have already accomplished the level-2 and successfully addressed the CSFs and CBs of level-3.

The fourth maturity level of an organization is 'Defined' which comprises of two CSFs and Two CBs as shown in Table 5.13. The CSFs of level-4 are (CSF3: allocation of resources) and (CSF5: project pilot implementation). Similarly the two CBs are (CB3: lack of Process improvement knowledge) and (CB5: lack of formal process improvement implementation methodology). Organization can achieve the level-4 of SPIIIM; if they have successfully attained the level-2 and level-3 as well address the CSFs and CBs of level-4.

The last and the highest maturity level is Level-5 (Optimizing). Level-5 comprised of one CSF and one CB. The reported CSF of level-5 is (CSF6: process improvement expertise) while the CB is (CB1: lack of organizational support) as shown in Table 5.13. Organization could achieve the level-5 of SPIIMM, if it has previously achieved and maintained level-2, level-3 and level-4 as well successfully address the CSF and CB of level-5.

In summary, GSD organizations could effectively execute the SPI programs if they have successfully achieved the maturity levels of SPIIMM.

5.9 Summary

In this chapter the complete architecture of SPIIMM is presented which could assist the GSD organizations to assess their maturity level relating to SPI. SPIIMM is based on the systematic literature review study and empirical study conducted with the SPI experts. The SPIIMM consist of three key components i.e. SPIIMM maturity level component, SPIIMM factors (CSFs and CBs) component and SPIIMM practices component. The aim of maturity level component is to provide an assessment levels to the GSD organization in order to know their abilities of SPI implementation. The SPIIMM factors (CSFs and CBs) component is structured with the aim to summarise the factors that can have positive or negative effects on SPI implementation in the domain of GSD. The SPIIMM practices component provides guidelines for organizations to understand and address their strong and weak areas for SPI implementation in GSD.

I have also discussed the results and analysis of the three case studies that were conducted to evaluate the industrial deployment of SPIIMM. In these case studies, SPIIMM was evaluated by the SPI experts and the results were remarkably positive. They have assessed the SPI maturity level of their firms using SPIIMM. They considered SPIIMM as robust model that could assist GSD organizations to assess their SPI maturity level and suggest the improvement practices.

The case studies experts were also requested to provide additional suggestions and improvements in the structure and components of SPIIMM based on their industrial experience. They were positively agreed with the existing components and maturity levels of SPIIMM except some minor changes regarding the positions of some CSFs,

CBs and practices. The suggested changes were made in the revised version of SPIIMM and updated accordingly.

SPIIMM is dynamic in nature and I predict that in future it will be further refined and evolve based on the industrial employment and trends of GSD organizations.

CHAPTER 6: CONCLUSION AND FUTURE DIRECTIONS

6.1 Introduction

This chapter encapsulates the overall results in relation to SPI implementation, drives up conclusions, and prospects for the future related research that could be conducted.

This chapter is organised as follows:

- In Section 6.2 the summary of the research questions is presented.
- In Section 6.3 a critique of the adopted methodology is presented.
- In Section 6.4, research contributions are discussed.
- Implications for the research are presented in the section 6.5.
- Implications for the industry are reported in the section 6.6.
- Future work is described in section 6.7.
- Reflections on research are provided in Section 6.8

6.2 Addressing the Research Questions

In this section, a summary of results is presented for each research question. The following research questions guided to achieve the main objective of this research study

RQ1. What are the success factors, as identified in the literature, do GSD organizations need to address in order to have a positive impact on SPI implementation?

The SLR research approach assists to address the RQ1 of this study. Using SLR technique, a total of 21 success factors were identified that could impact SPI program. The identified success factors are briefly discussed in section 4.2.1 (Table 4.1, Figure 4.1).

RQ2. What are the barriers, as identified in the literature, within GSD have a negative impact on SPI implementation?

I have adopted the SLR research method in order to answer RQ2. The SLR technique assists to extract the barriers that could negatively impact the process improvement activities. In this regard, 22 barriers that could undermine the SPI program were reported in section 4.3.1 (Table 4.7, Figure 4.4).

RQ3. What are the success factors, as identified in the real practice, do GSD organizations need to address in order to have a positive impact on SPI implementation?

RQ3 was developed to empirically (survey questionnaire) validate the success factors identified during the SLR study (RQ1); as well identify additional success factors which were not discussed in the literature. The participants of the survey were asked to confirm those factors which could positively impact the SPI activities in GSD environment. The results discussed in section 4.2.2 (Table 4.2) illustrate positive responses of the survey participants regarding the validity of the reported factors. They have also suggested new success factor i.e. 'shared cyber space' which have not been identified in literature during SLR study.

Among the reported success factors, six factors from the two data sets (SLR, empirical study) have been identified that are generally considered critical for SPI implementation in GSD environment. These critical success factors (CSFs) are: management commitment, staff involvement, project pilot implementation, process improvement expertise, allocation of resources and 3C (communication, coordination and control). These success factors were common in both the data sets. The results suggest that GSD organizations should focus on the identified CSFs, because these factors are presenting the key areas of SPI.

RQ4. What are the barriers, as identified in the real practice, within GSD have a negative impact on SPI implementation?

The aim of RQ3 is to empirically validate the barriers identified during the SR study (RQ2) and report additional barriers suggested by the survey respondents. The results and analysis presented in section 4.3.2 (Table 4.8) highlighted that majority of the survey respondents were positively agreed to consider the barriers identified during SLR study for SPI in GSD. They have not mentioned any additional new barriers that could negatively impact the SPI activities in GSD environment.

I have also categorised the most critical barriers in both the data sets (SLR, empirical study) by following the criteria discussed in section 4.2.4. Using the critical barriers (CBs) criteria, five barriers were ranked as CBs. The identified CBs are: lack of process improvement knowledge, lack of resources, lack of communication, lack of organizational support and lack of formal SPI implementation methodology. SPI teams should take the CBs more seriously, because these barriers should have a significant negative impact on the SPI program in GSD. These barriers are significantly discussed in both the data sets.

RQ5. Are there differences between the success factors identified in the literature and real practice?

The key objective of RQ5 is to compare the success factors identified in both data sets (SLR, empirical study) to understand the similarities and differences between the factors. In that sense, I have done the comparative analysis of both the studies based on the ranks of the identified success factors. The results discussed in section 4.2.3 demonstrate that there are more similarities than differences among the ranks of the factors. I have noticed minor differences in the ranks, as some factors have high ranks in one dataset but lower in the other.

I have also performed comparative analysis among the success factors of SLR and empirical study based on the organization size, experience level of the survey participants, expert's position, continents and study types. The detail analysis is reported in section 4.5. The aim of this analysis is to get an understanding of the factors in different contexts because the success factors are the core components of SPIIMM, which is a generic model beyond the differences of organization size, continents, expert's positions etc. Therefore, this analysis gives confidence to claim SPIIMM as a common model which could be used by any GSD organization.

RQ6. Are there differences between the barriers identified in the literature and real practice?

Barriers identified using SLR and empirical study were comparatively analysed to highlight the similarities and differences among their ranks. I have noticed some slight differences between the ranks of the two data sets as some of the barriers have high rank

in one data type and lower in the other. The detail rank wise analysis is discussed in section 4.3.3.

The identified barriers of the SLR and empirically study were additionally compared based on organization size, experience level of the survey participants, expert's position, continents and study types. This comparison highlighted the similarities and differences of the barriers in the domain of different perspectives. These results have supported SPIIMM to present as a general SPI implementation model for GSD organizations.

RQ7. What are the practices, as identified in the literature, to address the critical success factors and critical barriers for SPI in GSD?

I have categorised different success factors and barriers as the most critical for SPI implementation. The aim of RQ7 is to define practices that could be used to implement the CSFs and address CBs. In (Table 4.13, Figure 4.7), 31 practices are discussed that were identified using an SLR approach to implement the CSFs. Similarly, the SLR approach assists to identify the 25 practices to address the CBs (Table 4.14, Figure 4.8).

RQ8. What are the practices, as identified in real practice, to address the critical success factors and critical barriers for SPI in GSD?

I have also conducted an industrial survey with SPI experts to empirically validate the identified practices of SLR. The results of the questionnaire survey discussed in section 4.4.2 shows that more than 80% of the survey participants agreed to positively mark the practices of SLR for the CSFs and CBs. Table 4.16 reported 15 new practices recommended by the survey participants to implement the CSFs. Those practices were not been identified during the SLR study. I have also identified one new practice during the survey questionnaire study in order to address CB2 (i.e. team members

should have plan for frequent daily meetings). This practice was not acknowledged during the literature review.

RQ9. How can a practically robust software process improvement implementation and management model (SPIIMM) be developed?

Chapter 1 consists of different phases involved in the development of SPIIMM as shown in Figure 1.1. The first phase consists of the success criteria developed for SPIIMM. In the second and third phases, success factors and barriers were identified along their practices which were reported in phase four (chapter 4). I have also conducted an industrial questionnaire survey with the SPI experts to empirically validate the success factors, barriers, practices and identify additional new factors. In phase 5, I undertook rationalization and structuring of SPI implementation activities and based on the empirical and literature findings, the three core components of SPIIMM were designed as shown in Figure 5.1. All the three components were integrated to structure SPIIMM. SPIIMM was evaluated through three case studies conducted with the SPI experts. The experts have assessed the SPI maturity level of their respective organizations as discussed in section 5.8. The findings of the case studies indicate that SPIIMM is practically robust to measure the SPI maturity level on a GSD organization. This is evidenced by the satisfactory results of the feedback session conducted with the case studies participants (section 5.8). The feedback results reveal that the experts were positively agreed that SPIIMM is clear and could easily assist GSD organization to assess the SPI maturity level and provide further improvement practices. They have suggested some additional improvement in the structure of SPIIMM based on their industrial experience. Therefore, the experts' level evaluation allowed me to revise the original SPIIMM model to better reflect SPI process.

6.3 Limitations of the Study

In this research study, I have adopted SLR and mixed method (questionnaire survey, case study) approaches to develop SPIIMM.

SLR is used to identify the success factors and barriers that could impact the SPI program. We have also extracted different practices to address the identified success factors and barriers using SLR approach. A sample of 91 studies was selected to extract the data regarding the factors. With the numerous number of research articles on SPI, this research study may have missed some related research papers. However, this is not a systematic omission like other researchers of SLR (Khan, & Khan, 2013; Khan, & Keung, 2016).

The survey questionnaire was used to validate the factors extracted from the literature with the SPI practitioners. I have not directly verified the experiences and perceptions of the survey respondents. This might show that what the practitioners responded regarding the success factors and barriers may not be necessarily significant for SPI activities. Their perceptions might not be precise. Similarly, due to the limited time and resources, the sample size of survey questionnaire (n=111) might not be strong enough to justify the development and validity of SPIIMM. However, based on the different other existing studies (Khan, 2015; Ali, & Khan, 2016), these are adequate samples to justify the validity and assessment of SPIIMM.

The evaluation of SPIIMM on the small sample size (n=3) of the case study might not be effective for all GSD organizations. Each case study was responded by a single representative and the feedback of that individual may not present the population of the entire SPI team. I have adopted Motorola instrument (Daskalantonakis, 1994) in order to assess the identified CSFs and CBs along their practices. The use of the single

assessment instrument might not be enough to achieve more authentic results. Similarly, I have conducted all the case studies using email correspondence which did not provide any face to face interaction with the responded. Due to the lack of face to face communication, they might not have completely understood the documents provided for the case study.

6.4 Research Contributions

The research presented in this thesis contributes to the existing body of knowledge in six different ways. I have encapsulated the research contribution of this study in the following points.

- There are no previous studies that address SPI implementation challenges by developing a software process improvement implementation management model in the context of GSD
- A comprehensive analysis of software process improvement in the domain of global software development with the help of a mixed method approach (SLR, questionnaire survey, case study).
- Systematic literature review and empirical study of success factors and barriers that could impact the implementation of SPI program in GSD environment.
- Systematic literature review and empirical study of the practices that could assist SPI practitioners to successfully address the critical success factors and critical barriers.
- Designing and development of SPIIMM to assist GSD organizations to successfully execute SPI activities.

- The empirical evaluation of SPIIMM ensured that it is theoretically and practically robust in terms of measuring and improving the maturity level of organization for SPI implementation.

6.5 Implications for research

This research study has significant implications for the body of knowledge for the research in the following ways.

- Concerning the problem definition, I have thoroughly investigated the challenges of software process improvement in the domain of global software development.
- Regarding the solution, besides presenting SPIIMM, I have systematically studied and analyse the existing literature of software process improvement implementation with respect to GSD. It was helpful for my thesis to confirm that successful execution of SPI activities does lead to organizational success.
- This thesis provides a consolidated knowledge-base of software process improvement and global software development which has not been done before.

6.6 Implications for industry

Academic research faces major criticisms of the research community regarding the real world or industrial validity of the problem, solution, acceptance and applicability. In my research work, I have tried to fill this gap by adopting the mixed research method based on the existing literature and the industrial evaluation of the SPI related issues and challenges in the domain of GSD. I have conducted an industry survey to encapsulate the views and perceptions of the SPI experts regarding the SPIIMM. The survey participants provided their feedback regarding the confirmation and understating of the

SPI program in their respective organizations. SPIIMM was employed in a real world scenario by practicing the case study approach.

6.7 Future Directions

This section consists of future work related to the research project discussed in this thesis.

SLR study has illustrated categorical investigation of the success factors and barriers in different other domains. I am interested to apply this phenomenon in the context of SPI by categorically classifying the success factors and barriers for SPIIMM. This change will contribute to SPIIMM in the way that each factor will present in a specific category e.g. human, organization etc. It will assist SPI team members to manage and address the factors according to their parent category.

SPIIMM has been assessed and tested using case studies and expert's feedback process, additional evaluation of SPIIMM will require on the basis of large scale cases studies. SPIIMM will also implement in the domain of different types of organizations (small, medium, large) in order to observe its practical performance in different size organizations. This assessment will assist to further improve the generic nature of SPIIMM, which could be used to successfully execute SPI activities beyond the organization types.

In the future, the SPIIMM can be extended in the form of software tool to assist GSD organizations to assess and improve their SPI implementation capabilities. This is because the survey participants significantly considered to develop a tool based on the architecture of SPIIMM to facilitate SPI team members in evaluating and assessing SPI activities. This tool should be capable of identifying the SPI maturity level of an organization by assessing the CSFs and CBs. It should also identify the weak and strong

factors of each maturity level and then present the practices to address the weak factors. It will assist the organization to move the next higher maturity level. This tool support in the way to increase the visibility of processes, identify the weakness and understanding of processes.

6.8 Reflections

At the very beginning of my PhD studies, I did not have a concrete idea about the research topic and my supervisor guided to explore a specific research topic in the domain of Software Engineering specifically in the area of Software Process Improvement. It was an exploration phase of my research background, where each and every step contributed to make clear my research concepts. I have started the problem investigation by following the Systematic Literature Review process and it turned out to be extremely useful approach to critically analyse the existing literature. Reflecting on the research work conducted in this thesis, I learned the whole research process: problem definition, survey and case studies sampling, quantitative and qualitative data collection, analysis of the collected data and reporting of the results. The whole research process of this study makes it clear to me that research is a continuous process of reading, re-searching, asking questions, re-asking questions and so on. It also makes it clear that the researcher is the one who continuously look for the right research problem, research questions, objective, clarifications, relationships, evaluations, justification, predictions and theories.

At the end, I appreciate the fact that the entire research process of this thesis was a beneficial experience that helps me to become a self-learner by acquiring the ability to manage the research problems, and by gathering the data from the available literature and industrial empirical studies.

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Appendix A: Systematic Literature Review (SLR) Protocol

1. Introduction

Software development process is “an organized set of activities, methods, practices and transformations that people use to develop and maintain software and the associated procedures”. These activities and practices include project planning, system design, coding, testing and user manuals. In order to effectively manage the software quality issues various software development practices and approaches have been formulated. Software process improvement (SPI) is one of them and is most extensively used approach (Khan, & Keung, 2016). SPI gives organization with a commanding means of evaluating their existing abilities regarding the development of software systems and classifying their weak and strong facts. The main agenda of SPI is to understand and define the existing software development process of specific organization and direct those areas that can be measured and operate in order to accomplish the particular objectives of the product (Babar, & Niazi, 2008). (Zahran, 1998) defined SPI as "the discipline of defining, characterizing, improving and measuring software management, better product innovation, faster cycle time, greater product quality and reduced development costs simultaneously".

Regardless of the SPI implementation importance, the researchers show very little interest in the SPI implementation process. Within the last several years, we have viewed several standards and models including, CMM (Paulk et al., 1993), currently CMMI (SEI, 2002) and ISO's SPICE (Viadiu, Fa, & Saizarbitoria, 2006) for the purpose to enhance software processes in the software industry. These standard and models can lead the software organizations to develop quality products (Butler, & Lipke, 2000).

Regardless of different benefits, SPI implementation exhibit minimum adoption level and limited success (Niazi, 2015). In multi-site software development, SPI program

needs a long term approach. It requires a considerable amount of effort for complete implementation of an SPI process (Ramasubbu, 2014). Such efforts show that process improvement is usually considered an expensive technique for various software companies because they require significant resources for a long period of time. As the software organizations ready to allocate the resources do not always accomplish the anticipated outcomes. The estimated failure rate of SPI implementation is 70%, which shows a very high degree (Ngwenyama, & Nielsen, 2003). Most of the organizations are unwilling to initiate the SPI implementation due to significant investment of resources.

In spite of the significance of SPI, the researchers have paid very little attention in order to effectively implement the SPI programs in GSD (Khan, & Keung, 2016; Ramasubbu, 2014). For SPI implementation most of the organizations usually follow ad hoc techniques as compare to standard approaches. None of the available approaches have been determined in the context of GSD that could support the implementation of SPI program. So there must be any technique or method that could help the SPI team in the implementation of SPI initiatives in GSD.

Our results from literature review will give brief guideline to design a model to provide a functional framework for evaluation and improvement of SPI implementation programs in GSD. The model will based on critical success factors (CSFs) and critical barriers (CBs) discussed in previous research and it will be validated through empirical study conducted in GSD industry. For the investigation of CSFs and CBs, I will follow the Systematic Literature Review (SLR) approach.

SLR is the organized approach of documenting the results extracted from literature (Kitchenham, & Charters, 2007). SLR method gives a way of investigation, categorizing, and evaluating the present literature associated with any research area (Kitchenham, & Charters, 2007). The key role of SLR is to extract the appropriate

literature by applying inclusion and exclusion techniques at primary studies. SLR also guide towards the criteria used for the assessment of the extracted results from the selected primary studies (Kitchenham, & Charters, 2007).

An SLR approach plays a significant role in the better understanding of the problem and available approaches. SLR will use as a source to assess and understand all the existing research (Kitchenham, & Charters, 2007). SLR protocol is developed to investigate the existing CSFs and CBs that could affect the SPI process in GSD. I will also investigate the practices that could address the CSFs and CBs using SLR approach.

2. Research Questions

Highlighting the effective research questions are most significant component of any effective SLR approach (Kitchenham, & Charters, 2007). For research questions identification I will use the criteria (Population, Intervention and Outcome of relevance) defined by (Khan et al., 2013) as shown in Table 1.

Table 1: Research questions identification criteria

Population	Global Software Development organizations using SPI
Intervention	Success Factors, Barriers, practices
Outcomes of relevance	Positive and negative impact

After using the above criteria, the following research questions have been formulated.

RQ1. What are the factors, as identified in the literature, do GSD organizations need to address in order to have a positive impact on the SPI implementation?

[What are the success factors, as identified in the literature] “INTERVENTION” [do GSD organizations need to address] “POPULATION” [in order to have positive impact on SPI implementation] “OUTCOME OF RELEVANCE”.

RQ2. What are the barriers, as identified in the literature, within GSD have a negative impact on SPI implementation?

[What are the barriers, as identified in the literature] "INTERVENTION" [within GSD] "POPULATION" [have a negative impact on SPI implementation] "OUTCOME OF RELEVANCE".

RQ7. What are the practices, as identified in the literature, to address the critical success factors and critical barriers for SPI in GSD?

[What are the practices, as identified in the literature] "INTERVENTION" [to address the critical factors and critical barriers for SPI] "OUTCOME OF RELEVANCE" [in GSD] "POPULATION".

3. Search Strategy

3.1 Identification of Search Terms

The Following strategy has been developed in order to construct search terms (Khan et al, 2013):

a. Derive the major terms from the research questions, by identifying population, intervention and outcome of relevance.

b. To derive the major terms, search for alternative spellings and synonyms.

c. Verify the keywords in any relevant papers.

d. If the database allows, use Boolean "OR" operator to integrate alternative spellings and synonyms and use the "AND" operator to integrate the major terms.

I will assess each research question according to the above search strategy as follow:

RQ1. What are the factors, as identified in the literature, do GSD organizations need to address in order to have a positive impact on the SPI implementation?

Results for a:

Table 2: Major terms of RQ1

Population	GSD Organizations
Intervention	Factors
Outcomes of relevance	Positive impact on SPI implementation

Results for b:

Factors: ("factors" OR "aspects" OR "items" OR "elements" OR "drivers" OR "motivators" OR "variables" OR "characteristics" OR "parameters")

GSD: ("GSD" OR "global software development" OR "global software engineering" OR "distributed software development" OR "software outsourcing" OR "offshore software development" OR "information technology outsourcing" OR "software contracting-out" OR "IT outsourcing")

SPI: ("SPI" OR "software process improvement" OR "software process enhancement" OR "CMM" OR "CMMI" OR "SPICE" OR "software process enrichment" OR" software process evaluation" OR "software process assessment" OR "software process appraisal")

Positive impact: ("positive impact" OR "conclusive" OR "absolute" OR "concrete" OR "perfect" OR "reliable" OR "good effect" OR "best results")

Results for c:

The keywords and their alternatives are based on the existing literature in the domain of SPI and GSD (Babar and Niazi, 2008; Ramasubbu, 2014; Bano and Ikram, 2012; S. U. Khan et al, 2011).

Results for d:

Factors: (“factors” OR “aspects” OR “items” OR “elements” OR “drivers” OR “motivators” OR “variables” OR “characteristics” OR “parameters”) AND (“GSD” OR “global software development” OR “global software engineering” OR “distributed software development” OR “software outsourcing” OR “offshore software development” OR “information technology outsourcing” OR “software contracting-out” OR “IT outsourcing”) AND (“SPI” OR “software process improvement” OR “software process enhancement” OR “CMM” OR “CMMI” OR ”SPICE” OR “software process enrichment” OR” software process evaluation” OR “software process assessment” OR “software process appraisal”) AND (“positive impact” OR “conclusive” OR “absolute” OR “concrete” OR “perfect” OR “reliable” OR “good effect” OR “best results”)

RQ2. What are the barriers, as identified in the literature, within GSD have a negative impact on SPI implementation?

Results for a:

Table 3: Major terms of RQ2

Population	GSD
Intervention	Barriers
Outcomes of relevance	Negative impact on SPI implementation

Results for b:

Barriers: (“barriers” OR “obstacles” OR “hurdles” OR “risks” OR “risk analysis” OR “critical barriers” OR “difficulties” OR “impediments”)

GSD: (“GSD” OR “global software development” OR “global software engineering” OR “distributed software development” OR “software outsourcing” OR “offshore software development” OR “information technology outsourcing” OR “software contracting-out” OR “IT outsourcing”)

SPI: (“SPI” OR “software process improvement” OR “software process enhancement” OR “CMM” OR “CMMI” OR ”SPICE” OR “software process enrichment” OR” software process evaluation” OR “software process assessment” OR “software process appraisal”)

Negative impact: (“negative impact” OR “negative effects” OR “bad impact” OR “bad effects” OR “unwilling impact” OR “unreliable outcomes” OR “undesired results” OR “unsatisfactory results”)

Results for c:

The keywords and their alternatives are based on existing literature in the domain of SPI and GSD (Babar and Niazi, 2008; Ramasubbu, 2014; Bano and Ikram, 2012; Khan et al, 2011).

Results for d:

Barriers: (“barriers” OR “obstacles” OR “hurdles” OR “risks” OR “risk analysis” OR “critical barriers” OR “difficulties” OR “impediments”) AND (“GSD” OR “global software development” OR “global software engineering” OR “distributed software development” OR “software outsourcing” OR “offshore software development” OR “information technology outsourcing” OR “software contracting-out” OR “IT outsourcing”) AND (“SPI” OR “software process improvement” OR “software process enhancement” OR “CMM” OR “CMMI” OR ”SPICE” OR “software process enrichment” OR” software process evaluation” OR “software process assessment” OR “software process appraisal”) AND (“negative impact” OR “negative effects” OR “bad impact” OR “bad effects” OR “unwilling impact” OR “unreliable outcomes” OR “undesired results” OR “unsatisfactory results”)

RQ7. What are the practices, as identified in the literature, to address the critical success factors and critical barriers for SPI in GSD?

Results for a:

Table 4: Major terms of RQ3

Population	GSD
Intervention	Practices
Outcomes of relevance	Critical success factors and critical barriers for SPI

Results for b:

Practices: ("practices" OR "recommendations" OR" implementation practices" OR" improvements" OR "best practices" OR "solutions" OR "exercise" OR "suggestions" OR "execution")

Critical factors: ("critical factors" OR "important factors" OR "success factors" OR "positive elements" OR "critical success factors" OR "significant variables" OR "significant positive factors")

Critical barriers: ("critical barriers" OR "significant barriers" OR "important obstacles" OR "key barriers" OR "important barriers" OR "critical risks" OR "difficulties" OR "impediments")

GSD: ("GSD" OR "global software development" OR "global software engineering" OR "distributed software development" OR "software outsourcing" OR "offshore software development" OR "information technology outsourcing" OR "software contracting-out" OR "IT outsourcing")

Results for C:

The keywords and their alternatives are based on existing literature in the domain of SPI and GSD (Babar and Niazi, 2008; Ramasubbu, 2014; Bano and Ikram, 2012; Khan et al, 2011).

Results for d:

Practices: (“practices” OR “recommendations” OR” implementation practices” OR” improvements” OR “best practices” OR “solutions” OR “exercise” OR “suggestions” OR “execution”) AND (“critical factors” OR “important factors” OR “success factors” OR “positive elements” OR “critical success factors” OR “significant variables” OR “significant positive factors”) AND (“critical barriers” OR “significant barriers” OR “important obstacles” OR “key barriers” OR “important barriers” OR “critical risks” OR “difficulties” OR “impediments”) AND (“GSD” OR “global software development” OR “global software engineering” OR “distributed software development” OR “software outsourcing” OR “offshore software development” OR “information technology outsourcing” OR “software contracting-out” OR “IT outsourcing”)

3.2 Search Phases

The overall searching process consists of two main phase’s i.e. primary phase and secondary phase.

3.2.1 Primary Phase

Different online repositories were identified in order to categorize related research papers, journals, magazines and conferences etc. The selection of those repositories was based on the research experience and suggestions provided by (Chen, Babar, & Zhang, 2010). Details of the selected research sources are given below.

Publisher's Site: Publishers sites include published research study from their own repositories (Chen, Babar, & Zhang, 2010). Followings publisher's sites are selected for this study.

- Wiley Inter Science
- IEEE Xplore
- ACM Digital Library
- Springer Link

Index Engines: Index Engines contains the data of different other publisher's sites (Chen, Babar, & Zhang, 2010). Following index engines are identified for this research study:

- Google Scholar
- Science Direct

3.2.2 Secondary Phase

In the secondary search phase different companies and organizations as well as individuals will be contacted for data and unpublished technical works. It might include grey literature and technology white papers as well.

3.3 Search Documentation

During SLR, the extracted literature data should be well documented. Accurate search results documentation is necessary because it will make the search process precise and also makes it applicable. Strategy of search documentation will be same as proposed by (Kitchenham, & Charters, 2007). The search documentation strategy is discussed in Table 5.

Table 5: Search Documentation

Data Source	Record Keeping
Publisher's Site	Publisher's Name, Search Strategy, Date of Search, Year
Index Engines	Engine Name, Search Strategy, Date of Search
Selected Software Engineering Journals	Journal Name, Search Strategy, Year
Selected Software Engineering Conferences	Conference Name, Year, Date of Conference, Search Strategy

4. Quality Criteria for studies selection

All the selected research studies for SLR require the quality assessment. Following are the important steps that need to be focused.

4.1 Inclusion Criteria

Each selected article must be written in English and available in full text version. These articles must be conferences, journals, workshops, book articles and thesis. I have considered the studies which emphasis on process improvement activities in the distributed software development environment. More effort was put on the research articles that have discussed SPI success factors, barriers and their practices in the context of GSD. Those research articles certainly have more importance that provides empirical assessments supported with case studies.

4.2 Exclusion Criteria

The articles that did not explicitly discuss the success factors, barriers and practices for SPI in the context of GSD were excluded from this analysis, as well as those that neither focused on SPI standards nor provided enough detail about the software improvement process. Duplicates of the same results were also excluded. Further exclusions have been made in those studies that were written in a language other than English.

4.3 Primary studies selection

During the primary study selection process, tollgate approach proposed by (Afzal et al, 2009) was used to refine the selection process. The tollgate approach consists of five phases i.e. Ph-1 to Ph-5:

- Phase 1 (Ph-1): search through search terms.
- Phase 2 (Ph-2): inclusion and exclusion based on the title and abstract.
- Phase 3 (Ph-3): inclusion and exclusion based on the introduction and conclusions.
- Phase 4 (Ph-4): inclusion and exclusion based on the full text.
- Phase 5 (Ph-5): final selection of the articles to be included in the primary studies selection.

4.4 Study Quality Assessment

The Quality Assessment (QA) of the selected articles will perform concurrently with the data extraction phase. The guidelines provided by (Petticrew and Helen, 2008; Crombie, 1997; Fink, 2013) will follow in the design of this checklist Table 6.

For each given item QA1 to QA5, the assessment will carry out as follows:

a. The studies containing answers to the checklist question will give a score of 1 point.

b. The studies containing partial answers to the checklist question will give as a score of 0.5 points.

c. The studies not containing any answer to the checklist question will give as a score of 0 points.

The selected studies will also assess through informal external review to make sure that these studies have sufficient quality to be considered in this SLR study.

Table 6 Checklist for Quality assessment of selected studies

QA Questions	Checklist Questions
QA1	Do the adopted research methods address the research questions?
QA2	Does the study discuss any success factors or barriers for SPI?
QA3	Does the study discuss practices to address the success factors or barriers for SPI in GSD?
QA4	Is the collected data related to SPI?
QA5	Are the identified results related to justification of the research questions?

5. Data Extraction

5.1 Extracted Information

The purpose of the study is to collect the data, from the publications, which is focused on satisfying the research questions for the review. The following data will be extracted from each article.

- Article Title
- Complete Reference
- Year
- Study Type
    - Journal
    - Conference
    - Thesis
    - Research Report
- Success Factors
- Barriers
- Practices
- Adopted research Method

- Continent
- Company size

5.2 Process of data extraction

I will conduct this SLR and the supervisors will continuously assist to carry the SLR study. I will perform the inter-rater reliability analysis in order to neutralize the inter-person bias. Total three external independent reviewers will randomly select ten articles from the first phase 'Ph-1' and followed the selection phases 'Ph-2 to Ph-5' and quality assessment process. I will perform non-parametric Kendall's coefficient of concordance (W) (Eye et al, 2006) analysis in order to assess the inter-rater agreement among the reviewers.

6. Data Synthesis

In this phase, all the extracted findings will bring together and each question will exclusively evaluate against the results. The summaries of all the findings will be used for more investigation. The data synthesis for each research question can be developed as follow.

6.1 RQ1

It states that "What are the factors, as identified in the literature, do GSD organizations need to address in order to have a positive impact on SPI implementation?" After findings, I will be able to answer this question by investigating the success factors that could have a positive impact on the SPI implementation in GSD. If there will any factors that could impact the SPI implementation then they will be given more focus in detail and the findings will be documented in tabular form as given below in Table 7.

Table 7 Data Synthesis for RQ1

S. No	Paper Title	Authors	Year	Success Factor	Context	
					Collocated	GSD

6.2 RQ2

It states that "What are the barriers, as identified in the literature, within GSD have a negative impact on SPI implementation?" To answer this research question, I will investigate the barriers that have negative effect on SPI implementation. The question may be addressed by tabulating the summaries of the barriers as shown in Table 8.

6.3 RQ7

It states that "What are the practices, as identified in the literature, to address the critical success factors and critical barriers for SPI in GSD?" This question will also have a main focus on the investigation of any existing practices that could be used to address the identified CSFs and CBSs. The question may be addressed by tabulating the summaries of the practices as shown below in Table 8.

Table 8 Data Synthesis for RQ2 and RQ7

Data Synthesis for RQ2					
S.No	Paper Title	Authors	Year	Barriers	Summary
Data Synthesis for RQ7					
S.No	Paper Title	Authors	Year	Practices	Summary

Appendix B: Selected Primary Studies using SLR approach

Tracking #	Title	Study Type	Research Method	Year	Continent	Organization Size
LT1	Khan, U.S., Niazi, M., Ahmad, R.: Critical Success Factors for Offshore Software Development Outsourcing Vendors: An Empirical Study. Product-Focused Software Process Improvement, vol. (6156), pp. 146-160 (2010)	Conference/ PROFES	Questionnaire Survey	2010	Asia	Nil
LT2	Sulayman, M., Mendes, E., Urquhart, C., Riaz, M., Tempero, E.: 'Towards a theoretical framework of SPI success factors for small and medium web companies. Information and Software Technology, vol. 56, pp. 807-820 (2014)	Journal/IST	Mix (SLR, replication study, grounded theory)	2014	Asia	Mixed
LT3	Herbsleb, J.D., Dennis R.G.: A systematic survey of CMM experience and results. IEEE 18th International Conference on Software Engineering, pp.323-330 (1996)	Conference/ICSE	Questionnaire Survey	1996	North America	Nil
LT4	Rainer, A., Hall, T.: Key success factors for implementing software process improvement: a maturity-based analysis. Journal of systems and software, 62(2), pp.71-84 (2002)	Journal/JSS	Questionnaire Survey	2002	Europe	Large
LT5	Ramasubbu, N.: Governing Software Process Improvements in Globally Distributed Product Development. IEEE Transactions on Software Engineering, vol. 40, pp. 235-250 (2014)	Journal/TSE	Action Research	2015	North America	Nil
LT6	El Emam, K., Koru, A. G.: A replicated survey of IT software project failures, IEEE Software, vol. 25, pp. 84-90 (2008)	Journal/IEEE Software	Questionnaire Survey	2008	North America	Nil
LT7	Khan, A. W., Khan, S. U.: Critical success factors for offshore software outsourcing contract management from vendors' perspective: an exploratory study using a systematic literature review. IET software, vol. 7, pp. 327-338 (2013)	Journal/IET Software	SLR	2013	Asia	Mixed
LT8	Kautz, K., Nielsen, P. A.: Implementing software process improvement: two cases of technology transfer. 33rd Annual Hawaii International Conference on System Sciences, p. 1-10 (2000)	Conference/33rd Annual Hawaii International Conference on System Sciences (HICSS)	Case Study	2000	Europe	Large
LT9	Niazi, M., Wilson, D., Zowghi, D.: A maturity model for the implementation of software process improvement: an empirical study, Journal of systems and software, vol. 74, pp. 155-172 (2005)	Journal/JSS	Interview (Content Analysis)	2005	Australia	Mixed
LT10	Khan, A.A., Keung, J.: Systematic Review of success factors and barriers for Software Process Improvement in Global Software Development. IET Software, ISSN 1751-8814 (2016)	Journal/IET Software	SLR	2016	Asia	Mixed

LT11	Niazi, M., Wilson, D., Zowghi, D.: A model for the implementation of software process improvement: A pilot study. third International Conference on Quality Software, pp. 196-203 (2003)	Conference/ Third International Conference On Quality Software (ICQS)	Interview (Content Analysis)	2003	Australia	Mixed
LT12	Pettersson, F., Ivarsson, M., Gorschek, T., Öhman, P.: A practitioner's guide to light weight software process assessment and improvement planning. Journal of systems and software, vol. 81, pp. 972-995(2008)	Journal/JSS	Interview (Content Analysis)	2008	Europe	Nil
LT13	Iversen, J. H., Mathiassen, L., Nielsen, P. A.: Managing risk in software process improvement: an action research approach. MIS Quarterly, 2004, pp. 395-433(2004)	Journal/ MIS Quarterly (MISQ)	Action Research	2004	Europe	Nil
LT14	Rainer, A., Hall, T.: A quantitative and qualitative analysis of factors affecting software processes. Journal of systems and software, vol. 66, pp. 7-21(2003)	Journal/JSS	Mix (Questionnaire Survey, interview)	2003	Europe	Large
LT15	Dyba, T. : An empirical investigation of the key factors for success in software process improvement. IEEE Transactions on Software Engineering, 31(5), pp.410-424 (2005)	Journal/TSE	Questionnaire Survey	2005	Europe	Mixed
LT16	Niazi, M., Babar, M. A., Verner, J. M.: Software Process Improvement barriers: A cross-cultural comparison. Information and Software Technology, vol. 52, pp. 1204-1216 (2010)	Journal/IST	Questionnaire Survey	2010	Mixed	Mixed
LT17	Sulayman, M., Urquhart, C., Mendes, E., Seidel, S.: Software process improvement success factors for small and medium Web companies: A qualitative study. Information and Software Technology, vol. 54, pp. 479-500 (2012)	Journal/IST	Interview (Grounded Theory)	2012	Asia	Mixed
LT18	Richardson, I., Casey, V., Burton, J., McCaffery, F.: Global software engineering: A software process approach, Collaborative Software Engineering, Springer Berlin Heidelberg, Germany, pp. 35-56 (2010)	Book Chapter/ Collaborative Software Engineering	Mix(case study, action research)	2010	Europe	Large
LT19	Sulayman, M., Mendes, E.: Quantitative assessments of key success factors in software process improvement for small and medium web companies. Proceedings of the ACM Symposium on Applied Computing. pp. 2319-2323 (2010)	Conference/ SAC	Questionnaire Survey	2010	Asia	Mixed
LT20	Khan, S. U., Niazi, M., Ahmad, R.: Critical barriers for offshore software development outsourcing vendors: a systematic literature review. Asia-Pacific Software Engineering Conference , pp. 79-86 (2009)	Conference/ APSEC	SLR	2009	Asia	Mixed
LT21	Bayona-Oré, S., Calvo-Manzano, J. A., Cuevas, G., San-Feliu, T.: Critical success factors taxonomy for software process deployment. Software Quality	Journal/ Software Quality Journal	Mixed Method (Systematic Review,	2014	Europe	Small

	Journal, vol. 22, pp. 21-48, 2014	(SQJ)	Questionnaire Survey, Case Study)			
LT22	Mäntylä, M. V., Petersen, K., Lehtinen, T. O., Lassenius, C.: Time pressure: a controlled experiment of test case development and requirements review. in Proceedings of the 36th International Conference on Software Engineering, pp. 83-94 (2014)	Conference/ICSE	Case Study	2014	Europe	Small
LT23	Niazi, M., Wilson, D., Zowghi, D.: Critical success factors for software process improvement implementation: an empirical study, Software Process: Improvement and Practice, vol. 11, pp.193-211(2006)	Journal/JSEP	Interview (Content Analysis)	2006	Australia	Mixed
LT24	Bayona, S., Calvo-Manzano, J. A., San Feliu, T.: Review of Critical Success Factors Related to People in Software Process Improvement, Systems, Software and Services Process, Springer Berlin Heidelberg, Germany, pp. 179-189 (2013)	Book Chapter/ Systems, Software and Services Process Improvement (SSPI)	SLR	2013	Europe	Small
LT25	Baddoo, N., Hall, T.: De-Motivators of software process improvement: An analysis of practitioner's views. Journal of Systems and Software, vol. 66, pp. 23-33 (2003)	Journal/JSS	Questionnaire Survey	2003	Europe	Medium
LT26	Baddoo, N., Hall, T., Wilson, D.: Implementing a people focused SPI programme. 11th European Software Control and Metrics Conference, pp.373-382 (2000)	Conference/ ESCOM	Mixed Method (focus group discussions, questionnaires, structured interviews and Repertory Grid Technique (RGT))	2000	Europe	small
LT27	Niazi, M., Wilson, D., Zowghi, D.: Critical barriers for software process improvement implementation: An empirical study. IASTED Conference on Software Engineering, pp. 389-395(2004)	Conference/ IASTED	Interview (Content Analysis)	2004	Australia	Mixed
LT28	Khan, S. U., Niazi, M., Ahmad, R.: Factors influencing clients in the selection of offshore software outsourcing vendors: An exploratory study using a systematic literature review. Journal of Systems and Software, vol. 84, pp. 686-699 (2011)	Journal/JSS	SLR	2011	Asia	Mixed
LT29	Moitra, D.: Managing change for (SPI) initiatives: A practical experience-based approach. Software Process Improvement and Practice, pp. 199-207 (1998)	Journal/JSEP	Case Study	1998	Asia	Large
LT30	Hall, T., Beecham, S., Verner, J., Wilson, D.: The impact of staff turnover on software projects: the importance of understanding what makes software practitioners tick. Proceedings of the ACM SIGMIS CPR conference on Computer	Conference/ ACM SIGMIS CPR	Interview (Content Analysis)	2008	North America	Large

	personnel doctoral consortium and research, pp. 30-39 (2008)					
LT31	Niazi, M., Wilson, D., Zowghi, D., Wong, B.: A model for the implementation of software process improvement: An empirical study. Product-Focused Software Process Improvement, pp. 1-16 (2004)	Conference/ PROFES	Interview (Content Analysis)	2004	Australia	Mixed
LT32	Niazi, M.: 'Software process improvement implementation: avoiding critical barriers, CROSSTALK. The Journal of Defense Software Engineering, vol. 22, pp. 24-27 (2009)	Journal /Defense Software Engineering	Interview (Content Analysis)	2009	Australia	Mixed
LT33	Shah, H. , Harrold, M. J., Sinha, S.: 'Global software testing under deadline pressure: Vendor-side experiences , Information and Software Technology, vol. 56, pp. 6-19 (2014)	Journal/IST	Mixed Method (Interviews, participant observations)	2014	North America	small
LT34	Ågerfalk, P., Fitzgerald, M. , Olsson, H.H., Conchúir, E.O.: Benefits of Global Software Development: The Known and Unknown. Making Globally Distributed Software Development a Success Story, Springer Berlin Heidelberg, Vol.5007, pp. 1-9. (2008)	Book Chapter/ Making Globally Distributed Software Development a Success Story	Informal Literature Review	2008	Europe	Nil
LT35	Taweel, A., Delaney, B., Arvanitis, T.N., Zhao, L.: Communication, Knowledge and Co-ordination Management in Globally Distributed Software Development: Informed by a scientific Software Engineering Case Study. presented at the Proceedings of theFourth IEEE International Conference on Global Software Engineering, pp.370-375 (2009)	Conference/ICGSE	Case Study	2009	Europe	Nil
LT36	Conchúir, O. E., Ågerfalk, J.P., Olsson, H.H., Fitzgerald, B.: Global software development: where are the benefits? Communications of the ACM, vol. 52, pp. 127-131 (2009)	Journal/ Communications of the ACM	Interview (Content Analysis)	2009	Mixed	Large
LT37	Wiegers, K.: Software process improvement: Ten traps to avoid. Software Development, vol. 4, (1996)	Magazine/Software Development	Informal Literature Review	1996	North America	Medium
LT38	Mohd, N.N.H, Ahmad, R., Hassan, H.N.: Resistance factors in the implementation of software process improvement project. IEEE International Symposium on Information Technology, pp. 1-10 (2008)	Conference/ITNG	Questionnaire Survey	2008	Asia	Small
LT39	Dutra. E., Santos, G.: Software Process Improvement Implementation Risks: A Qualitative Study Based on Software Development Maturity Models Implementations in Brazil.Product-Focused Software Process Improvement, pp. 43-60 (2015)	Conference/ PROFES	Mixed (SLR, Interview)	2015	South America	Nil
LT40	Mishra, D., Mishra, A.: Software process improvement methodologies for small and medium enterprises. Product-Focused Software Process Improvement, pp. 273-288 (2008)	Conference/ PROFES	Questionnaire Survey	2008	Asia	Nil

LT41	Niazi, M.: A comparative study of software process improvement implementation success factors. Journal of Software: Evolution and Process, 27(9), 700-722 (2015)	Journal/JSEP	Mixed (SLR, Informal literature review, snowballing)	2015	Mixed	Mixed
LT42	Niazi, M., Babar, A.M., Katugampola, M.N.: Demotivators of software process improvement: an empirical investigation. Software Process: Improvement and Practice 13(3), 249-264 (2008)	Journal/JSEP	Questionnaire Survey	2008	Mixed	Mixed
LT43	Khan, A. A., Basri, S., Dominic, P.D.D., Fazal, E. A.: A Survey based study on Factors effecting Communication in GSD. Research Journal of Applied Sciences, Engineering and Technology, 7 (7), 1309-1317 (2013)	Journal/JASET	Questionnaire Survey	2013	Asia	small
LT44	Shih, C.C., Huang, S. J.: Exploring the relationship between organizational culture and software process improvement deployment. Information & Management, vol. 47, pp. 271-281 (2010)	Journal/Information and Management	Questionnaire Survey	2010	Asia	Medium
LT45	Babar, M. A. Verner, M.J., Nguyen, T.P.: Establishing and maintaining trust in software outsourcing relationships: An empirical investigation. Journal of Systems and Software, 80(9), 1438-1449 (2007)	Journal/JSEP	Mixed (Case Study, Interview)	2007	Asia	Medium
LT46	Oza,V.N., Hall, T., Rainer, A., Grey, S.: Trust in software outsourcing relationships: An empirical investigation of Indian software companies. Information and Software Technology, vol. 48, pp. 345-354 (2006)	Journal/IST	Mixed (Case Study, Interview)	2006	Asia	Large
LT47	Moe, B.N., Šmite, D.: Understanding a lack of trust in Global Software Teams: a multiple-case study. Software Process: Improvement and Practice, vol. 13, pp. 217-231 (2008)	Journal/JSEP	Case Study	2008	Europe	Large
LT48	Emam, K.E., Smith, B.: Fusaro, P.: Success factors and barriers for software process improvement. Better software practice for business benefit: Principles and experience. IEEE Computer Society, (1999)	Book chapter/ Better software practice for business benefit: Principles and experience	Case Study	1999	North America	Nil
LT49	Dybå,T.: Enabling software process improvement: an investigation of the importance of organizational issues. Empirical Software Engineering , 7(4), pp.387-390 (2002)	Journal/EMSE	Case Study	2002	Europe	Nil
LT50	Nasir, M.H.N.M., Ahmad, R., Hassan, N.H.: An Empirical Study of Barriers in the Implementation of Software Process Improvement Project in Malaysia. Journal of Applied Sciences, Vo l(8), pp.4362-4368 (2008)	Journal of Applied Sciences	Questionnaire Survey	2008	Asia	Small
LT51	Ross, M.: Process Improvement - Barriers and Opportunities for Teaching and Training. Proceedings of the International Workshop on Software Process Education, Training and Professionalism, Gothenburg, Sweden, pp.1-6(2015)	Conference/ IWSPEPT	Case Study	2015	Europe	Nil

LT52	Lepasaar, M., Varkoi,T., Jaakkola, H.: Models and Success Factors of Process Change. in Product Focused Software Process Improvement Springer Berlin Heidelberg, vol. (2188), pp. 68-77 (2001)	Conference/ PROFES	Case Study	2001	Europe	Nil
LT53	Khan U.S., Niazi, M., Ahmad,R.: Critical success factors for offshore software development outsourcing vendors: A systematic literature review. Fourth IEEE International Conference On Global Software Engineering, pp.207-216 (2009)	Conference/ ICGSE	Questionnaire Survey	2010	Asia	Nil
LT54	Ilyas, M., Khan, S. U.: Software integration in global software development: Success factors for GSD vendors. in 16th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing , pp. 1-6 (2015)	Conference/ SNPD	SLR	2015	Asia	Nil
LT55	Khan, S. U., Alam, A. U.: Knowledge Sharing Management Model (KSMM) for Software Development Outsourcing Vendors. International Journal of Advances in Science and Technology, vol (4238), pp. 135-144 (2012)	Journal/IJAST	SLR	2012	Asia	Nil
LT56	Alsaade, F., Zaman, N., Hassan, F.N., Abdullah, A.: An Improved Software Development Process for Small and Medium Software Development Enterprises Based on Client's Perspective. Trends in Applied Sciences Research, vol(9), pp.254-261(2014)	Journal/ Trends in Applied Sciences Research	Case Study	2014	Asia	Nil
LT57	Rafael, P., Audy, LN.J., Evaristo, R.: An empirical study on global software development: Offshore insourcing of IT projects. Proceedings of the International Workshop on Global Software Development, International Conference on Software Engineering (ICSE), Vol(24), (2004)	Conference/ International Workshop on Global Software Development	Case Study	2004	South America	Large
LT58	Christiansen, H. M.: Meeting the challenge of communication in offshore software development. in Software Engineering Approaches for Offshore and Outsourced Development, ed: Springer, pp. 19-26(2007)	Book Chapter/ Software Engineering Approaches for Offshore and Outsourced Development	Case Study	2007	Europe	Nil
LT59	Stefanie, B., Hickl, S., Oberweis, A.: Risk Management in Global Software Development Process Planning. 37th EUROMICRO Conference on Software Engineering and Advanced Applications (SEAA), pp-357-361 (2011)	Conference/ EUROMICRO	Case Study	2011	Europe	Nil
LT60	Paasivaara. M., Lassenius, C.: Could global software development benefit from agile methods?. In International Conference on Global Software Engineering, pp.	Conference/ ICGSE	Informal literature review	2006	Europe	Nil

	109-113 (2006)					
LT61	Herbsleb, J. D., Mockus, A., Finholt, A.T., Grinter, E.R.: An empirical study of global software development: distance and speed. in Proceedings of the 23rd international conference on software engineering, pp. 81-90 (2001)	Conference/ ICSE	Questionnaire Survey	2001	Mixed	Large
LT62	Plugge, A., Janssen, M.: Managing change in IT outsourcing arrangements: an offshore service provider perspective on adaptability. An International Journal of Strategic Outsourcing, vol (2), pp. 257-274 (2009)	Journal/ International Journal of Strategic Outsourcing	Mixed Method(Case Study/Informal literature review)	2009	Europe	Nil
LT63	Jennex, M. E., Adelakun, O.: Success factors for offshore information system development. Journal of Information Technology Case and Application Research. Vol(5), pp. 12-31(2003)	Book Chapter/ Information Systems Development	Mixed Method(Questionnaire Survey /Informal literature review)	2003	North America	Nil
LT64	Kuhrmann, M., Konopka, C., Nellemann, P., Diebold, P., Münch, J.: Software process improvement: where is the evidence?: initial findings from a systematic mapping study. Proceedings of the International Conference on Software and System Process, pp.107-116 (2015)	Conference/ ICSS	SLR	2015	Europe	Nil
LT65	Remus, U., Wiener, M.: Critical success factors for managing offshore software development projects. Journal of Global Information Technology Management, vol(12), pp. 6-29 (2009)	Journal/JGIM	Interview (Grounded theory)	2009	Australia	Mixed
LT66	Viana, D., Conte, T., Vilela, D., Souza, R. B.C., Santos, G., Prikladnicki, R.: The influence of human aspects on software process improvement: Qualitative research findings and comparison to previous studies. In 16th International Conference on Evaluation & Assessment in Software Engineering (EASE), pp. 121-125 (2012)	Conference/ EASE	Interview (Grounded theory)	2012	South America	Small
LT67	Anandasivam, G., Mukhopadhyay, T., Krishnan, S.M.: The role of software processes and communication in offshore software development. Communications of the ACM, 45(4), pp.193-200 (2002)	Journal/Communication of the ACM	Questionnaire Survey	2002	Asia	Nil
LT68	Krishna, S., Sahay, S., Walsham, G. :Managing cross-cultural issues in global software outsourcing. Communications of the ACM, 47(4), pp. 62-66 (2004)	Journal/Communication of the ACM	Case Study	2004	Asia	Nil
LT69	Kobitzsch, W., Dieter, R., Raimund L. F.: Outsourcing in India [software development]. Software, IEEE 18(2), pp-78-86 (2001)	Journal/IEEE Software	Case Study	2001	Asia	Small
LT70	Subhas, C.M., Kumar, V., Kumar, U.: Identifying some important success factors in adopting agile software development practices. Journal of Systems and Software, 82(11), pp-1869-1890(2009)	Journal/JSS	Questionnaire Survey	2009	Mixed	Mixed
LT71	Santos, G., Montoni, M., Vasconcellos, J., Figueiredo, S., Cabral, R., Cerdeiral C., Katsurayama, E.A., Lupo, P., Zanetti, D., Rocha, R.A.: Implementing software process improvement initiatives in small and medium-size enterprises in Brazil," in	Conference/ QUATIC	Case Study	2007	South America	Mixed

	6th International Conference on Quality of Information and Communications Technology, pp. 187-198 (2007)					
LT72	Ferreira, M. G., Wazlawick, R. S.: Software Process Improvement: A organizational change that need to be managed and motivated. International Journal of Computer, Electrical, Automation, Control and Information Engineering , vol. 6, p. 19 (2011)	Journal	Questionnaire Survey	2011	South America	Nil
LT73	Prikladnicki, R., Audy, N.L.J., Damian, D., Oliveira, D.C.T.: Distributed Software Development: Practices and challenges in different business strategies of offshoring and onshoring," in Second IEEE International Conference on Global Software Engineering, pp. 262-274(2007)	Conference/ ICGSE	Case Study	2007	Mixed	Mixed
LT74	Niazi, M., Babar, M. A.: De-motivators of software process improvement: An analysis of vietnamese practitioners' views," in Product-Focused Software Process Improvement, pp. 118-131 (2007)	Conference/ PROFES	Questionnaire Survey	2007	Asia	Small
LT75	Babar, M. A., Niazi, M.: Implementing Software Process Improvement Initiatives: An Analysis of Vietnamese Practitioners' Views, in IEEE International Conference on Global Software Engineering, pp. 67-76 (2008)	Conference/ ICGSE	Questionnaire Survey	2008	Asia	Small
LT76	Bunditwongrat, N., Mathupayas, T., Atcharawan, N.: An empirical framework of key success factors for software process improvement. Proceedings of the European Conference on Information Management & Evaluation, pp-82-90 (2011)	Conference/ ICIME	Questionnaire Survey	2011	Asia	Nil
LT77	Phongpaibul, M., Boehm, B.: Improving quality through software process improvement in Thailand: initial analysis, in ACM SIGSOFT Software Engineering Notes, pp. 1-6 (2005)	Conference/ WoSQ	Interview (Grounded Theory)	2005	Asia	Nil
LT78	Mishra, D., Mishra, A.: Software process improvement in SMEs: A comparative view, Computer Science and Information Systems, vol. 6, pp. 111-140 (2009)	Journal/ CSIS	Case Study	2009	Asia	Mixed
LT79	Wilson, N.D., Hall, T., Baddoo, N.: A framework for evaluation and prediction of software process improvement success. Journal of systems and software, 59(2), pp.135-142 (2001)	Journal/JSS	Interview (Grounded Theory)	2001	Europe	Mixed
LT80	Sommerville, I., Rodden, T.: Human, social and organisational influences on the software process," Software Process, vol. 4, pp. 194-199 (1996)	Journal/JSEP	Case Study	1996	Europe	Nil
LT81	Beecham, S., Hall, T., Rainer, A.: Software process improvement problems in twelve software companies: An empirical analysis. Empirical software engineering. 8(1), pp.7-42 (2003)	Journal/EMSE	Interview (Content Analysis)	2003	Europe	Mixed
LT82	Baddoo, N., Hall, T.: Motivators of Software Process Improvement: an analysis of practitioners' views. Journal of systems and software, vol. 62, pp. 85-96 (2002)	Journal/JSS	Interview (Content Analysis)	2002	Europe	Mixed
LT83	Katumba, B., Knauss, E.: Agile Development in Automotive Software	Conference/	Case Study	2014	Europe	Large

	Development: Challenges and Opportunities. in Product-Focused Software Process Improvement, ed: Springer, pp. 33-47(2014)	PROFES				
LT84	Niazi, M.: Software Process Improvement: A Road to Success. in Product-Focused Software Process Improvement. vol. 4034, Springer Berlin Heidelberg, pp. 395-401 (2006)	Conference/ PROFES	Informal literature review	2006	Europe	Nil
LT85	Valtanen, A., Sihvonen, H.M.: Employees' Motivation for SPI: Case Study in a Small Finnish Software Company," in Software Process Improvement. vol. 16, Springer Berlin Heidelberg, pp. 152-163(2008)	Chapter/ Software Process Improvement	Mixed Method (Interview, Questionnaire Survey)	2008	Europe	Small
LT86	Dybå, T.: Factors of software process improvement success in small and large organizations: an empirical study in the scandinavian context. ACM SIGSOFT Software Engineering Notes, vol. 28, pp. 148-157 (2003)	Conference/ FSE	Questionnaire Survey	2003	Europe	Mixed
LT87	Cater-Steel, A., Toleman, M., Rout, T.: Process improvement for small firms: An evaluation of the RAPID assessment-based method. Information and Software Technology, vol. 48, pp. 323-334 (2006)	Journal/IST	Questionnaire Survey	2006	Australia	Small
LT88	Staples, M., Niazi, M.: Two case studies on small enterprise motivation and readiness for CMMI. in Proceedings of the 11th International Conference on Product Focused Software, 2010, pp. 63-66	Conference/ PROFES	Interview (Content Analysis)	2010	Australia	Small
LT89	S. Basri, O'Connor, R.: A study of knowledge management process practices in very small software companies. American Journal of Economics and Business Administration, vol. 3, pp. 636-644 (2012)	Journal/ Economics and Business Administration	Questionnaire Survey	2012	Europe	Small
LT90	Laporte, C. Y., Desharnais, M. J., Abouelfattah, M. M., Bamba, C.J., Renault, A., Habra, N.: Initiating Software Process Improvement in Small Enterprises: Experiments with CETIC's Micro-Evaluation Framework. International Conference on Software Development (SWDCREK) Reykjavik, Iceland (2005)	Conference/ SWDCREK	Case Study	2005	North America	Small
LT91	Valtanen, A., Sihvonen, M.H.: Employees motivation for SPI: Case study in a small Finnish software company. in Software Process Improvement, pp. 152-163, (2008)	Conference/EuroSPI	Mixed Method (Interview, Questionnaire Survey)	2008	Europe	Small

Appendix C: Quality Assessment Scores of Selected Primary Studies

Tracking #	QA1	QA2	QA3	QA4	QA5	Final Score
LT1	1	1	0	0	1	3
LT2	0.5	1	0.5	1	0.5	3.5
LT3	0.5	1	0.5	1	0.5	3.5
LT4	1	1	0	1	1	4
LT5	1	1	0	1	1	4
LT6	0.5	0.5	0.5	1	0.5	3
LT7	1	0.5	0	0.5	1	3
LT8	0.5	0.5	0	1	0.5	2.5
LT9	1	1	0	1	1	4
LT10	1	1	0.5	0	1	3.5
LT11	0.5	1	0	1	0.5	3
LT12	0.5	1	0	1	0.5	3
LT13	0.5	0.5	0	1	0.5	2.5
LT14	1	1	0	1	1	4
LT15	0.5	1	0.5	1	1	4
LT16	1	0.5	0	1	0.5	3
LT17	1	1	0	1	1	4
LT18	0.5	0.5	0	0.5	1	2.5
LT19	0.5	1	0.5	1	0.5	3.5
LT20	1	0	0	0.5	1	2.5
LT21	0.5	1	0.5	1	1	4
LT22	0.5	0.5	0	0.5	0.5	2
LT23	1	1	0	1	1	4
LT24	0.5	1	0.5	1	0.5	3.5
LT25	1	1	0.5	1	1	4.5
LT26	0.5	1	1	1	0.5	4
LT27	1	1	0	1	1	4
LT28	1	0	0	0	1	2
LT29	0.5	1	1	1	0.5	4
LT30	1	0.5	0	1	1	3.5
LT31	1	1	0	1	1	4
LT32	1	1	0	1	1	4
LT33	1	0.5	0	0	1	2.5
LT34	0.5	0	0	0	0.5	1
LT35	0.5	0.5	0	0	0.5	1.5
LT36	0.5	0	0	0	1	1.5
LT37	0.5	1	0.5	1	0.5	3.5

LT38	0.5	1	0	1	1	3.5
LT39	0.5	1	0.5	1	0.5	3.5
LT40	0.5	0.5	0.5	1	0.5	2.5
LT41	1	0	0	1	1	3
LT42	1	1	0.5	1	1	4.5
LT43	1	0.5	0.5	0	1	3
LT44	0.5	0.5	0.5	1	0.5	3
LT45	0.5	0.5	0.5	0	0.5	2
LT46	1	0.5	0.5	0	1	3
LT47	1	0.5	0	0	1	2.5
LT48	0.5	1	0	1	1	3.5
LT49	0.5	1	0.5	1	1	4
LT50	0.5	1	0.5	1	1	4
LT51	0.5	0.5	0	0.5	0.5	2
LT52	0.5	0	0	1	1	2.5
LT53	1	0	0	0	1	2
LT54	1	0	0	0	1	2
LT55	1	0.5	0	0	0.5	2
LT56	0	0.5	0	1	0.5	2
LT57	0.5	0	0	0	1	1.5
LT58	0.5	0.5	0	0.5	1	2.5
LT59	0.5	0.5	0	0	1	2
LT60	0.5	0.5	0	0	0.5	1.5
LT61	1	0.5	0.5	0	1	3
LT62	0.5	0.5	0	0	1	2
LT63	1	0	0	0	1	2
LT64	1	0.5	0	1	1	3.5
LT65	0.5	0	0	0	1	1.5
LT66	0.5	0.5	0.5	1	0.5	3
LT67	0.5	0.5	0	0.5	0.5	2
LT68	0.5	0	0	0.5	1	2
LT69	0.5	0	0	0	1	1.5
LT70	1	0	0	0	1	2
LT71	0.5	0.5	0	1	1	3
LT72	1	0.5	0	1	1	3.5
LT73	0.5	0.5	0	1	1	3
LT74	1	1	0.5	1	1	4.5
LT75	1	1	0.5	1	1	4.5
LT76	1	1	0.5	1	1	4.5

LT77	0.5	0.5	0	1	1	3
LT78	0.5	0.5	0	1	0.5	2.5
LT79	0.5	0.5	0	1	1	3
LT80	1	0.5	0	1	1	3.5
LT81	0.5	0.5	0.5	1	1	3.5
LT82	1	0.5	0	1	1	3.5
LT83	0.5	1	0.5	1	1	4
LT84	1	0	0	1	1	3
LT85	1	0.5	0	1	1	3.5
LT86	0.5	1	0	1	0.5	3
LT87	1	0.5	1	1	0.5	4
LT88	0.5	0.5	1	1	0.5	3.5
LT89	0.5	0	0	1	0.5	2
LT90	0.5	0	1	1	0.5	3
LT91	1	1	0	1	1	4

Appendix D: Details of the Survey Participants

S.No	Job Title	Experience	Country	Primary Business Function	Scope of the company	Size	Adopted SPI standards/ models	SPI in operation (Years)
1.	Software Engineer	5	Nigeria	Collocated software development	Vendor	Medium	Not sure	10
2.	Software Engineer	2	China	Collocated/Global software development	Vendor	Large	Not sure	4
3.	Researcher	5	China	Collocated software development	Vendor	Large	Not sure	0
4.	Researcher	8	Pakistan	SPI Consultancy	Vendor	Medium	CMMILevel-2 (Managed)	3
5.	Researcher	12	China	Software Engineering research	Vendor	Small	Not sure	2
6.	Researcher	8	Saudi Arabia	Research Institute	Vendor	Medium	CMMILevel-3 (Defined)	2
7.	Researcher	1	China	Global Software Development	Vendor	Medium	CMMILevel-4 (Quantitatively Managed)	5
8.	Researcher	18	Pakistan	Collocated software development	Vendor	Small	CMMILevel-2 (Managed)	5
9.	Senior process executive	>4	India	Global Software Development	Vendor	Large	CMMILevel-4 (Quantitatively Managed)	4-7
10.	Researcher	4	Pakistan	Research Institute	Vendor	Medium	Not sure	5
11.	Professor emeritus	46	Norway	SPI research	Client	Large	ISO	10
12.	Researcher	20	Cyprus	Research Institute	Client	Small	No	0
13.	Professor	18	Saudi Arabia	Research	Vendor	Large	CMMILevel-3 (Defined)	5
14.	Researcher	10	Pakistan	Research	Vendor	Medium	HEC, Pakistan	10
15.	Researcher	3	Pakistan	Research	Vendor	Small	Not sure	0
16.	Researcher	4	Pakistan	Research	Vendor	Medium	Not sure	0
17.	Software Applications Developer	4	China	Telecommunications	Vendor	Large	CMMILevel-4 (Quantitatively Managed)	4
18.	CEO	5	Pakistan	Global Software Development	Vendor	Small	Nil	0
19.	CTO	22	Netherlands	Global Software Development	Client	Medium	Nil	0

20.	Software Engineer	1	China	Collocated/Global software development	Vendor	Medium	CMMILevel-4 (Quantitatively Managed)	2
21.	IT In charge	<1	UAE	Global Software Development	Client	Medium	Nil	0
22.	SPI consultant	40	USA	SPI consulting	Client	Small	Nil	0
23.	Consultant	20	China	Global Software Development	Vendor	Large	CMMILevel-3 (Defined)	3
24.	Software Developer	3	Nigeria	Collocated Software Development	Vendor	Medium	ISO	2-3
25.	Researcher	35	UK	Research	Client	Large	Nil	0
26.	Researcher	4	Malaysia	Research	Vendor	Large	Not sure	0
27.	CEO	5	Pakistan	Global Software Development	Vendor	Small	CMMILevel-1 (Initial)	<1
28.	Project Manager	4	Pakistan	Collocated/Global software development	Vendor	Small	CMMILevel-1 (Initial)	1
29.	Professor	7	Pakistan	Research	Vendor	Large	Not sure	5
30.	Web Developer	2	Pakistan	Collocated/Global software development	Vendor	Medium	CMMILevel-2 (Managed)	Nil
31.	Software Engineer	3	Pakistan	Collocated software development	Vendor	Small	CMMILevel-1 (Initial)	2
32.	Research	5	China	Research; Education	Vendor	Large	Not sure	2
33.	Senior SPI Consultant	42	UK	Consultancy & Training	Client	Small	Provide CMMI Consultancy to other companies	4
34.	Manager	11	Vietnam	Collocated Software Development; BPO, Data Entry, Image Processing	Vendor	Small	CMMILevel-3 (Defined)	8
35.	Global Process Lead	12	UK	Process Leadership	Client	Large	ISO	6
36.	Interim Manager	27	USA	Interim Management of Software Development	Client	Small	ISO	25
37.	Assistant Vice President	27	China	Finance	Vendor	Not sure	Self-developed	15
38.	SEO executive	3	Pakistan	Collocated/Global software development	Vendor	Medium	CMMILevel-1 (Initial)	<1
39.	Professor	15	Denmark	Research	Client	Small	Nil	0
40.	Chief operating officer	9	Pakistan	Global Software Development/web development and design	Vendor	small	CMMILevel-1 (Initial)	1

41.	Senior web developer	5	Pakistan	Global Software Development	Vendor	Medium	Not sure	Nil
42.	Software Engineer	2	Pakistan	Collocated/Global software development	Vendor	Small	CMMILevel-1 (Initial)	<1
43.	Manager	7	Pakistan	Collocated/Global software development	Vendor	Medium	Not sure	Nil
44.	Senior Executive Consultant	15	USA	Business Function	Client	Large	Other	15
45.	Software Engineer	1	China	Collocated Software Development	Vendor	Medium	Not sure	Nil
46.	SPI Practitioner	11	India	Collocated Software Development/Consulting services	Vendor	Medium	Not sure	Nil
47.	Researcher	8	Saudi Arabia	Research	Vendor	Large	Not Sure	Nil
48.	Software Developer	4	Pakistan	Global software development	Vendor	Medium	CMMILevel-2 (Managed)	Nil
49.	Process Management Consultant	30+	UK	Consultancy	Client	Large	Multiple	5
50.	VP and CTO, Namcook Analytics LLC	45	USA	Consultancy/Research	Client	Small	CMMILevel-3 (Defined)	15
51.	Professor	30	Colombia	Research	Client	Small	Not Sure	Nil
52.	Professor	8	Pakistan	Global Software Development/Research	Vendor	Small	Not Sure	Nil
53.	Social Media/Admin Assistant	2	Pakistan	Collocated/Global software development	Vendor	Small	Not Sure	Nil
54.	iOS Developer	2	Pakistan	Collocated/Global software development	Vendor	Small	Not Sure	Nil
55.	Professor	23	Norway	Research	Client	Medium	Not Sure	Nil
56.	CMMI Lead Appraiser	30	Germany	Global Software Development	Client	Medium	CMMILevel-2 (Managed)	Nil
57.	Senior Software	20	Vietnam	Automotive Software	Vendor	Small	CMMILevel-3 (Defined)	13

	Project Manager							
58.	Researcher	25	India	Research	Vendor	Large	Nil	Nil
59.	Quality Assurance	3	Pakistan	Global Software Development	Vendor	Medium	CMMILevel-3 (Defined)	3
60.	Chairman and MD	40	India	Collocated Software Development	Vendor	Small	Not initiated	0
61.	Researcher	<1	Sweden	Research	Client	Small	Not Sure	Nil
62.	Professor	10	Pakistan	Research	Client	Large	Not Sure	Nil
63.	Professor	30	UAE	Global Software Development/ Banking & Insurance	Client	Large	CMMILevel-1 (Initial)	2
64.	Agile Coach / Consultant	7	Malaysia	Consultation / Coaching / Training	Vendor	Medium	Not Sure	Nil
65.	Senior Developer	2	Pakistan	Collocated Software Development	Vendor	Small	Not Sure	Nil
66.	Researcher	9	China	Research	Vendor	Medium	Not Sure	Nil
67.	IT Officer	5	Pakistan	Research/ SAP development	Vendor	Large	ISO	<1
68.	Software Developer	5	Ghana	Global Software Development	Vendor	Small	Not Sure	Nil
69.	Researcher	5	Ghana	Research	Vendor	Large	ISO	8
70.	Consultant	55	USA	Global Software Development	Client	Small	CMMILevel-5 (Optimizing)	20
71.	Professor	14	Pakistan	Research	Vendor	Large	Not Sure	Nil
72.	Researcher	15	Pakistan	Collocated Software Development/ Global Software Development/ Research	Vendor	Small	Not Sure	4
73.	Researcher	5	Pakistan	Research	Vendor	Large	Not Sure	Nil
74.	Lecturer	11	Pakistan	Research	Vendor	Small	Not Sure	Nil
75.	FOUNDER of Bangalore Software Process Improvement Network (BSPIN)	27	India	Global Software Development	Vendor	Medium	ISO	3
76.	Web developer	2	Pakistan	Collocated Software Development	Vendor	Small	Not Sure	0
77.	Professor	8	Spain	Research	Client	Medium	Research Centre	Nil

78.	Manager	17	France	Global Software Development	Client	Medium	ISO	10
79.	Research assistant	7	Saudi Arabia	Research	Vendor	Not sure	Not Sure	Nil
80.	Process Consultant	30	USA	Project management support	Client	Medium	working on CMMI-SVC	<2
81.	Researcher	2	Pakistan	Global Software Development/ Research	Vendor	Small	Not Sure	Nil
82.	Lecturer	10	UK	Collocated Software Development	Client	Medium	CMMILevel-2 (Managed)	Nil
83.	SPIIM leader	30	New Zealand	Implementing SPI	Client	Small	CMMILevel-3 (Defined)	20
84.	Software Engineer	14	Brazil	Oil and Gas	Client	Large	ISO	Nil
85.	Professor	25	Denmark	Research	Client	Medium	No process model	Nil
86.	Lecturer	7	South Africa	Research	Client	Large	Not Sure	Nil
87.	Senior VP, Operational Excellence	30	USA	Solutions and Services. Software and Systems engineering and service delivery	Client	Large	CMMILevel-3 (Defined)	20
88.	Web Developer	20	USA	Global Software Development	Client	Small	CMMILevel-1 (Initial)	<1
89.	Product Manager	10	Norway	Collocated Software Development/ Research	Client	Medium	CMMILevel-5 (Optimizing)	5
90.	Software Engineer	4	Pakistan	Global Software Development	Vendor	Medium	CMMILevel-3 (Defined)	2
91.	Configuration Manager	15	India	Collocated Software Development	Vendor	Medium	Not Sure	Nil
92.	Project Coordinator / QA Professional	8	UAE	Global Software Development	Client	Large	ISO	5
93.	Assistant Vice President	21	Germany	Global Software Development	Client	Large	CMMILevel-5 (Optimizing)	10
94.	Product Manager	10	Vietnam	Global Software Development	Vendor	Large	CMMILevel-5 (Optimizing)	5
95.	Professor	41	UK	Research	Vendor	Large	Not Sure	Nil
96.	Software Engineer	2	Pakistan	Global Software Development	Vendor	Medium	ISO	Nil
97.	Configuration	15	USA	Collocated Software	Client	Medium	Not Sure	Not Sure

	Manager			Development				
98.	Professor	40	Australia	Research	Vendor	Large	Research Centre	Nil
99.	Software Requirements Analyst	4	Pakistan	Global Software Development	Vendor	Medium	CMMILevel-1 (Initial)	Nil
100.	Software Engineer	4	Pakistan	Global Software Development	Vendor	Medium	CMMILevel-3 (Defined)	2
101.	Executive Vice President	21	China	Global Software Development	Vendor	Large	CMMILevel-5 (Optimizing)	10
102.	Web Developer	5	Pakistan	Collocated Software Development, Global Software Development	Vendor	Medium	ISO	Nil
103.	Research Associate	5	Spain	Research	Vendor	Large	Not Sure	Not Sure
104.	Software Engineer	1	Pakistan	Collocated Software Development, Global Software Development	Vendor	Medium	Not Sure	Not Sure
105.	Senior Mobile Developer	3	Pakistan	Global Software Development	Vendor	Medium	CMMILevel-1 (Initial)	1
106.	Software Engineer	1.5	Pakistan	Global Software Development	Vendor	Medium	Not Sure	1
107.	Web Developer	20	Canada	Global Software Development	Vendor	Small	CMMILevel-1 (Initial)	Nil
108.	Researcher	15	Canada	Research	Vendor	Medium	Not Sure	4
109.	Researcher	9	Japan	Research	Vendor	Medium	Not Sure	Not Sure
110.	Agile Coach / Consultant	7	New Zealand	Consultation , Coaching , Training	Vendor	Medium	Not Sure	Not Sure
111.	Researcher	25	Australia	Research	Client	Large	Nil	Nil

Appendix E: Survey Questionnaire

Software Process Improvement Implementation Management and Model (SPIIMM) for GSD industry

PARTICIPANT INFORMATION SHEET

RESEARCH TITLE

A Model for Software Process Improvement implementation and Management in Global Software Development

RESEARCHER INFORMATION

I am Arif Ali Khan, a PhD candidate in the Department of Computer Science at City University of Hong Kong under the supervision of Assistant Professor Dr. Jacky Keung.

KEY TERMS

Software Process Improvement (SPI): an approach used to comprehend the software process and to monitor the implementation of change in that process for the purpose of achieving the particular objectives such as to enhance software development period and budget along with the required efficiency.

Global Software Development (GSD): the plan of action in which the software development is performed under various geographical, cultural and temporal boundaries.

DESCRIPTION OF PROJECT

The aim of this project is to develop a model that will assist Global Software Development (GSD) organizations to evaluate their strengths and weaknesses regarding the implementation of Software Process Improvement (SPI) activities. The focus of this research survey is to investigate the viewpoints and experiences of experts from industry and academia regarding the factors that can positively or negatively influence

the SPI process in the domain of GSD. If you are a researcher or practitioner who has experience in Software Engineering or SPI related research studies, then you are invited to participate in this research survey. Your response would be highly acknowledged.

SURVEY PROCEDURE

You will be requested to complete the survey questionnaire, which will take approximately 10-15 minutes. You will be asked a number of questions relating to success factors, barriers and practices relating to the implementation of Software Process Improvement in the context of GSD. I will use your given responses to construct a final list of success factors, barriers and their practices. This list will assist me to develop Software Process Improvement Implementation and Management Model (SPIIMM) for GSD industry.

DATA REPOSITORY

The collected data will be stored keep on password protected account. The data will be analyzed and the results will be used for the PhD research work and research publications. All the results and the related publication will be available upon the request.

PRIVACY OF COLLECTED DATA

Information gathered from this questionnaire will strictly be confidential. Entire information will be used for research purposes only and will not be shared with third party under any circumstances. Responses shall not be disclosed in any output form from this research.

RIGHT TO WITHDRAW FROM PARTICIPATION

In this research survey, the participation of any researcher is completely voluntary. The respondent has complete right to withdraw from the survey at any stage. Please be aware that once you have submitted the survey, the collected data cannot be withdrawn.

CONTACTS DETAIL

In case of any query regarding the survey, you can contact Arif Ali Khan at (+852) xxxxxxxx or email at xxxxxxx@my.cityu.edu.hk. You may also contact with my supervisor Jacky Keung at (+852)-xxxx-xxxx or email at xxxxxxxxx@cityu.edu.hk

I agree to participate in this research survey by completing the questionnaire. I understand that only the researcher will have access to the collected data. I understand that the results of this study will be available from the researcher upon the request. I also understand that the researcher will not disclose my identity in any research publication that results from this survey. I agree to participate in this research survey under the terms and conditions provided to me.

- ☐ Yes
- ☐ No

Section- A1 (Respondent Information)		
Full Name (optional)		Job Title / Position
Have you ever been participated in an outsourcing/ offshoring GSD project?	Yes ☐	No ☐
	Not sure ☐	Other
Working Experience (Years) in Global Software development and Software Process Improvement related projects.		
What is the scope of your company?	Client ☐	Vendor ☐
	Not sure ☐	Other
Email Address		
Current address of your organization including country		
How many years of industry/academia experience do you have in your field?		
Have you ever participated in Software Process Improvement Project?	Yes ☐	No ☐
Section- A2 (Organization Detail)		
Name of Organization (Optional)		
What is the primary business function of your organization? (You may tick more than one)	Global/offshore Software development ☐	Collocated Software development ☐
	Research ☐	Other
Please specify the size of your organization.	Small ☐	Medium ☐
	Large ☐	Not sure ☐
Please specify the number of employees in your organization.	Less than 20 ☐	21-100 ☐

	101-200 ☐	Greater than 200 ☐
Please specify the type of your organization	National ☐	Multinational ☐
	Not sure ☐	Other
Does your organization adopted Software Process Improvement standards or models? (CMMI/ISO)	CMMILevel-1 (Initial) ☐	CMMILevel-2 (Managed) ☐
	CMMILevel-3 (Defined) ☐	CMMILevel-4 (Quantitatively Managed) ☐
	CMMILevel-5 (Optimizing) ☐	ISO ☐
	Not sure ☐	Other ☐
How long has your process improvement program been in operation? (Years)		

Section-B1 (Software Process Improvement Success Factors)

The aim of this section is to specify success factors that could impact the implementation of the Software Process improvement program in Global Software Development. We have extracted various success factors from the literature using Systematic Literature Review (SLR) approach.

Please rank each success factor according to your own understanding and experience.

Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA), Neutral (NU), Slightly Disagree (SD), Moderately Disagree (MD), Extremely Disagree (ED)

Success Factors	EA	MA	SA	NU	SD	MD	ED
Management commitment	☐	☐	☐	☐	☐	☐	☐
Staff involvement	☐	☐	☐	☐	☐	☐	☐
Strong relationship between team members	☐	☐	☐	☐	☐	☐	☐
Information sharing	☐	☐	☐	☐	☐	☐	☐
Process improvement expertise	☐	☐	☐	☐	☐	☐	☐
Process improvement leadership	☐	☐	☐	☐	☐	☐	☐

Process improvement awareness	☐	☐	☐	☐	☐	☐	☐
Skilled human resources	☐	☐	☐	☐	☐	☐	☐
3C's (communication, coordination and control)	☐	☐	☐	☐	☐	☐	☐
Mutual understanding between team members	☐	☐	☐	☐	☐	☐	☐
Continuous organizational support	☐	☐	☐	☐	☐	☐	☐
Allocation of resources	☐	☐	☐	☐	☐	☐	☐
Organizational culture	☐	☐	☐	☐	☐	☐	☐
Organizational infrastructure	☐	☐	☐	☐	☐	☐	☐
Overseas site's response	☐	☐	☐	☐	☐	☐	☐
SPI consultancy	☐	☐	☐	☐	☐	☐	☐
Joint management infrastructure	☐	☐	☐	☐	☐	☐	☐
Setting process improvement goals	☐	☐	☐	☐	☐	☐	☐
Project pilot implementation	☐	☐	☐	☐	☐	☐	☐
Process improvement evaluation	☐	☐	☐	☐	☐	☐	☐
Process improvement standards and procedures	☐	☐	☐	☐	☐	☐	☐
Add Success Factors apart from the listed ones							

Section B2- Software process improvement barriers

The aim of this section is to specify barriers that could negatively impact the implementation of the Software Process improvement program in Global Software Development. We have extracted various barriers from the literature using Systematic Literature Review (SLR) approach.

Please rank each barrier according to your own understanding and experience.

Extremely Agree (EA), Moderately Agree (MA), Slightly Agree (SA), Neutral (NU), Slightly Disagree (SD), Moderately Disagree (MD), Extremely Disagree (ED)

Barriers	EA	MA	SA	NU	SD	MD	ED
Inexperienced staff	☐	☐	☐	☐	☐	☐	☐
Staff turnover	☐	☐	☐	☐	☐	☐	☐
Cultural difference	☐	☐	☐	☐	☐	☐	☐
Lack of trust	☐	☐	☐	☐	☐	☐	☐
Lack of process improvement knowledge	☐	☐	☐	☐	☐	☐	☐
Lack of training	☐	☐	☐	☐	☐	☐	☐
Lack of feedback	☐	☐	☐	☐	☐	☐	☐
Personality clashes	☐	☐	☐	☐	☐	☐	☐
Workload	☐	☐	☐	☐	☐	☐	☐
Organizational politics	☐	☐	☐	☐	☐	☐	☐
Time pressure	☐	☐	☐	☐	☐	☐	☐
Lack of resources	☐	☐	☐	☐	☐	☐	☐
Lack of communication	☐	☐	☐	☐	☐	☐	☐
Lack of organizational support	☐	☐	☐	☐	☐	☐	☐
Temporal distance	☐	☐	☐	☐	☐	☐	☐
Poor organizational infrastructure	☐	☐	☐	☐	☐	☐	☐
Budget constraints	☐	☐	☐	☐	☐	☐	☐
Organizational changes	☐	☐	☐	☐	☐	☐	☐
Lack of sponsorship	☐	☐	☐	☐	☐	☐	☐
Lack of formal process improvement implementation methodology	☐	☐	☐	☐	☐	☐	☐
Lack of implementation tools and standards	☐	☐	☐	☐	☐	☐	☐
Stalling on action plan implementation	☐	☐	☐	☐	☐	☐	☐
Add barriers apart from the listed ones							

Section-C1 (Practices for Identified Critical Success Factors)

The aim of this section is to rank various practices identified for the total six Critical Success Factors (CSFs). We have ranked total six factors as Critical for Software Process Improvement using criteria of factors having frequency ≥ 50 as critical.

Please rank the given practices for each Critical Success Factor and add additional practices apart from the identified ones.

Critical Success Factor-1: Management Commitment

Management commitment is the extent to which the higher and lower level management in an organization support, finance, realize and participate in Software Process Improvement program.

I have identified the following practices for this factor.

Practices	EA	MA	SA	NU	SD	MD	ED
Strong support and commitment of organizational management for software process improvement program.	☐	☐	☐	☐	☐	☐	☐
Management provides and sustain resources for process improvement program.	☐	☐	☐	☐	☐	☐	☐
Continuously monitor the process improvement activities.	☐	☐	☐	☐	☐	☐	☐
Provide an infrastructure that could encourage the team members to participate in SPI activities.	☐	☐	☐	☐	☐	☐	☐
Continuously encourage the efforts of process improvement team members.	☐	☐	☐	☐	☐	☐	☐
Add practices, according to your own understanding for this critical success factor apart from the listed ones.							

Critical Success Factor-2: Staff Involvement

Staff Involvement is the degree to which employees of the organization owns, trust, acquire, perform and believe the process improvement program.

I have identified the following practices for this factor.

Practices	EA	MA	SA	NU	SD	MD	ED
Employees must adopt process innovations in their day-to-day activities.	☐	☐	☐	☐	☐	☐	☐
Staff members should participate in process improvement because they have detailed knowledge of strengths and weaknesses of the current processes.	☐	☐	☐	☐	☐	☐	☐
Facilitate process improvement team members.	☐	☐	☐	☐	☐	☐	☐
Properly monitor the staff members so that every member feels the sense of responsibility.	☐	☐	☐	☐	☐	☐	☐
Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.	☐	☐	☐	☐	☐	☐	☐

Add practices, according to your own understanding for this critical success factor apart from the listed ones.							
Critical Success Factor-3: Allocation of Resources Allocations of resources are the dedication of time and resources to process improvement activities. I have identified the following practices for this factor.							
Practices	**EA**	**MA**	**SA**	**NU**	**SD**	**MD**	**ED**
There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.	☐	☐	☐	☐	☐	☐	☐
Management should have a broader picture of the resources and time required in order to conduct the process improvement program.	☐	☐	☐	☐	☐	☐	☐
Provide all the required technological resources including hardware and software.	☐	☐	☐	☐	☐	☐	☐
Process improvement team members have been allocated sufficient time for process improvement program.	☐	☐	☐	☐	☐	☐	☐
Provides adequate budget and human resources from the very start of the process improvement project implementation.	☐	☐	☐	☐	☐	☐	☐
Add practices, according to your own understanding for this critical success factor apart from the listed ones.							
Critical Success Factor-4: 3C's (Communication, Coordination, Control) 3C's (Communication, coordination and control) is the degree to which process team members communicate, coordinate and control process improvement activities. I have identified the following practices for this factor.							
Practices	**EA**	**MA**	**SA**	**NU**	**SD**	**MD**	**ED**
Regular travel to distributed sites creates group cohesiveness among team members.	☐	☐	☐	☐	☐	☐	☐
Encourage the use of effective communication, coordination and control tools and techniques.	☐	☐	☐	☐	☐	☐	☐
Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.	☐	☐	☐	☐	☐	☐	☐
Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.	☐	☐	☐	☐	☐	☐	☐
Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.	☐	☐	☐	☐	☐	☐	☐
Organization should appoint liaison among the geographically distributed teams.	☐	☐	☐	☐	☐	☐	☐

Add practices, according to your own understanding for this critical success factor apart from the listed ones.							
Critical Success Factor-5: Project Pilot Implementation Project pilot implementation is the testing phase for all the selected models or standards for software process improvement. I have identified the following practices for this factor.							
Practices	**EA**	**MA**	**SA**	**NU**	**SD**	**MD**	**ED**
Implement process improvement for testing on a small scale.	☐	☐	☐	☐	☐	☐	☐
Develop criteria for pilot implementation of process improvement.	☐	☐	☐	☐	☐	☐	☐
Capture the feedback from the pilot implementation and use for future process improvement activities.	☐	☐	☐	☐	☐	☐	☐
Continuously monitor the results of pilot process improvement implementation.	☐	☐	☐	☐	☐	☐	☐
Provide adequate resources for pilot implementation.	☐	☐	☐	☐	☐	☐	☐
Add practices, according to your own understanding for this critical success factor apart from the listed ones.							
Critical Success Factor-6: Process Improvement Expertise Process improvement expertise is the extent to which individuals can achieve specific process improvement goals and objectives. I have identified the following practices for this factor.							
Practices	**EA**	**MA**	**SA**	**NU**	**SD**	**MD**	**ED**
Process improvement team members have a deep understanding of software quality and software processes.	☐	☐	☐	☐	☐	☐	☐
Expertise needs continuous improvement by means of training.	☐	☐	☐	☐	☐	☐	☐
The team consists of individuals having previous process improvement experience, knowledge and necessary skills.	☐	☐	☐	☐	☐	☐	☐
Use the previous experience of process improvement projects in global software development.	☐	☐	☐	☐	☐	☐	☐
Draw on the expertise of external assessors/consultants as mentors.	☐	☐	☐	☐	☐	☐	☐
Add practices, according to your own understanding for this critical success factor apart from the listed ones.							
Section-C2 (Practices for Identified Critical Barriers) The aim of this section is to rank various practices identified for the total five Critical Barriers (CBs). We have ranked total five barriers as Critical for Software Process Improvement using criteria of barriers having frequency ≥ 50 as critical. Please rank the given practices for each Critical Barrier and add any other apart from the identified ones.							

Critical Barrier-1: Lack of organizational support

Lack of organizational support is the extent to which the process improvement teams didn't get the enough support from the organization management.

I have identified the following practices for this barrier.

Practices	EA	MA	SA	NU	SD	MD	ED
Management committed to support SPI team members.	☐	☐	☐	☐	☐	☐	☐
Top level management should make software process improvement practices as the fundamental part of the software development cycle.	☐	☐	☐	☐	☐	☐	☐
Develop criteria to continuously monitor the progress of the process improvement team.	☐	☐	☐	☐	☐	☐	☐
Management commit to provide adequate resources and training for process improvement activities.	☐	☐	☐	☐	☐	☐	☐
Management is willing to participate in assessment meetings and improvement workshops.	☐	☐	☐	☐	☐	☐	☐
Add practices, according to your own understanding for this critical barrier apart from the listed ones.							

Critical Barrier-2: Lack of Communication

Lack of communication is the extent to which the distributed team members have limited access to coordinate and control process improvement activities.

I have identified the following practices for this barrier.

Practices	EA	MA	SA	NU	SD	MD	ED
Regular travel to distributed sites creates group cohesiveness among team members.	☐	☐	☐	☐	☐	☐	☐
Promote efficient offshore relationship.	☐	☐	☐	☐	☐	☐	☐
Promote the use of advance communication and information technology tools and practices.	☐	☐	☐	☐	☐	☐	☐
Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.	☐	☐	☐	☐	☐	☐	☐
Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.	☐	☐	☐	☐	☐	☐	☐
Add practices, according to your own understanding for this critical barrier apart from the listed ones.							

Critical Barrier-3: Lack of Process Improvement Knowledge

Lack of process improvement knowledge refers to the team members having a limited understanding of process improvement program implementation.

I have identified the following practices for this barrier.

Practices	EA	MA	SA	NU	SD	MD	ED
Detail process improvement knowledge.	☐	☐	☐	☐	☐	☐	☐
Conduct regular training session for team members.	☐	☐	☐	☐	☐	☐	☐
Establish a mechanism to continuously monitor the progress of each SPI team member.	☐	☐	☐	☐	☐	☐	☐
Encourage team building activities	☐	☐	☐	☐	☐	☐	☐
Promote process improvement awareness among process improvement team members.	☐	☐	☐	☐	☐	☐	☐
Add practices, according to your own understanding for this critical barrier apart from the listed ones.							

Critical Barrier-4: Lack of formal process improvement implementation methodology

Lack of formal process improvement implementation methodology refers to the necessity to have technique which consists of complete process deployment strategy, process improvement activities, tasks, and measures.

I have identified the following practices for this barrier.

Practices	EA	MA	SA	NU	SD	MD	ED
Establish technical infrastructure to implement the process improvement program.	☐	☐	☐	☐	☐	☐	☐
Use applications of process, implementation or product indicators as an effective management tool for process improvement.	☐	☐	☐	☐	☐	☐	☐
Promote the awareness of process improvement application tools and standards among team members.	☐	☐	☐	☐	☐	☐	☐
Adopt standards for the assessment of processes.	☐	☐	☐	☐	☐	☐	☐
Use of licensed software tools.	☐	☐	☐	☐	☐	☐	☐
Add practices, according to your own understanding for this critical barrier apart from the listed ones.							

Critical Barrier-5: Lack of Resources

Lack of resources is the extent to which the organizational management couldn't provide the sufficient resources to successfully execute SPI activities.

I have identified the following practices for this barrier.

Practices	**EA**	**MA**	**SA**	**NU**	**SD**	**MD**	**ED**
Project planning done in order to estimate all the required resources.	☐	☐	☐	☐	☐	☐	☐
Management commits to allocate sufficient time for SPI activities.	☐	☐	☐	☐	☐	☐	☐
A mechanism developed to avoid time pressure.	☐	☐	☐	☐	☐	☐	☐
Team members agree to allocate time for SPI activities.	☐	☐	☐	☐	☐	☐	☐
Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.	☐	☐	☐	☐	☐	☐	☐
Add practices, according to your own understanding for this critical barrier apart from the listed ones.							

Thank you very much for your time to take my survey.
Your response is contributing to my research.

Arif Ali Khan
PhD Candidate
Department of Computer Science, City University of Hong Kong
Email: xxxxxxx@my.cityu.edu.hk
Cell No: +852xxxxxxxx

Appendix F: Invitation Letter for Case Studies

Dear Sir/Madam

I would like to invite you to participate in a research study 'Software Process Improvement Implementation and Management Model (SPIIMM) for Global Software Development (GSD)'. This research project is conducted by Arif Ali Khan, a PhD candidate in Department of Computer Science, City University of Hong Kong.

The key objective of this research project is to develop SPIIMM that could assist GSD organizations in designing the effective software process improvement (SPI) implementation strategies. In this regard, I would like to conduct a case study in order to assess the effectiveness of SPIIMM. I will provide you a copy of the case study results and discussions. I believe that the results of case study will assist the practitioners in the designing of effective SPI implementation strategies.

The data collected using the case study will be used for research purposes only and will not be shared with third party under any circumstances. Responses shall not be disclosed in any output form from this research. The results and analysis of this study will comprehensively publish such that specific respondent participating in this case study could not be identified. The relevant guideline document will send you before the case study. You have complete right to withdraw from the case study at any stage.

In this case study, the participation of any expert is completely voluntary. In case of any query regarding this research project, you can contact Arif Ali Khan at (+852) xxxxxxxx or email at xxxxxxxxx@my.cityu.edu.hk. You may also contact with my supervisor Dr. Jacky Keung at (+852)-xxxx-xxxx or email at xxxxxxxxx@cityu.edu.hk

I will really appreciate if you would agree to participate in the case study. To do so, please reply to this letter advising your availability to arrange time for case study. I will send you a guideline document about SPIIMM prior to the case study.

Yours Sincerely,

Arif Ali Khan
PhD Candidate
Department of Computer Science,
City University of Hong Kong

Appendix G: Guideline Document for SPIIMM Case Study

1. INTRODUCTION TO SPIIMM

I have developed a model that could assist Global Software Development (GSD) organizations in designing effective software process improvement (SPI) implementation strategies. This model will evaluate the weaknesses and strengths of a GSD organization in terms of SPI. I have adopted the concepts of available models i.e. CMMI [1], IMM [2] and SOVRM [4] in order to develop SPIIMM.

The brief structure of SPIIMM is shown in Figure 1, which consists of the following three key components:

- SPIIMM maturity level component
- SPIIMM factors (CSFs and CBs) component
- SPIIMM practices component

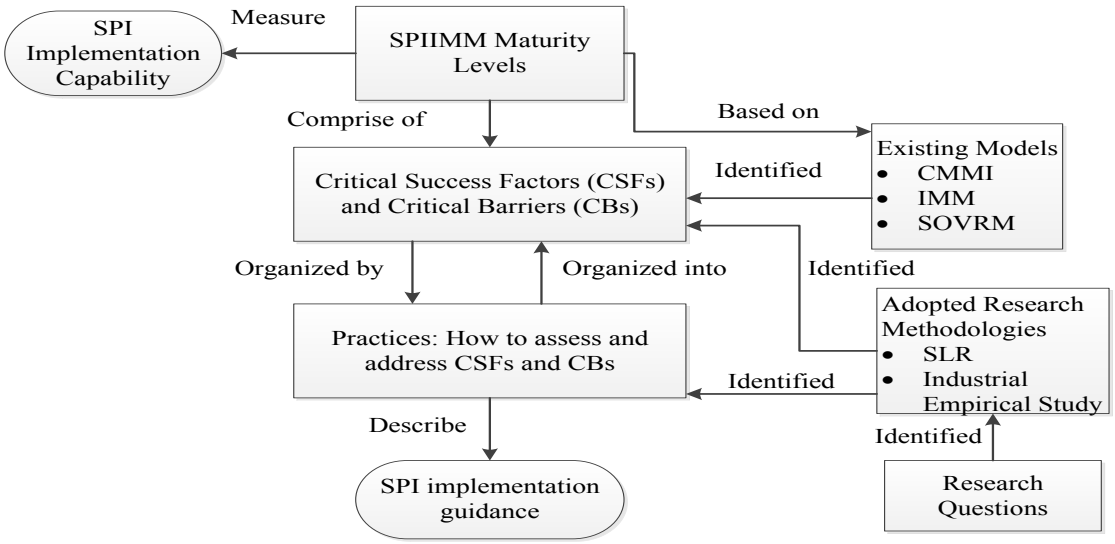

Figure 1 Structure of SPIIMM

SPIIMM Maturity level component consists of five maturity levels and the aim of maturity levels component is to provide an assessment level to GSD organization in order to know their abilities of SPI implementation. The five maturity levels are shown in Table 1.

The SPIIMM factors (critical success factors (CSFs) and critical barrier (CBs)) component is structured with the aim to summaries the factors that can have positive or negative effects on SPI implementation in the domain of GSD. The CSFs and CBs were identified using systematic literature review (SLR) and survey empirical study conducted with SPI experts. CSFs and CBs present the key areas relating to SPI, where organizations need to give much attention. Under each CSF and CB, different practices are designed that will assist an organization how to implement each factor. All the identified practices along their respective CSFs and CBs are discussed in the attached file (Assessment of SPIIMM critical success factors (CSFs) and critical barriers (CBs) using the Motorola assessment Instrument). In total 72 practices were found that could address the identified CSFs and CBs.

Table 1 Maturity levels of SPIIMM

Maturity Levels	**Focus of Maturity level**	**CSFs**	**CBs**
Level-1 (Initial)	SPI implementation is not planned and this maturity level can be best described as one of chaotic processes.	Nil	Nil
Level-2 (Commitment)	Organizational management commits to support the implementation of SPI activities	CSF1: Management Commitment	CB3: Lack of Process Improvement Knowledge
Level-3 (Communication)	Organization has properly addressed the communication issues.	CSF2: Staff Involvement	CB2: Lack of Communication
		CSF4: 3C's (Communication, Coordination, Control)	
Level-4 (Defined)	Organization has properly structure and reported the SPI processes.	CSF3: Allocation of Resources	CB4: Lack of Resource
		CSF5: Project Pilot Implementation	CB5: Lack of formal process improvement implementation methodology
Level-5 (Optimizing)	Organization have plan for continuous software process improvement	CSF6: Process Improvement Expertise	CB1: Lack of organizational support

2. CASE STUDY

I have selected case study approach in order to assess the effectiveness of SPIIMM. Case study technique is considered as one of the influential assessment tools and can provide useful real world information. In this research, multiple case studies will conduct to evaluate the effectiveness of SPIIMM in the real world practice. At the end of each case study, the respondent will ask to participate in the feedback session in order to obtain the feedback regarding the SPIIMM.

2.1 Your role

The role of participant is to use SPIIMM and check its usability and ease of use. To use SPIIMM, you will use the Motorola assessment tool provided in Table 2. It consists of the following three evaluation dimensions [3].

- **Approach:** The criterion of this dimension is the support and commitment of organizational management to the practice also the capability of an organization to implement the corresponding practice.

- **Deployment:** The criterion of this dimension is the consistent and uniform implementation of practice across all the project areas.

- **Results:** In this dimension the criterion is about the breadth and consistency of positive results over time and across the project areas.

Each dimension should assign a score from 0-10 [3].

Table 2 Motorola assessment tool

Score	Key Activity evaluation dimensions		
	Approach Score Range: 0, 2, 4, 6, 8, 10	**Deployment** Score Range: 0, 2, 4, 6, 8, 10	**Results** Score Range: 0, 2, 4, 6, 8, 10
Poor (0)	No management recognition of need No organizational ability No organizational commitment Practice not evident	No part of the organization uses the practice No part of the organization shows interest	Ineffective
Weak (2)	Management begins to recognize need Support items for the practice start to be created A few parts of organization are able to implement the practice	Fragmented use Inconsistent use Deployed in some parts of the organization Limited to monitoring/verification of use	Spotty results Inconsistent results Some evidence of effectiveness for some parts of the organization
Fair (4)	Wide but not complete commitment by management Road map for practice implementation defined Several supporting items for the practice in place	Less fragmented use Some consistency in use Deployed in some major parts of the organization Monitoring/verification of use for several parts of the organization	Consistent and positive results for several parts of the organization Inconsistent results for other parts of the organization
Marginally qualified (6)	Some management commitment; some management becomes proactive Practice implementation well under way across parts of the organization Supporting items in place	Deployed in some parts of the organization Mostly consistent use across many parts of the organization Monitoring/verification of use for many parts of the organization	Positive measurable results in most parts of the organization Consistently positive results over time across many parts of the organization
Qualified (8)	Total management commitment Majority of management is proactive Practice established as an integral part of the process Supporting items encourage and facilitate the use of practice	Deployed in almost all parts of the organization Consistent use across almost all parts of the organization Monitoring/verification of use for almost all parts of the organization	Positive measurable results in almost all parts of the organization Consistently positive results over time across almost all parts of the organization
Outstanding (10)	Management provides zealous leadership and commitment Organizational excellence in the practice recognized even outside the company	Pervasive and consistent deployed across all parts of the organization Consistent use over time across all parts of the organization Monitoring/verification for all parts of the organization	Requirements exceeded Consistently world-class results Counsel sought by others

Using the Motorola tool, you have to complete the assessment using the following steps.

- Step-1: Compute the three dimensional score of the Motorola instrument for each practice of CSFs and CBs.

- Step-2: The calculated three dimensional scores of each practice are summed together and divided by three (3). The final calculated score is rounding the nearest whole number.

- Step-3: Step-2 should repeat for each practice of the identified CSFs and CBs. Add the scores of all the practices together in order to calculate the overall score for specific CSF or CB.

- Step-4: Relating the assessment score to SPIIMM: a score of 7 or above for a specific CSF or CB will show that a particular CSF or CB has been effectively addressed [3]. If the score of any CSF or CB is lower than seven then the addressing of that particular CSF or CB considered as weak [3].

- Step-5: To achieve a specific maturity level of SPIIMM, it is vital to address all the CSFs and CBs of that particular maturity level. For example, if the organization wants to attain the maturity level-3 of SPIIMM it is must to address all the CSFs and CBs of level 3 i.e. (CSF2: staff involvement), (CSF4: 3C's (communication, coordination, control)) and (CB2: lack of communication) and their average score should be seven or above. In Table 3 the evaluation example of SPIIM is shown by following the above five steps of Motorola instrument.

'P-CSF' represents a practice for critical success factor. The results presented in Table 3 demonstrate that the practices identified for success factor (CSF1: management commitment) have overall average score 5. It revealed that the success factor (CSF1: management commitment) is not completely addressed because its score is less than 7.

- To assess the SPI maturity level of an organization, it is vital to go through the evaluation of all the practices identified for CSFs and CBs.

All the practices identified to address each CSF and CB are discussed in the attached file (Assessment of SPIIMM critical success factors (CSFs) and critical barriers (CBs) using Motorola assessment Instrument).

Table 3 Asse ss ment example using Motorola asse ss ment Instrument

CSF1:Management Commitment					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF1	Strong support and commitment of organizational management for software process improvement program.	6	6	8	7
P2-CSF1	Management provides and sustain resources for process improvement program.	4	2	2	3
P3-CSF1	Continuously monitor the process improvement activities.	6	4	4	5
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.	4	4	2	3
P5-CSF1	Continuously encourage the efforts of process improvement team members.	6	8	8	7
Total of 'average scores'= (add all the average score values at the right most column)					25
Overall score= Total of 'average score'/ total number of practices= (25/5=5)					5

3. References

[1] Chrissis, M. B., Konrad, M. and Shrum, S. 2006. CMMl: guidelines for process integration and product improvement. Addison Wesley.

[2] Niazi, M., Wilson, D., Zowghi., D.: A maturity model for the implementation of software process improvement: an empirical study. Journal of Systems and Software 74.2 (2005): 155-172.

[3] Daskalantonakis, M. K. 1994. Achieving higher SEI levels, IEEE Software II (4). 17-24.

[4] Khan, U.S.: Software outsourcing vendors' readiness model (SOVRM). Diss. Keele University, 2011.

Appendix H: SPIIMM Success Factors and Barriers Assessment Document

Assessment of SPIIMM critical success factors (CSFs) and critical barriers (CBs) using the Motorola assessment Instrument

1. Assessment of Critical Success Factors (CSFs) using the given practices

In this section the list of all the identified CSFs along their practices are given in the following Table 1. Please assess each CSF for your organization using the given practices and score each practice for their specific CSF. This assessment will highlight the maturity level of your organizations regarding the SPI implementation.

The assessment example is provided in the guideline document for SPIIMM Case Study assessment process.

Table 1: Practices for the identified CSFs

CSF1:Management Commitment					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF1	Strong support and commitment of organizational management for software process improvement program.				
P2-CSF1	Management provides and sustain resources for process improvement program.				
P3-CSF1	Continuously monitor the process improvement activities				
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.				
P5-CSF1	Continuously encourage the efforts of process improvement team members.				
P6-CSF1	Top level management should lead the initiation and implementation of				

	SPI program.				
P7-CSF1	Management encourage and drive the bottom-up staff in SPI activities.				
P8-CSF1	Organizational management motivate SPI team members as well the non SPI staff members to accept the changes of process improvement.				
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.				
P10-CSF1	Tope level management lead the initiation and implementation of SPI program				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					
CSF2: Staff Involvement					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF2	Employees must adopt process innovations in their day-to-day activities.				
P2-CSF2	Staff members should participate in process improvement because they have detailed knowledge of strengths and weaknesses of current processes.				
P3-CSF2	Facilitate process improvement team members.				
P4-CSF2	Properly monitor the staff members so that every member feels the sense of responsibility.				
P5-CSF2	Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.				
P6-CSF2	Each distributed site should have technical leader that could lead the development process, coordinate with the team members and schedule the process improvement				

	activities.				
P7-CSF2	Regularly discuss the rationale for process improvement efforts with staff.				
P8-CSF2	Explicitly describe the benefits of SPI to both the team members and organization.				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					
CSF3: Allocation of Resources					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF3	There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.				
P2-CSF3	Management should have a broader picture of the resources and time required in order to conduct the process improvement program.				
P3-CSF3	Provide all the required technological resources including hardware and software.				
P4-CSF3	Process improvement team members have been allocated sufficient time for process improvement program.				
P5-CSF3	Provide adequate budget and human resources from the very start of the process improvement project implementation.				
P6-CSF3	The organization set priorities of what they choose to implement based on resources and budget - they don't have to do everything at once.				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					
CSF4: 3C's (Communication, Coordination, Control)					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	

P1-CSF4	The team members should frequently visit the geographically distributed sites in order to develop group cohesiveness.				
P2-CSF4	Encourage the use of effective communication, coordination and control tools and techniques.				
P3-CSF4	Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.				
P4-CSF4	Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.				
P5-CSF4	Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.				
P6-CSF4	Organization should appoint liaison among the geographically distributed teams.				
P7-CSF4	Frequent planning of interactions between distributed sites: daily stand-up/call improves this largely.				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					
CSF5: Project Pilot Implementation					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF5	Implement process improvement for testing on a small scale.				
P2-CSF5	Develop criteria for pilot implementation of process improvement.				
P3-CSF5	Capture the feedback from the pilot implementation and use for future process improvement activities.				
P4-CSF5	Continuously monitor the				

	results of pilot process improvement implementation.				
P5-CSF5	Provide adequate resources for pilot implementation.				
P6-CSF5	Publicise and communicate widely pilot implementation success story.				
P7-CSF5	Test earlier, provide examples and reiterate fast.				
P8-CSF5	Explicitly discuss the results of the pilot implementation				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					
CSF6: Process Improvement Expertise					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF6	Process improvement team members have a deep understanding of software quality and software processes.				
P2-CSF6	Expertise needs continuous improvement by means of training.				
P3-CSF6	The team consists of individuals having previous process improvement experience, knowledge and necessary skills.				
P4-CSF6	Use the previous experience of process improvement projects in global software development.				
P5-CSF6	Draw on the expertise of external assessors/consultants as mentors.				
P6-CSF6	Use consultants to facilitate and guide.				
P7-CSF6	The users of the system as well as the implementation team need to understand the basics of a quality process.				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					

2. Assessment of Critical Barrier (CBs) using the given practices

This section contains CBs along their practices as given in the following Table 2. Please assess each CB for your organization using the given practices and score each practice for their specific CB. This assessment will highlight the maturity level of your organizations regarding the SPI implementation.

The assessment example is provided in guideline document for SPIIMM Case Study assessment process.

Table 2: Practices for the identified CBs

CB1: Lack of organizational support					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB1	Management committed to support SPI team members.				
P2- CB1	Top level management should make software process improvement practices as the fundamental part of the software development cycle.				
P3- CB1	Develop criteria to continuously monitor the progress of the process improvement team.				
P4- CB1	Management commit to provide adequate resources and training for process improvement activities.				
P5- CB1	Management is willing to participate in assessment meetings and improvement workshops.				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					
CB2: Lack of Communication					
		Key Activity evaluation dimensions			Average Score

Practice S. No	Practices	Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	(Average of the dimension values)
P1- CB2	Regular travel to distributed sites creates group cohesiveness among the team members.				
P2- CB2	Promote efficient offshore relationship.				
P3- CB2	Promote the use of advance communication and information technology tools and practices.				
P4- CB2	Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.				
P5- CB2	Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.				
P6-CB2	Team members should have plan for frequent daily meetings				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					
CB3: Lack of Process Improvement Knowledge					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB3	Detail process improvement knowledge.				
P2- CB3	Conduct regular training session for team members.				
P3- CB3	Establish a mechanism to continuously monitor the progress of each SPI team member.				
P4- CB3	Encourage team				

	building activities				
P5- CB3	Promote process improvement awareness among process improvement team members.				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					
CB4: Lack of formal process improvement implementation methodology					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CB4	Establish technical infrastructure to implement the process improvement program.				
P2- CB4	Use applications of process, implementation or product indicators as an effective management tool for process improvement.				
P3-CB4	Promote the awareness of process improvement application tools and standards among team members.				
P4-CB4	Adopt standards for the assessment of processes.				
P5-CB4	Use of licensed software tools.				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					
CB5: Lack of Resources					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CB5	Project planning done in order to estimate all the required resources.				
P2-CB5	Management commits to allocate sufficient time for SPI activities.				
P3-CB5	A mechanism developed to avoid time pressure.				
P4-CB5	Team members agree to				

	allocate time for SPI activities.				
P5-CB5	Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.				
Total of 'average scores'= (add all the average score values at the right most column)					
Overall score= Total of 'average score'/ total number of practices					

Appendix H1: Case Study at Company A: Assessment Results of SPIIMM Success Factors and Barriers

Assessment of SPIIMM critical success factors (CSFs) and critical barriers (CBs) using Motorola assessment Instrument

1. Assessment of Critical Success Factors (CSFs) using the given practices

In this section the list of all the identified CSFs along their practices are given in the following Table 1. Please assess each CSF for your organization using the given practices and score each practice for their specific CSF. This assessment will highlight the maturity level of your organizations regarding the SPI implementation.

The assessment example is provided in the guideline document for SPIIMM Case Study assessment process.

Table 1: Practices for the identified CSFs

CSF1:Management Commitment					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF1	Strong support and commitment of organizational management for software process improvement program.	8	8	6	7
P2-CSF1	Management provides and sustain resources for process improvement program.	8	8	6	7
P3-CSF1	Continuously monitor the process improvement activities	10	10	8	9
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.	10	10	8	9
P5-CSF1	Continuously encourage the efforts of process improvement team members.	8	6	6	7
P6-CSF1	Top level management should lead the initiation and implementation of SPI program.	8	8	6	7
P7-CSF1	Management encourage and	6	6	4	5

	drive the bottom-up staff in SPI activities.				
P8-CSF1	Organizational management motivate SPI team members as well the non SPI staff members to accept the changes of process improvement.	8	6	6	7
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.	8	6	4	6
P10-CSF1	Tope level management should show long time commitment.	8	8	6	7
Total of 'average scores'= (add all the average score values at the right most column)					71
Overall score= Total of 'average score'/ total number of practices					7.1
CSF2: Staff Involvement					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF2	Employees must adopt process innovations in their day-to-day activities.	8	6	4	6
P2-CSF2	Staff members should participate in process improvement because they have detailed knowledge of strengths and weaknesses of current processes.	8	6	4	6
P3-CSF2	Facilitate process improvement team members.	8	6	6	7
P4-CSF2	Properly monitor the staff members so that every member feels the sense of responsibility.	10	8	6	8
P5-CSF2	Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.	10	8	8	9
P6-CSF2	Each distributed site should have technical leader that could lead the development process, coordinate with the team members and schedule the process improvement activities.	10	8	8	9
P7-CSF2	Regularly discuss the rationale for process improvement efforts with staff.	8	6	6	7
P8-CSF2	Explicitly describe the	8	6	6	7

	benefits of SPI to both the team members and organization.				
Total of 'average scores'= (add all the average score values at the right most column)					59
Overall score= Total of 'average score'/ total number of practices					7.37
CSF3: Allocation of Resources					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF3	There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.	10	8	8	9
P2-CSF3	Management should have a broader picture of the resources and time required in order to conduct the process improvement program.	10	8	8	9
P3-CSF3	Provide all the required technological resources including hardware and software.	10	8	8	9
P4-CSF3	Process improvement team members have been allocated sufficient time for process improvement program.	10	8	8	9
P5-CSF3	Provide adequate budget and human resources from the very start of the process improvement project implementation.	10	8	8	9
P6-CSF3	The organization set priorities of what they choose to implement based on resources and budget - they don't have to do everything at once.	10	8	6	8
Total of 'average scores'= (add all the average score values at the right most column)					53
Overall score= Total of 'average score'/ total number of practices					8.83
CSF4: 3C's (Communication, Coordination, Control)					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF4	The team members should frequently visit the geographically distributed sites in order to develop group cohesiveness.	8	8	6	7

P2-CSF4	Encourage the use of effective communication, coordination and control tools and techniques.	8	8	6	7
P3-CSF4	Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.	8	6	6	7
P4-CSF4	Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.	10	8	8	9
P5-CSF4	Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.	8	6	4	6
P6-CSF4	Organization should appoint liaison among the geographically distributed teams.	8	8	8	8
P7-CSF4	Frequent planning of interactions between distributed sites: daily stand-up/call improves this largely.	8	6	4	6
Total of 'average scores'= (add all the average score values at the right most column)					50
Overall score= Total of 'average score'/ total number of practices					7.14
CSF5: Project Pilot Implementation					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF5	Implement process improvement for testing on a small scale.	2	2	2	2
P2-CSF5	Develop criteria for pilot implementation of process improvement.	2	2	2	2
P3-CSF5	Capture the feedback from the pilot implementation and use for future process improvement activities.	2	2	2	2
P4-CSF5	Continuously monitor the results of pilot process improvement implementation.	2	2	2	2
P5-CSF5	Provide adequate resources for pilot implementation.	2	2	2	2
P6-CSF5	Publicise and communicate widely pilot implementation	2	2	2	2

	success story.				
P7-CSF5	Test earlier, provide examples and reiterate fast.	2	2	2	2
P8-CSF5	Explicitly discuss the results of the pilot implementation	2	2	2	2
Total of 'average scores'= (add all the average score values at the right most column)					16
Overall score= Total of 'average score'/ total number of practices					2
CSF6: Process Improvement Expertise					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF6	Process improvement team members have a deep understanding of software quality and software processes.	10	8	6	8
P2-CSF6	Expertise needs continuous improvement by means of training.	8	8	6	7
P3-CSF6	The team consists of individuals having previous process improvement experience, knowledge and necessary skills.	8	6	6	7
P4-CSF6	Use the previous experience of process improvement projects in global software development.	8	6	6	7
P5-CSF6	Draw on the expertise of external assessors/consultants as mentors.	2	2	2	2
P6-CSF6	Use consultants to facilitate and guide.	2	2	2	2
P7-CSF6	The users of the system as well as the implementation team need to understand the basics of a quality process.	8	6	6	7
Total of 'average scores'= (add all the average score values at the right most column)					40
Overall score= Total of 'average score'/ total number of practices					5.71

2. Assessment of Critical Barrier (CBs) using the given practices

This section contains CBs along their practices as given in the following Table 2. Please assess each CB for your organization using the given practices and score each practice for their specific CB. This assessment will highlight the maturity level of your organizations regarding the SPI implementation.

The assessment example is provided in guideline document for SPIIMM Case Study assessment process.

Table 2: Practices for the identified CBs

CB1: Lack of organizational support					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB1	Management committed to support SPI team members.	10	8	8	9
P2- CB1	Top level management should make software process improvement practices as the fundamental part of the software development cycle.	10	8	6	8
P3- CB1	Develop criteria to continuously monitor the progress of the process improvement team.	6	6	6	6
P4- CB1	Management commit to provide adequate resources and training for process improvement activities.	8	6	6	7
P5- CB1	Management is willing to participate in assessment meetings and improvement workshops.	10	8	8	9
Total of 'average scores'= (add all the average score values at the right most column)					39
Overall score= Total of 'average score'/ total number of practices					7.8
CB2: Lack of Communication					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB2	Regular travel to distributed sites creates group cohesiveness among the team members.	8	6	6	7
P2- CB2	Promote efficient offshore relationship.	10	8	8	9
P3- CB2	Promote the use of advance communication and information technology	8	8	6	7

	tools and practices.				
P4- CB2	Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.	10	8	8	9
P5- CB2	Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.	10	8	8	9
P6-CB2	Team members should have plan for frequent daily meetings	8	6	6	7
Total of 'average scores'= (add all the average score values at the right most column)					48
Overall score= Total of 'average score'/ total number of practices					8
CB3: Lack of Process Improvement Knowledge					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB3	Detail process improvement knowledge.	8	6	6	7
P2- CB3	Conduct regular training session for team members.	10	8	6	8
P3- CB3	Establish a mechanism to continuously monitor the progress of each SPI team member.	6	6	4	5
P4- CB3	Encourage team building activities	8	6	6	7
P5- CB3	Promote process improvement awareness among process improvement team members.	8	8	8	8
Total of 'average scores'= (add all the average score values at the right most column)					35
Overall score= Total of 'average score'/ total number of practices					7
CB4: Lack of formal process improvement implementation methodology					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CB4	Establish technical infrastructure to implement the process improvement program.	10	8	8	9

P2- CB4	Use applications of process, implementation or product indicators as an effective management tool for process improvement.	10	8	8	9
P3-CB4	Promote the awareness of process improvement application tools and standards among team members.	10	8	8	9
P4-CB4	Adopt standards for the assessment of processes.	10	8	8	9
P5-CB4	Use of licensed software tools.	10	10	10	10
Total of 'average scores'= (add all the average score values at the right most column)					46
Overall score= Total of 'average score'/ total number of practices					9
CB5: Lack of Resources					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CB5	Project planning done in order to estimate all the required resources.	10	8	8	9
P2-CB5	Management commits to allocate sufficient time for SPI activities.	8	8	6	7
P3-CB5	A mechanism developed to avoid time pressure.	6	6	4	5
P4-CB5	Team members agree to allocate time for SPI activities.	8	6	6	7
P5-CB5	Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.	8	6	6	7
Total of 'average scores'= (add all the average score values at the right most column)					35
Overall score= Total of 'average score'/ total number of practices					7

Appendix H2: Case Study at Company B: Assessment Results of SPIIMM Success Factors and Barriers

Assessment of SPIIMM critical success factors (CSFs) and critical barriers (CBs) using Motorola assessment Instrument

1. Assessment of Critical Success Factors (CSFs) using the given practices

In this section the list of all the identified CSFs along their practices are given in the following Table 1. Please assess each CSF for your organization using the given practices and score each practice for their specific CSF. This assessment will highlight the maturity level of your organizations regarding the SPI implementation.

The assessment example is provided in guideline document for SPIIMM Case Study assessment process.

Table 1: Practices for the identified CSFs

CSF1:Management Commitment					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF1	Strong support and commitment of organizational management for software process improvement program.	10	10	10	10
P2-CSF1	Management provides and sustain resources for process improvement program.	10	8	8	8
P3-CSF1	Continuously monitor the process improvement activities	10	6	8	8
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.	10	10	10	10
P5-CSF1	Continuously encourage the efforts of process improvement team members.	6	6	6	6

P6-CSF1	Top level management should lead the initiation and implementation of SPI program.	2	0	6	3
P7-CSF1	Management encourage and drive the bottom-up staff in SPI activities.	10	10	8	9
P8-CSF1	Organizational management motivate SPI team members as well the non SPI staff members to accept the changes of process improvement.	6	6	6	6
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.	6	6	6	6
P10-CSF1	Tope level management should show long time commitment.	2	2	2	3
Total of 'average scores'= (add all the average score values at the right most column)					77
Overall score= Total of 'average score'/ total number of practices					7.7
CSF2: Staff Involvement					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF2	Employees must adopt process innovations in their day-to-day activities.	6	6	6	6
P2-CSF2	Staff members should participate in process improvement because they have detailed knowledge of strengths and weaknesses of current processes.	2	0	0	0.66
P3-CSF2	Facilitate process improvement team members.	6	6	0	4
P4-CSF2	Properly monitor the staff members so that every member feels the sense of responsibility.	8	8	8	8
P5-CSF2	Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.	10	10	10	10
P6-CSF2	Each distributed site should have technical leader that could lead the development process, coordinate with the team members and schedule the process improvement activities.	8	2	6	5

P7-CSF2	Regularly discuss the rationale for process improvement efforts with staff.	0	0	0	0
P8-CSF2	Explicitly describe the benefits of SPI to both the team members and organization.	10	6	6	7
Total of 'average scores'= (add all the average score values at the right most column)					40.66
Overall score= Total of 'average score'/ total number of practices					5.08
CSF3: Allocation of Resources					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF3	There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.	10	6	4	7
P2-CSF3	Management should have a broader picture of the resources and time required in order to conduct the process improvement program.	10	6	4	7
P3-CSF3	Provide all the required technological resources including hardware and software.	10	6	4	7
P4-CSF3	Process improvement team members have been allocated sufficient time for process improvement program.	10	6	4	7
P5-CSF3	Provide adequate budget and human resources from the very start of the process improvement project implementation.	10	6	4	7
P6-CSF3	The organization set priorities of what they choose to implement based on resources and budget - they don't have to do everything at once.	10	8	6	7
Total of 'average scores'= (add all the average score values at the right most column)					42
Overall score= Total of 'average score'/ total number of practices					7
CSF4: 3C's (Communication, Coordination, Control)					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	

P1-CSF4	Organization should appoint liaison among the geographically distributed teams.	0	0	0	0
P2-CSF4	Frequent planning of interactions between distributed sites: daily stand-up/call improves this largely.	10	6	6	7
P3-CSF4	The team members should frequently visit the geographically distributed sites in order to develop group cohesiveness.	0	0	0	0
P4-CSF4	Encourage the use of effective communication, coordination and control tools and techniques.	10	8	6	8
P5-CSF4	Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.	10	8	8	9
P6-CSF4	Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.	0	0	0	0
P7-CSF4	Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.	0	0	0	0
Total of 'average scores'= (add all the average score values at the right most column)					24
Overall score= Total of 'average score'/ total number of practices					3.42
CSF5: Project Pilot Implementation					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF5	Implement process improvement for testing on a small scale.	10	10	10	10
P2-CSF5	Develop criteria for pilot implementation of process improvement.	10	10	10	10
P3-CSF5	Capture the feedback from the pilot implementation and use for future process improvement activities.	10	10	10	10
P4-CSF5	Continuously monitor the results of pilot process	10	10	10	10

	improvement implementation.				
P5-CSF5	Provide adequate resources for pilot implementation.	10	10	10	10
P6-CSF5	Publicise and communicate widely pilot implementation success story.	10	10	10	10
P7-CSF5	Test earlier, provide examples and reiterate fast.	10	10	10	10
P8-CSF5	Explicitly discuss the results of the pilot implementation.	10	10	10	10
Total of 'average scores'= (add all the average score values at the right most column)					80
Overall score= Total of 'average score'/ total number of practices					10
CSF6: Process Improvement Expertise					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF6	Process improvement team members have a deep understanding of software quality and software processes.	10	10	10	10
P2-CSF6	Expertise needs continuous improvement by means of training.	0	0	10	3
P3-CSF6	The team consists of individuals having previous process improvement experience, knowledge and necessary skills.	10	10	10	10
P4-CSF6	Use the previous experience of process improvement projects in global software development.	10	10	10	10
P5-CSF6	Draw on the expertise of external assessors/consultants as mentors.	10	10	10	10
P6-CSF6	Use consultants to facilitate and guide.	10	10	10	10
P7-CSF6	The users of the system as well as the implementation team need to understand the basics of a quality process.	10	10	10	10
Total of 'average scores'= (add all the average score values at the right most column)					63
Overall score= Total of 'average score'/ total number of practices					9

2. Assessment of Critical Barrier (CBs) using the given practices

This section contains CBs along their practices as given in the following Table 2. Please assess each CB for your organization using the given practices and score each practice

for their specific CB. This assessment will highlight the maturity level of your organizations regarding the SPI implementation.

The assessment example is provided in guideline document for SPIIMM Case Study assessment process.

Table 2: Practices for the identified CBs

CB1: Lack of organizational support					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB1	Management committed to support SPI team members.	8	6	8	7
P2- CB1	Top level management should make software process improvement practices as the fundamental part of the software development cycle.	10	10	10	10
P3- CB1	Develop criteria to continuously monitor the progress of the process improvement team.	0	4	4	3
P4- CB1	Management commit to provide adequate resources and training for process improvement activities.	0	0	0	0
P5- CB1	Management is willing to participate in assessment meetings and improvement workshops.	0	8	10	6
Total of 'average scores'= (add all the average score values at the right most column)					26
Overall score= Total of 'average score'/ total number of practices					5.2
CB2: Lack of Communication					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB2	Regular travel to distributed sites creates group cohesiveness among the team members.	10	10	8	9

P2- CB2	Promote efficient offshore relationship.	8	4	4	5
P3- CB2	Promote the use of advance communication and information technology tools and practices.	10	10	10	10
P4- CB2	Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.	6	6	4	5
P5- CB2	Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.	10	8	8	9
P6-CB2	Team members should have plan for frequent daily meetings.	4	4	4	4
Total of 'average scores'= (add all the average score values at the right most column)					42
Overall score= Total of 'average score'/ total number of practices					7
CB3: Lack of Process Improvement Knowledge					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB3	Detail process improvement knowledge.	10	10	10	10
P2- CB3	Conduct regular training session for team members.	0	0	0	0
P3- CB3	Establish a mechanism to continuously monitor the progress of each SPI team member.	0	0	0	0
P4- CB3	Encourage team building activities.	0	8	8	5
P5- CB3	Promote process improvement awareness among process improvement team members.	4	4	4	4
Total of 'average scores'= (add all the average score values at the right most column)					19
Overall score= Total of 'average score'/ total number of practices					3.8
CB4: Lack of formal process improvement implementation methodology					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	

					values)
P1-CB4	Establish technical infrastructure to implement the process improvement program.	10	10	10	10
P2- CB4	Use applications of process, implementation or product indicators as an effective management tool for process improvement.	10	10	10	10
P3-CB4	Promote the awareness of process improvement application tools and standards among team members.	10	10	10	10
P4-CB4	Adopt standards for the assessment of processes.	10	10	10	10
P5-CB4	Use of licensed software tools.	10	10	10	10
Total of 'average scores'= (add all the average score values at the right most column)					50
Overall score= Total of 'average score'/ total number of practices					10
CB5: Lack of Resources					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CB5	Project planning done in order to estimate all the required resources.	10	10	10	10
P2-CB5	Management commits to allocate sufficient time for SPI activities.	6	8	6	7
P3-CB5	A mechanism developed to avoid time pressure.	0	0	0	0
P4-CB5	Team members agree to allocate time for SPI activities.	10	6	6	7
P5-CB5	Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.	10	10	10	10
Total of 'average scores'= (add all the average score values at the right most column)					34
Overall score= Total of 'average score'/ total number of practices					6.8

Appendix H3: Case Study at Company C: Assessment Results of SPIIMM Success Factors and Barriers

Assessment of SPIIMM critical success factors (CSFs) and critical barriers (CBs) using Motorola assessment Instrument

1. Assessment of Critical Success Factors (CSFs) using the given practices

In this section the list of all the identified CSFs along their practices are given in the following Table 1. Please assess each CSF for your organization using the given practices and score each practice for their specific CSF. This assessment will highlight the maturity level of your organizations regarding the SPI implementation.

The assessment example is provided in guideline document for SPIIMM Case Study assessment process.

Table 1: Practices for the identified CSFs

CSF1:Management Commitment					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF1	Strong support and commitment of organizational management for software process improvement program.	8	6	6	6.6
P2-CSF1	Management provides and sustain resources for process improvement program.	10	8	8	8.6
P3-CSF1	Continuously monitor the process improvement activities	8	8	8	8
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.	6	4	2	4
P5-CSF1	Continuously encourage the efforts of process improvement team members.	10	8	8	8.6

P6-CSF1	Top level management should lead the initiation and implementation of SPI program.	8	6	6	6.6
P7-CSF1	Management encourage and drive the bottom-up staff in SPI activities.	10	8	6	8
P8-CSF1	Organizational management motivate SPI team members as well the non SPI staff members to accept the changes of process improvement.	8	6	6	6.6
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.	8	6	6	6.6
P10-CSF1	Tope level management should show long time commitment.	10	8	6	8
Total of 'average scores'= (add all the average score values at the right most column)					71.6
Overall score= Total of 'average score'/ total number of practices					7.1
CSF2: Staff Involvement					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF2	Employees must adopt process innovations in their day-to-day activities.	10	8	8	8.6
P2-CSF2	Staff members should participate in process improvement because they have detailed knowledge of strengths and weaknesses of current processes.	8	6	6	6.6
P3-CSF2	Facilitate process improvement team members.	10	8	8	8.6
P4-CSF2	Properly monitor the staff members so that every member feels the sense of responsibility.	10	8	6	8
P5-CSF2	Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.	8	6	4	6
P6-CSF2	Each distributed site should have technical leader that could lead the	10	8	8	8.6

	development process, coordinate with the team members and schedule the process improvement activities.				
P7-CSF2	Regularly discuss the rationale for process improvement efforts with staff.	8	8	6	7.3
P8-CSF2	Explicitly describe the benefits of SPI to both the team members and organization.	10	8	8	8.6
Total of 'average scores'= (add all the average score values at the right most column)					62.3
Overall score= Total of 'average score'/ total number of practices					7.7
CSF3: Allocation of Resources					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF3	There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.	10	8	8	8.6
P2-CSF3	Management should have a broader picture of the resources and time required in order to conduct the process improvement program.	10	8	6	8
P3-CSF3	Provide all the required technological resources including hardware and software.	8	6	6	6.6
P4-CSF3	Process improvement team members have been allocated sufficient time for process improvement program.	10	6	4	6.6
P5-CSF3	Provide adequate budget and human resources from the very start of the process improvement project implementation.	10	8	8	8.6
P6-CSF3	The organization set priorities of what they choose to implement based on resources and budget - they don't have to do everything at once.	6	6	4	5.3
Total of 'average scores'= (add all the average score values at the right most column)					43.7

Overall score= Total of 'average score'/ total number of practices					7.2
CSF4: 3C's (Communication, Coordination, Control)					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF4	The team members should frequently visit the geographically distributed sites in order to develop group cohesiveness.	6	6	4	5.3
P2-CSF4	Encourage the use of effective communication, coordination and control tools and techniques.	10	8	6	8
P3-CSF4	Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.	8	4	4	5.3
P4-CSF4	Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.	4	4	2	3.3
P5-CSF4	Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.	10	8	4	7.3
P6-CSF4	Organization should appoint liaison among the geographically distributed teams.	8	6	6	6.6
P7-CSF4	Frequent planning of interactions between distributed sites: daily stand-up/call improves this largely.	8	4	4	5.3
Total of 'average scores'= (add all the average score values at the right most column)					41.1
Overall score= Total of 'average score'/ total number of practices					5.8
CSF5: Project Pilot Implementation					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	

P1-CSF5	Provide adequate resources for pilot implementation.	10	8	8	8.6
P2-CSF5	Publicise and communicate widely pilot implementation success story.	8	6	6	6.6
P3-CSF5	Test earlier, provide examples and reiterate fast.	10	8	8	8.6
P4-CSF5	Explicitly discuss the results of the pilot implementation	8	6	6	6.6
P5-CSF5	Implement process improvement for testing on a small scale.	8	6	4	6
P6-CSF5	Develop criteria for pilot implementation of process improvement.	8	4	4	6
P7-CSF5	Capture the feedback from the pilot implementation and use for future process improvement activities.	6	4	2	4
P8-CSF5	Continuously monitor the results of pilot process improvement implementation.	8	6	6	6.6
Total of 'average scores'= (add all the average score values at the right most column)					53
Overall score= Total of 'average score'/ total number of practices					6.6
CSF6: Process Improvement Expertise					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CSF6	Process improvement team members have a deep understanding of software quality and software processes.	6	4	4	4.6
P2-CSF6	Expertise needs continuous improvement by means of training.	8	6	4	6
P3-CSF6	The team consists of individuals having previous process improvement experience, knowledge and necessary skills.	8	4	2	4.6
P4-CSF6	Use the previous experience of process improvement projects in global software	10	6	6	7.3

	development.				
P5-CSF6	Draw on the expertise of external assessors/consultants as mentors.	8	8	4	6.6
P6-CSF6	Use consultants to facilitate and guide.	8	6	4	6
P7-CSF6	The users of the system as well as the implementation team need to understand the basics of a quality process.	6	4	4	4.6
Total of 'average scores'= (add all the average score values at the right most column)					39.7
Overall score= Total of 'average score'/ total number of practices					5.6

2. Assessment of Critical Barrier (CBs) using the given practices

This section contains CBs along their practices as given in the following Table 2. Please assess each CB for your organization using the given practices and score each practice for their specific CB. This assessment will highlight the maturity level of your organizations regarding the SPI implementation.

The assessment example is provided in guideline document for SPIIMM Case Study assessment process.

Table 2: Practices for the identified CBs

CB1: Lack of organizational support					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB1	Management committed to support SPI team members.	8	6	4	6
P2- CB1	Top level management should make software process improvement practices as the fundamental part of the software development cycle.	8	6	4	3
P3- CB1	Develop criteria to continuously monitor the progress of the process improvement team.	6	4	4	4.6

P4- CB1	Management commit to provide adequate resources and training for process improvement activities.	8	6	6	6.6
P5- CB1	Management is willing to participate in assessment meetings and improvement workshops.	10	8	8	8.6
Total of 'average scores'= (add all the average score values at the right most column)					28.8
Overall score= Total of 'average score'/ total number of practices					5.7
CB2: Lack of Communication					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1- CB2	Regular travel to distributed sites creates group cohesiveness among the team members.	8	6	6	6.6
P2- CB2	Promote efficient offshore relationship.	8	6	4	6
P3- CB2	Promote the use of advance communication and information technology tools and practices.	10	8	8	8.6
P4- CB2	Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.	8	6	4	6
P5- CB2	Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.	10	8	8	8.6
P6-CB2	Team members should have plan for frequent daily meetings	8	4	4	5.3
Total of 'average scores'= (add all the average score values at the right most column)					41.1
Overall score= Total of 'average score'/ total number of practices					6.8
CB3: Lack of Process Improvement Knowledge					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	

P1- CB3	Detail process improvement knowledge.	8	6	4	6
P2- CB3	Conduct regular training session for team members.	10	8	6	8
P3- CB3	Establish a mechanism to continuously monitor the progress of each SPI team member.	8	6	6	6.6
P4- CB3	Encourage team building activities	10	8	8	8.6
P5- CB3	Promote process improvement awareness among process improvement team members.	10	8	6	8
Total of 'average scores'= (add all the average score values at the right most column)					37.2
Overall score= Total of 'average score'/ total number of practices					7.4
CB4: Lack of formal process improvement implementation methodology					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	
P1-CB4	Establish technical infrastructure to implement the process improvement program.	8	4	4	5.3
P2- CB4	Use applications of process, implementation or product indicators as an effective management tool for process improvement.	10	8	6	8
P3-CB4	Promote the awareness of process improvement application tools and standards among team members.	10	8	6	8
P4-CB4	Adopt standards for the assessment of processes.	8	6	4	6
P5-CB4	Use of licensed software tools.	10	8	8	8.6
Total of 'average scores'= (add all the average score values at the right most column)					35.9
Overall score= Total of 'average score'/ total number of practices					7.1
CB5: Lack of Resources					
Practice S. No	**Practices**	**Key Activity evaluation dimensions**			Average Score (Average of the dimension values)
		Approach (0,2,4,6,8,10)	Deployment (0,2,4,6,8,10)	Results (0,2,4,6,8,10)	

P1-CB5	Project planning done in order to estimate all the required resources.	10	8	8	8
P2-CB5	Management commits to allocate sufficient time for SPI activities.	8	4	2	4.6
P3-CB5	A mechanism developed to avoid time pressure.	6	4	2	4
P4-CB5	Team members agree to allocate time for SPI activities.	8	6	6	6.6
P5-CB5	Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.	10	8	8	8
Total of 'average scores'= (add all the average score values at the right most column)					31.2
Overall score= Total of 'average score'/ total number of practices					6.2

Appendix I: Feedback Questionnaire for Case Study Participants

CONSENT FORM

Project Title: Software Process Improvement Implementation Model (SPIIMM) for Global Software Development (GSD)

Name of Investigator: Arif Ali Khan

Please Tick the box

1	I confirm that I have carefully reviewed the document titled "Guideline document for SPIIMM Case Study assessment process" which provides sufficient information about the above project.	☐
2	I confirm that I am participating in this case study on a voluntary basis and could withdraw from it at any stage.	☐
3	I understand that the data collected using this case study will keep confidential and will not share with third party under any circumstances.	☐
4	I confirm that I could be contacted to participate in any future case study relating to Software Process Improvement (SPI).	☐

Section- A (Respondent Information)			
Full Name (optional)		Job Title / Position	
Working Experience (Years) in Global Software development and Software Process Improvement related projects.			
Email Address			
Name and address of your organization including country			
How many years of industry/academia experience do			
Date			

Extremely High (EH), Moderately High (MH), High (H), Neutral (NU), Extremely Low (EL), Moderately Low (ML), Low (L)

	EH	MH	H	NU	EL	ML	L
Rate your knowledge about software process improvement.	☐	☐	☐	☐	☐	☐	☐
Rate your experience relating to software process improvement.	☐	☐	☐	☐	☐	☐	☐
Section- B (Feedback on assessment of SPIIMM)							
Section-B1 (Ease of Learning)	EH	MH	H	NU	EL	ML	L
1. Representation of SPIIMM is simple.	☐	☐	☐	☐	☐	☐	☐
2. SPIIMM need little SPI knowledge to understand.	☐	☐	☐	☐	☐	☐	☐

3. It's simple to understand the practices of critical success factors and barriers.	☐	☐	☐	☐	☐	☐	☐
4. It's simple to understand the Motorola assessment technique.	☐	☐	☐	☐	☐	☐	☐
5. It's simple to implement SPIIMM for process improvement activities.	☐	☐	☐	☐	☐	☐	☐
6. It's simple to understand the maturity levels of SPIIMM along their critical success factors and critical barriers.	☐	☐	☐	☐	☐	☐	☐
7. SPIIMM needs training to fully understand.	☐	☐	☐	☐	☐	☐	☐
Section-B2 (User Satisfaction)	EH	MH	H	NU	EL	ML	L
8. SPIIMM is generic in nature and could be installed in different global software development organizations.	☐	☐	☐	☐	☐	☐	☐
9. SPIIMM could help an on organization to understand weak and strong areas of process improvement	☐	☐	☐	☐	☐	☐	☐
10. The use of SPIIMM could improve the software process of our organization.	☐	☐	☐	☐	☐	☐	☐
11. I will prefer to use SPIIMM in my organization	☐	☐	☐	☐	☐	☐	☐
12. I am confident with the results of SPIIMM.	☐	☐	☐	☐	☐	☐	☐
13. The software tool of SPIIMM could facilitate the experts to implement SPI.	☐	☐	☐	☐	☐	☐	☐
14. SPIIMM is a useful model for global software development organizations.	☐	☐	☐	☐	☐	☐	☐
Section-B3 (Structure of SPIIMM)	EH	MH	H	NU	EL	ML	L
15. The core components of SPIIMM are self-exploratory and no need of further explanation to be used effectively.	☐	☐	☐	☐	☐	☐	☐
16. The SPIIMM components are practical and could be used in GSD industry.	☐	☐	☐	☐	☐	☐	☐
17. The implementation of SPIIMM could assist an organization to identify issues relating to SPI.	☐	☐	☐	☐	☐	☐	☐
18. The five maturity levels of SPIIMM are enough to assess the SPI maturity level of an organization.	☐	☐	☐	☐	☐	☐	☐
19. Would you like to suggest further improvements or suggestions for SPI?							
20. Are there any additional components for SPIIMM and also give the reasons.							
21. Please give your opinion related to the adopted Motorola assessment method.							
22. Please give your opinion related to the classification of practices across critical success factors and critical barriers.							

Section-C (Review of Practices)

In this section, I would like you to review the selected practices identified for critical success factors (CSFs) and critical barriers (CBs). Please give your opinion if I need to modify/change any specific practice according to your knowledge and experience.

Section-C1 (Practices for CSFs)

CSF1: Management Commitment

Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CSF1	Strong support and commitment of organizational management for	

	software process improvement program.	
P2-CSF1	Management provides and sustain resources for process improvement program.	
P3-CSF1	Continuously monitor the process improvement activities	
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.	
P5-CSF1	Continuously encourage the efforts of process improvement team members.	
P6-CSF1	Top level management should lead the initiation and implementation of SPI program.	
P7-CSF1	Management encourage and drive the bottom-up staff in SPI activities.	
P8-CSF1	Organizational management motivate SPI team members as well the non SPI staff members to accept the changes of process improvement.	
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.	
P10-CSF1	Tope level management should show long time commitment.	
CSF2: Staff Involvement		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CSF2	Employees must adopt process innovations in their day-to-day activities.	
P2-CSF2	Staff members should participate in process improvement because they have detailed knowledge of strengths and weaknesses of current processes.	
P3-CSF2	Facilitate process improvement team members.	
P4-CSF2	Properly monitor the staff members so that every member feels the sense of responsibility.	
P5-CSF2	Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.	
P6-CSF2	Each distributed site should have technical leader that could lead the development process, coordinate with the team members and schedule the process improvement activities.	
P7-CSF2	Regularly discuss the rationale for process improvement efforts with staff.	
P8-CSF2	Explicitly describe the benefits of SPI to both the team members and organization.	
CSF3: Allocation of Resources		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CSF3	There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.	
P2-CSF3	Management should have a broader picture of the resources and time required in order to conduct the process improvement program.	
P3-CSF3	Provide all the required technological resources including hardware and software.	
P4-CSF3	Process improvement team members have been allocated sufficient time for process improvement program.	
P5-CSF3	Provide adequate budget and human resources from the very start of the process improvement project implementation.	
P6-CSF3	The organization set priorities of what they choose to implement based on resources and budget - they don't have to do everything at once.	
CSF4: 3C's (Communication, Coordination, Control)		

Practices S. No	Practices	Suggestions/ Change (if needed)
P1-CSF4	The team members should frequently visit the geographically distributed sites in order to develop group cohesiveness.	
P2-CSF4	Encourage the use of effective communication, coordination and control tools and techniques.	
P3-CSF4	Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.	
P4-CSF4	Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.	
P5-CSF4	Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.	
P6-CSF4	Organization should appoint liaison among the geographically distributed teams.	
P7-CSF4	Frequent planning of interactions between distributed sites: daily stand-up/call improves this largely.	
CSF5: Project Pilot Implementation		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CSF5	Implement process improvement for testing on a small scale.	
P2-CSF5	Develop criteria for pilot implementation of process improvement.	
P3-CSF5	Capture the feedback from the pilot implementation and use for future process improvement activities.	
P4-CSF5	Continuously monitor the results of pilot process improvement implementation.	
P5-CSF5	Provide adequate resources for pilot implementation.	
P6-CSF5	Publicise and communicate widely pilot implementation success story.	
P7-CSF5	Test earlier, provide examples and reiterate fast.	
P8-CSF5	Explicitly discuss the results of the pilot implementation.	
CSF6: Process Improvement Expertise		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CSF6	Process improvement team members have a deep understanding of software quality and software processes.	
P2-CSF6	Expertise needs continuous improvement by means of training.	
P3-CSF6	The team consists of individuals having previous process improvement experience, knowledge and necessary skills.	
P4-CSF6	Use the previous experience of process improvement projects in global software development.	
P5-CSF6	Draw on the expertise of external assessors/consultants as mentors.	
P6-CSF6	Use consultants to facilitate and guide.	
P7-CSF6	The users of the system as well as the implementation team need to understand the basics of a quality process.	
Section-C2 (Practices for CBs)		
CB1: Lack of organizational support		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1- CB1	Management committed to support SPI team members.	
P2- CB1	Top level management should make software process improvement	

	practices as the fundamental part of the software development cycle.	
P3- CB1	Develop criteria to continuously monitor the progress of the process improvement team.	
P4- CB1	Management commit to provide adequate resources and training for process improvement activities.	
P5- CB1	Management is willing to participate in assessment meetings and improvement workshops.	
CB2: Lack of Communication		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1- CB2	Regular travel to distributed sites creates group cohesiveness among the team members.	
P2- CB2	Promote efficient offshore relationship.	
P3- CB2	Promote the use of advance communication and information technology tools and practices.	
P4- CB2	Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.	
P5- CB2	Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.	
P6-CB2	Team members should have plan for frequent daily meetings	
CB3: Lack of Process Improvement Knowledge		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1- CB3	Detail process improvement knowledge.	
P2- CB3	Conduct regular training session for team members.	
P3- CB3	Establish a mechanism to continuously monitor the progress of each SPI team member.	
P4- CB3	Encourage team building activities	
P5- CB3	Promote process improvement awareness among process improvement team members.	
CB4: Lack of formal process improvement implementation methodology		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CB4	Establish technical infrastructure to implement the process improvement program.	
P2- CB4	Use applications of process, implementation or product indicators as an effective management tool for process improvement.	
P3-CB4	Promote the awareness of process improvement application tools and standards among team members.	
P4-CB4	Adopt standards for the assessment of processes.	
P5-CB4	Use of licensed software tools.	
CB5: Lack of Resources		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CB5	Project planning done in order to estimate all the required resources.	
P2-CB5	Management commits to allocate sufficient time for SPI activities.	
P3-CB5	A mechanism developed to avoid time pressure.	
P4-CB5	Team members agree to allocate time for SPI activities.	
P5-CB5	Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.	

Appendix I1: Feedback Response at Company A, B, C

1. CONSENT FORM (Company A)

Project Title: Software Process Improvement Implementation Model (SPIIMM) for Global Software Development (GSD)

Name of Investigator: Arif Ali Khan

Please Tick the box

1	I confirm that I have carefully reviewed the document titled "Guideline document for SPIIMM Case Study assessment process" which provides sufficient information about the above project.	☒
2	I confirm that I am participating in this case study on voluntary basis and could withdraw from it at any stage.	☒
3	I understand that the data collected using this case study will keep confidential and will not share with third party under any circumstances.	☒
4	I confirm that I could be contacted to participate in any future case study relating to Software Process Improvement (SPI).	☒

Section- A (Respondent Information)			
Full Name (optional)		Job Title / Position	Chief Engineer(SW engineering)
Working Experience (Years) in Global Software development and Software Process Improvement related projects.	11		
Email Address			
Name and address of your organization including country			
How many years of industry/academia experience do you have in your field?	11		
Date	20-08-2016		

Extremely High (EH), Moderately High (MH), High (H), Neutral (NU), Extremely Low (EL), Moderately Low (ML), Low (L)

	EH	MH	H	NU	EL	ML	L
Rate your knowledge about software process improvement.	☐	☐	☒	☐	☐	☐	☐
Rate you experience relating to software process improvement.	☐	☒	☐	☐	☐	☐	☐
Section- B(Feedback on assessment of SPIIMM)							
Section-B1 (Ease of Learning)	EH	MH	H	NU	EL	ML	L
1. Representation of SPIIMM is simple.	☒	☒	☐	☐	☐	☐	☐

2. SPIIMM need little SPI knowledge to understand.	☐	☐	☒	☐	☐	☐	☐
3. It's simple to understand the practices of critical success factors and barriers.	☐	☐	☒	☐	☐	☐	☐
4. It's simple to understand the Motorola assessment technique.	☐	☐	☒	☐	☐	☐	☐
5. It's simple to implement SPIIMM for process improvement activities.	☐	☒	☐	☐	☐	☐	☐
6. It's simple to understand the maturity levels of SPIIMM along their critical success factors and critical barriers.	☐	☒	☐	☐	☐	☐	☐
7. SPIIMM needs training to fully understand.	☐	☐	☒	☐	☐	☐	☐
Section-B2 (User Satisfaction)	EH	MH	H	NU	EL	ML	L
8. SPIIMM is generic in nature and could be installed in different global software development organizations.	☐	☒	☐	☐	☐	☐	☐
9. SPIIMM could help an organization to understand weak and strong areas of process improvement	☐	☐	☒	☐	☐	☐	☐
10. The use of SPIIMM could improve the software process of our organization.	☐	☐	☐	☒	☐	☐	☐
11. I will prefer to use SPIIMM in my organization	☐	☐	☒	☐	☐	☐	☐
12. I am confident with the results of SPIIMM.	☐	☒	☐	☐	☐	☐	☐
13. The software tool of SPIIMM could facilitate the experts to implement SPI.	☐	☐	☒	☐	☐	☐	☐
14. SPIIMM is a useful model for global software development organizations.	☐	☒	☐	☐	☐	☐	☐
Section-B3 (Structure of SPIIMM)	EH	MH	H	NU	EL	ML	L
15. The core components of SPIIMM are self-exploratory and no need of further explanation to be used effectively.	☐	☐	☐	☐	☐	☐	☒
16. The SPIIMM components are practical and could be used in GSD industry.	☐	☐	☐	☒	☐	☐	☐
17. The implementation of SPIIMM could assist an organization to identify issues relating to SPI.	☐	☐	☐	☒	☐	☐	☐
18. The five maturity levels of SPIIMM are enough to assess the SPI maturity level of an organization.	☐	☐	☐	☒	☐	☐	☐
19. Would you like to suggest further improvements or suggestions for SPI?	Nil						
20. Are there any additional components for SPIIMM and also give the reasons.	Nil						
21. Please give your opinion related to the adopted Motorola assessment method.	Nil						
22. Please give your opinion related to the classification of practices across critical success factors and critical barriers.	Nil						

Section-C (Review of Practices)

In this section, I would like you to review the selected practices identified for critical success factors (CSFs) and critical barriers (CBs). Please give your opinion if I need to modify/change any specific practice according to your knowledge and experience.

Section-C1 (Practices for CSFs)

CSF1:Management Commitment

Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CSF1	Strong support and commitment of organizational management for	

	software process improvement program.	
P2-CSF1	Management provides and sustain resources for process improvement program.	
P3-CSF1	Continuously monitor the process improvement activities	
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.	
P5-CSF1	Continuously encourage the efforts of process improvement team members.	
P6-CSF1	Top level management should lead the initiation and implementation of SPI program.	
P7-CSF1	Management encourage and drive the bottom-up staff in SPI activities.	
P8-CSF1	Organizational management motivate SPI team members as well the non SPI staff members to accept the changes of process improvement.	
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.	
P10-CSF1	Tope level management should show long time commitment.	
CSF2: Staff Involvement		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CSF2	Employees must adopt process innovations in their day-to-day activities.	
P2-CSF2	Staff members should participate in process improvement because they have detailed knowledge of strengths and weaknesses of current processes.	
P3-CSF2	Facilitate process improvement team members.	
P4-CSF2	Properly monitor the staff members so that every member feels the sense of responsibility.	
P5-CSF2	Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.	
P6-CSF2	Each distributed site should have technical leader that could lead the development process, coordinate with the team members and schedule the process improvement activities.	
P7-CSF2	Regularly discuss the rationale for process improvement efforts with staff.	
P8-CSF2	Explicitly describe the benefits of SPI to both the team members and organization.	
CSF3: Allocation of Resources		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CSF3	There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.	
P2-CSF3	Management should have a broader picture of the resources and time required in order to conduct the process improvement program.	
P3-CSF3	Provide all the required technological resources including hardware and software.	
P4-CSF3	Process improvement team members have been allocated sufficient time for process improvement program.	
P5-CSF3	Provide adequate budget and human resources from the very start of the process improvement project implementation.	
P6-CSF3	The organization set priorities of what they choose to implement based on resources and budget - they don't have to do everything at once.	
CSF4: 3C's (Communication, Coordination, Control)		
Practices S.No	**Practices**	**Suggestions/Change**

		(if needed)
P1-CSF4	The team members should frequently visit the geographically distributed sites in order to develop group cohesiveness.	
P2-CSF4	Encourage the use of effective communication, coordination and control tools and techniques.	
P3-CSF4	Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.	
P4-CSF4	Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.	
P5-CSF4	Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.	
P6-CSF4	Organization should appoint liaison among the geographically distributed teams.	
P7-CSF4	Frequent planning of interactions between distributed sites: daily stand-up/call improves this largely.	
CSF5: Project Pilot Implementation		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CSF5	Implement process improvement for testing on a small scale.	
P2-CSF5	Develop criteria for pilot implementation of process improvement.	
P3-CSF5	Capture the feedback from the pilot implementation and use for future process improvement activities.	
P4-CSF5	Continuously monitor the results of pilot process improvement implementation.	
P5-CSF5	Provide adequate resources for pilot implementation.	
P6-CSF5	Publicise and communicate widely pilot implementation success story.	
P7-CSF5	Test earlier, provide examples and reiterate fast.	
P8-CSF5	Explicitly discuss the results of the pilot implementation.	
CSF6: Process Improvement Expertise		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CSF6	Process improvement team members have a deep understanding of software quality and software processes.	
P2-CSF6	Expertise needs continuous improvement by means of training.	
P3-CSF6	The team consists of individuals having previous process improvement experience, knowledge and necessary skills.	
P4-CSF6	Use the previous experience of process improvement projects in global software development.	
P5-CSF6	Draw on the expertise of external assessors/consultants as mentors.	
P6-CSF6	Use consultants to facilitate and guide.	
P7-CSF6	The users of the system as well as the implementation team need to understand the basics of a quality process.	
Section-C2 (Practices for CBs)		
CB1: Lack of organizational support		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1- CB1	Management committed to support SPI team members.	
P2- CB1	Top level management should make software process improvement practices as the fundamental part of the software development cycle.	
P3- CB1	Develop criteria to continuously monitor the progress of the process	

	improvement team.	
P4- CB1	Management commit to provide adequate resources and training for process improvement activities.	
P5- CB1	Management is willing to participate in assessment meetings and improvement workshops.	
CB2: Lack of Communication		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1- CB2	Regular travel to distributed sites creates group cohesiveness among the team members.	
P2- CB2	Promote efficient offshore relationship.	
P3- CB2	Promote the use of advance communication and information technology tools and practices.	
P4- CB2	Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.	
P5- CB2	Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.	
P6-CB2	Team members should have plan for frequent daily meetings.	
CB3: Lack of Process Improvement Knowledge		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1- CB3	Detail process improvement knowledge.	Rephrase to meaningful sentence.
P2- CB3	Conduct regular training session for team members.	
P3- CB3	Establish a mechanism to continuously monitor the progress of each SPI team member.	
P4- CB3	Encourage team building activities	
P5- CB3	Promote process improvement awareness among process improvement team members.	
CB4: Lack of formal process improvement implementation methodology		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CB4	Establish technical infrastructure to implement the process improvement program.	
P2- CB4	Use applications of process, implementation or product indicators as an effective management tool for process improvement.	
P3-CB4	Promote the awareness of process improvement application tools and standards among team members.	
P4-CB4	Adopt standards for the assessment of processes.	
P5-CB4	Use of licensed software tools.	
CB5: Lack of Resources		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CB5	Project planning done in order to estimate all the required resources.	
P2-CB5	Management commits to allocate sufficient time for SPI activities.	
P3-CB5	A mechanism developed to avoid time pressure.	
P4-CB5	Team members agree to allocate time for SPI activities.	
P5-CB5	Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.	

2. CONSENT FORM (Company B)

Project Title: Software Process Improvement Implementation Model (SPIIMM) for Global Software Development (GSD)

Name of Investigator: Arif Ali Khan

Please Tick the box

1	I confirm that I have carefully reviewed the document titled "Guideline document for SPIIMM Case Study assessment process" which provides sufficient information about the above project.	■
2	I confirm that I am participating in this case study on voluntary basis and could withdraw from it at any stage.	■
3	I understand that the data collected using this case study will keep confidential and will not share with third party under any circumstances.	■
4	I confirm that I could be contacted to participate in any future case study relating to Software Process Improvement (SPI).	■

Section- A (Respondent Information)			
Full Name (optional)		Job Title / Position	
Working Experience (Years) in Global Software development and Software Process Improvement related projects.			
Email Address			
Name and address of your organization including country			
How many years of industry/academia experience do you have in your field?			
Date			

Extremely High (EH), Moderately High (MH), High (H), Neutral (NU), Extremely Low (EL), Moderately Low (ML), Low (L)

	EH	MH	H	NU	EL	ML	L
Rate your knowledge about software process improvement.	■	☐	☐	☐	☐	☐	☐
Rate you experience relating to software process improvement.	■	☐	☐	☐	☐	☐	☐
Section- B (Feedback on assessment of SPIIMM)							
Section-B1 (Ease of Learning)	EH	MH	H	NU	EL	ML	L
1. Representation of SPIIMM is simple.	☐	■	☐	☐	☐	☐	☐

2. SPIIMM need little SPI knowledge to understand.	■	☐	☐	☐	☐	☐	☐
3. It's simple to understand the practices of critical success factors and barriers.	☐	☐	■	☐	☐	☐	☐
4. It's simple to understand the Motorola assessment technique.	☐	☐	■	☐	☐	☐	☐
5. It's simple to implement SPIIMM for process improvement activities.	☐	■	☐	☐	☐	☐	☐
6. It's simple to understand the maturity levels of SPIIMM along their critical success factors and critical barriers.	☐	☐	■	☐	☐	☐	☐
7. SPIIMM needs training to fully understand.	☐	☐	☐	■	☐	☐	☐
Section-B2 (User Satisfaction)	EH	MH	H	NU	EL	ML	L
8. SPIIMM is generic in nature and could be installed in different global software development organizations.	☐	☐	■	☐	☐	☐	☐
9. SPIIMM could help an on organization to understand weak and strong areas of process improvement	☐	■	☐	☐	☐	☐	☐
10. The use of SPIIMM could improve the software process of our organization.	☐	☐	■	☐	☐	☐	☐
11. I will prefer to use SPIIMM in my organization	☐	☐	■	☐	☐	☐	☐
12. I am confident with the results of SPIIMM.	■	☐	☐	☐	☐	☐	☐
13. The software tool of SPIIMM could facilitate the experts to implement SPI.	☐	■	☐	☐	☐	☐	☐
14. SPIIMM is a useful model for global software development organizations.	☐	☐	■	☐	☐	☐	☐
Section-B3 (Structure of SPIIMM)	EH	MH	H	NU	EL	ML	L
15. The core components of SPIIMM are self-exploratory and no need of further explanation to be used effectively.	☐	☐	■	☐	☐	☐	☐
16. The SPIIMM components are practical and could be used in GSD industry.	☐	☐	■	☐	☐	☐	☐
17. The implementation of SPIIMM could assist an organization to identify issues relating to SPI.	☐	■	☐	☐	☐	☐	☐
18. The five maturity levels of SPIIMM are enough to assess the SPI maturity level of an organization.	☐	☐	■	☐	☐	☐	☐
19. Would you like to suggest further improvements or suggestions for SPI?	Nil						
20. Are there any additional components for SPIIMM and also give the reasons.	Nil						
21. Please give your opinion related to the adopted Motorola assessment method.	The method is too complex, especially for the delivery method you have chosen. My guess is that you'll get more reliable results if you observe this in focus groups.						
22. Please give your opinion related to the classification of practices across critical success factors and critical barriers.	Nil						

Section-C (Review of Practices)

In this section, I would like you to review the selected practices identified for critical success factors (CSFs) and critical barriers (CBs). Please give your opinion if I need to modify/change any specific practice according to your knowledge and experience.

Section-C1 (Practices for CSFs)

CSF1: Management Commitment

Practices S. No	**Practices**	**Suggestions/ Change (if needed)**

P1-CSF1	Strong support and commitment of organizational management for software process improvement program.	
P2-CSF1	Management provides and sustain resources for process improvement program.	
P3-CSF1	Continuously monitor the process improvement activities	
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.	
P5-CSF1	Continuously encourage the efforts of process improvement team members.	
P6-CSF1	Top level management should lead the initiation and implementation of SPI program.	
P7-CSF1	Management encourage and drive the bottom-up staff in SPI activities.	
P8-CSF1	Organizational management motivate SPI team members as well the non SPI staff members to accept the changes of process improvement.	
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.	
P10-CSF1	Tope level management should show long time commitment.	
CSF2: Staff Involvement		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CSF2	Employees must adopt process innovations in their day-to-day activities.	
P2-CSF2	Staff members should participate in process improvement because they have detailed knowledge of strengths and weaknesses of current processes.	
P3-CSF2	Facilitate process improvement team members.	
P4-CSF2	Properly monitor the staff members so that every member feels the sense of responsibility.	
P5-CSF2	Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.	
P6-CSF2	Each distributed site should have technical leader that could lead the development process, coordinate with the team members and schedule the process improvement activities.	
P7-CSF2	Regularly discuss the rationale for process improvement efforts with staff.	
P8-CSF2	Explicitly describe the benefits of SPI to both the team members and organization.	
CSF3: Allocation of Resources		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CSF3	There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.	
P2-CSF3	Management should have a broader picture of the resources and time required in order to conduct the process improvement program.	
P3-CSF3	Provide all the required technological resources including hardware and software.	
P4-CSF3	Process improvement team members have been allocated sufficient time for process improvement program.	
P5-CSF3	Provide adequate budget and human resources from the very start of the process improvement project implementation.	
P6-CSF3	The organization set priorities of what they choose to implement based on resources and budget - they don't have to do everything at once.	
CSF4: 3C's (Communication, Coordination, Control)		

Practices S. No	Practices	Suggestions/ Change (if needed)
P1-CSF4	The team members should frequently visit the geographically distributed sites in order to develop group cohesiveness.	
P2-CSF4	Encourage the use of effective communication, coordination and control tools and techniques.	
P3-CSF4	Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.	
P4-CSF4	Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.	
P5-CSF4	Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.	
P6-CSF4	Organization should appoint liaison among the geographically distributed teams.	
P7-CSF4	Frequent planning of interactions between distributed sites: daily stand-up/call improves this largely.	
CSF5: Project Pilot Implementation		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CSF5	Implement process improvement for testing on a small scale.	
P2-CSF5	Develop criteria for pilot implementation of process improvement.	
P3-CSF5	Capture the feedback from the pilot implementation and use for future process improvement activities.	
P4-CSF5	Continuously monitor the results of pilot process improvement implementation.	
P5-CSF5	Provide adequate resources for pilot implementation.	
P6-CSF5	Publicise and communicate widely pilot implementation success story.	
P7-CSF5	Test earlier, provide examples and reiterate fast.	
P8-CSF5	Explicitly discuss the results of the pilot implementation.	
CSF6: Process Improvement Expertise		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CSF6	Process improvement team members have a deep understanding of software quality and software processes.	
P2-CSF6	Expertise needs continuous improvement by means of training.	
P3-CSF6	The team consists of individuals having previous process improvement experience, knowledge and necessary skills.	
P4-CSF6	Use the previous experience of process improvement projects in global software development.	
P5-CSF6	Draw on the expertise of external assessors/consultants as mentors.	
P6-CSF6	Use consultants to facilitate and guide.	
P7-CSF6	The users of the system as well as the implementation team need to understand the basics of a quality process.	
Section-C2 (Practices for CBs)		
CB1: Lack of organizational support		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1- CB1	Management committed to support SPI team members.	
P2- CB1	Top level management should make software process improvement	

	practices as the fundamental part of the software development cycle.	
P3- CB1	Develop criteria to continuously monitor the progress of the process improvement team.	
P4- CB1	Management commit to provide adequate resources and training for process improvement activities.	
P5- CB1	Management is willing to participate in assessment meetings and improvement workshops.	
CB2: Lack of Communication		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1- CB2	Regular travel to distributed sites creates group cohesiveness among the team members.	
P2- CB2	Promote efficient offshore relationship.	
P3- CB2	Promote the use of advance communication and information technology tools and practices.	
P4- CB2	Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.	
P5- CB2	Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.	
P6-CB2	Team members should have plan for frequent daily meetings.	
CB3: Lack of Process Improvement Knowledge		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1- CB3	Detail process improvement knowledge.	
P2- CB3	Conduct regular training session for team members.	
P3- CB3	Establish a mechanism to continuously monitor the progress of each SPI team member.	
P4- CB3	Encourage team building activities	
P5- CB3	Promote process improvement awareness among process improvement team members.	
CB4: Lack of formal process improvement implementation methodology		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CB4	Establish technical infrastructure to implement the process improvement program.	
P2- CB4	Use applications of process, implementation or product indicators as an effective management tool for process improvement.	
P3-CB4	Promote the awareness of process improvement application tools and standards among team members.	
P4-CB4	Adopt standards for the assessment of processes.	
P5-CB4	Use of licensed software tools.	
CB5: Lack of Resources		
Practices S. No	**Practices**	**Suggestions/ Change (if needed)**
P1-CB5	Project planning done in order to estimate all the required resources.	
P2-CB5	Management commits to allocate sufficient time for SPI activities.	
P3-CB5	A mechanism developed to avoid time pressure.	
P4-CB5	Team members agree to allocate time for SPI activities.	
P5-CB5	Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.	

3. CONSENT FORM (Company C)

Project Title: Software Process Improvement Implementation Model (SPIIMM) for Global Software Development (GSD)

Name of Investigator: Arif Ali Khan

Please Tick the box

1	I confirm that I have carefully reviewed the document titled "Guideline document for SPIIMM Case Study assessment process" which provides sufficient information about the above project.	☒
2	I confirm that I am participating in this case study on voluntary basis and could withdraw from it at any stage.	☒
3	I understand that the data collected using this case study will keep confidential and will not share with third party under any circumstances.	☒
4	I confirm that I could be contacted to participate in any future case study relating to Software Process Improvement (SPI).	☒

Section- A (Respondent Information)			
Full Name (optional)		Job Title / Position	Senior Project Manager/Consultant
Working Experience (Years) in Global Software development and Software Process Improvement related projects.	30		
Email Address			
Name and address of your organization including country			
How many years of industry/academia experience do you have in your field?	30		
Date	25-08-2016		

Extremely High (EH), Moderately High (MH), High (H), Neutral (NU), Extremely Low (EL), Moderately Low (ML), Low (L)

	EH	MH	H	NU	EL	ML	L
Rate your knowledge about software process improvement.	☒	☐	☐	☐	☐	☐	☐

Rate you experience relating to software process improvement.	☒	☐	☐	☐	☐	☐	☐
Section- B(Feedback on assessment of SPIIMM)							
Section-B1 (Ease of Learning)	EH	MH	H	NU	EL	ML	L
1. Representation of SPIIMM is simple.	☒	☐	☐	☐	☐	☐	☐
2. SPIIMM need little SPI knowledge to understand.	☒	☐	☐	☐	☐	☐	☐
3. It's simple to understand the practices of critical success factors and barriers.	☒	☐	☐	☐	☐	☐	☐
4. It's simple to understand the Motorola assessment technique.	☐	☐	☒	☐	☐	☐	☐
5. It's simple to implement SPIIMM for process improvement activities.	☐	☒	☐	☐	☐	☐	☐
6. It's simple to understand the maturity levels of SPIIMM along their critical success factors and critical barriers.	☐	☒	☐	☐	☐	☐	☐
7. SPIIMM needs training to fully understand.	☐	☐	☐	☒	☐	☐	☐
Section-B2 (User Satisfaction)	EH	MH	H	NU	EL	ML	L
8. SPIIMM is generic in nature and could be installed in different global software development organizations.	☐	☐	☒	☐	☐	☐	☐
9. SPIIMM could help an organization to understand weak and strong areas of process improvement	☒	☐	☐	☐	☐	☐	☐
10. The use of SPIIMM could improve the software process of our organization.	☐	☐	☒	☐	☐	☐	☐
11. I will prefer to use SPIIMM in my organization	☐	☐	☒	☐	☐	☐	☐
12. I am confident with the results of SPIIMM.	☐	☐	☒	☐	☐	☐	☐
13. The software tool of SPIIMM could facilitate the experts to implement SPI.	☐	☒	☐	☐	☐	☐	☐
14. SPIIMM is a useful model for global software development organizations.	☒	☐	☐	☐	☐	☐	☐
Section-B3 (Structure of SPIIMM)	EH	MH	H	NU	EL	ML	L
15. The core components of SPIIMM are self-exploratory and no need of further explanation to be used effectively.	☐	☐	☒	☐	☐	☐	☐
16. The SPIIMM components are practical and could be used in GSD industry.	☐	☐	☒	☐	☐	☐	☐
17. The implementation of SPIIMM could assist an organization to identify issues relating to SPI.	☒	☐	☐	☐	☐	☐	☐
18. The five maturity levels of SPIIMM are enough to assess the SPI maturity level of an organization.	☒	☐	☐	☐	☐	☐	☐
19. Would you like to suggest further improvements or suggestions for SPI?	Revise the (CB: lack of process improvement knowledge) reported at maturity level-2 of SPIIMM. They could know all about process improvement knowledge but still not committed. Knowledge on its own does not guarantee commitment. Therefore I would like to suggest to move (CB: lack of process improvement knowledge) to Level-4 and move (CB: lack of resources) to Level-2 because the Lack of resources could negatively impact the commitment of organization management.						
20. Are there any additional components for SPIIMM and also give the reasons.							
21. Please give your opinion related to the adopted							

Motorola assessment method.	
22. Please give your opinion related to the classification of practices across critical success factors and critical barriers.	

Section-C (Review of Practices)

In this section, I would like you to review the selected practices identified for critical success factors (CSFs) and critical barriers (CBs). Please give your opinion if I need to modify/change any specific practice according to your knowledge and experience.

Section-C1 (Practices for CSFs)

CSF1:Management Commitment

Practices S.No	Practices	Suggestions/Change (if needed)
P1-CSF1	Strong support and commitment of organizational management for software process improvement program.	
P2-CSF1	Management provides and sustain resources for process improvement program.	
P3-CSF1	Continuously monitor the process improvement activities	
P4-CSF1	Provide an infrastructure that could encourage the team members to participate in SPI activities.	
P5-CSF1	Continuously encourage the efforts of process improvement team members.	
P6-CSF1	Top level management should lead the initiation and implementation of SPI program.	
P7-CSF1	Management encourage and drive the bottom-up staff in SPI activities.	
P8-CSF1	Organizational management motivate SPI team members as well the non SPI staff members to accept the changes of process improvement.	
P9-CSF1	Users see that the change is of benefit to them as individuals as well as to the entire organisation.	
P10-CSF1	Tope level management should show long time commitment.	

CSF2: Staff Involvement

Practices S.No	Practices	Suggestions/Change (if needed)
P1-CSF2	Employees must adopt process innovations in their day-to-day activities.	
P2-CSF2	Staff members should participate in process improvement because they have detailed knowledge of strengths and weaknesses of current processes.	
P3-CSF2	Facilitate process improvement team members.	This practice might be more valuable if consider in the domain of CSF1. The provision of basic facilities will show the great interest of higher management in SPI related activities.
P4-CSF2	Properly monitor the staff members so that every member feels the sense of responsibility.	
P5-CSF2	Organization should establish process teams and forums which could help the staff members to exchange the innovative ideas.	
P6-CSF2	Each distributed site should have technical leader that could lead the development process, coordinate with the team members and schedule the process improvement activities.	
P7-CSF2	Regularly discuss the rationale for process improvement efforts with staff.	

P8-CSF2	Explicitly describe the benefits of SPI to both the team members and organization.	
CSF3: Allocation of Resources		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CSF3	There should be a proper strategy to estimate, allocate and provide the available resources for process improvement activities.	
P2-CSF3	Management should have a broader picture of the resources and time required in order to conduct the process improvement program.	
P3-CSF3	Provide all the required technological resources including hardware and software.	
P4-CSF3	Process improvement team members have been allocated sufficient time for process improvement program.	
P5-CSF3	Provide adequate budget and human resources from the very start of the process improvement project implementation.	
P6-CSF3	The organization set priorities of what they choose to implement based on resources and budget - they don't have to do everything at once.	
CSF4: 3C's (Communication, Coordination, Control)		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CSF4	The team members should frequently visit the geographically distributed sites in order to develop group cohesiveness.	
P2-CSF4	Encourage the use of effective communication, coordination and control tools and techniques.	
P3-CSF4	Conduct training sessions for remote team members in order to resolve cultural, linguistic and behavioural issues.	
P4-CSF4	Plan the roles, relationships and rules to facilitate the coordination and control over geographical, temporal and cultural distances.	
P5-CSF4	Use different communication means such as video conferencing, regular rotation of staff members and team building activities in order to organize frequent meetings.	
P6-CSF4	Organization should appoint liaison among the geographically distributed teams.	
P7-CSF4	Frequent planning of interactions between distributed sites: daily stand-up/call improves this largely.	
CSF5: Project Pilot Implementation		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CSF5	Implement process improvement for testing on a small scale.	
P2-CSF5	Develop criteria for pilot implementation of process improvement.	
P3-CSF5	Capture the feedback from the pilot implementation and use for future process improvement activities.	
P4-CSF5	Continuously monitor the results of pilot process improvement implementation.	
P5-CSF5	Provide adequate resources for pilot implementation.	
P6-CSF5	Publicise and communicate widely pilot implementation success story.	
P7-CSF5	Test earlier, provide examples and reiterate fast.	
P8-CSF5	Explicitly discuss the results of the pilot implementation.	
CSF6: Process Improvement Expertise		

Practices S.No	Practices	Suggestions/Change (if needed)
P1-CSF6	Process improvement team members have a deep understanding of software quality and software processes.	
P2-CSF6	Expertise needs continuous improvement by means of training.	
P3-CSF6	The team consists of individuals having previous process improvement experience, knowledge and necessary skills.	
P4-CSF6	Use the previous experience of process improvement projects in global software development.	
P5-CSF6	Draw on the expertise of external assessors/consultants as mentors.	
P6-CSF6	Use consultants to facilitate and guide.	
P7-CSF6	The users of the system as well as the implementation team need to understand the basics of a quality process.	
Section-C2 (Practices for CBs)		
CB1: Lack of organizational support		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1- CB1	Management committed to support SPI team members.	
P2- CB1	Top level management should make software process improvement practices as the fundamental part of the software development cycle.	
P3- CB1	Develop criteria to continuously monitor the progress of the process improvement team.	
P4- CB1	Management commit to provide adequate resources and training for process improvement activities.	
P5- CB1	Management is willing to participate in assessment meetings and improvement workshops.	
CB2: Lack of Communication		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1- CB2	Regular travel to distributed sites creates group cohesiveness among the team members.	
P2- CB2	Promote efficient offshore relationship.	
P3- CB2	Promote the use of advance communication and information technology tools and practices.	
P4- CB2	Arrange training and workshops to understand both the culture of the people participating in distributed process improvement.	
P5- CB2	Encourage video conferencing during process improvement implementation, especially when traveling and face to face is difficult.	
P6-CB2	Team members should have plan for frequent daily meetings.	
CB3: Lack of Process Improvement Knowledge		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1- CB3	Detail process improvement knowledge.	
P2- CB3	Conduct regular training session for team members.	
P3- CB3	Establish a mechanism to continuously monitor the progress of each SPI team member.	
P4- CB3	Encourage team building activities	
P5- CB3	Promote process improvement awareness among process improvement team members.	

CB4: Lack of formal process improvement implementation methodology		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CB4	Establish technical infrastructure to implement the process improvement program.	
P2- CB4	Use applications of process, implementation or product indicators as an effective management tool for process improvement.	
P3-CB4	Promote the awareness of process improvement application tools and standards among team members.	
P4-CB4	Adopt standards for the assessment of processes.	
P5-CB4	Use of licensed software tools.	
CB5: Lack of Resources		
Practices S.No	**Practices**	**Suggestions/Change (if needed)**
P1-CB5	Project planning done in order to estimate all the required resources.	
P2-CB5	Management commits to allocate sufficient time for SPI activities.	
P3-CB5	A mechanism developed to avoid time pressure.	
P4-CB5	Team members agree to allocate time for SPI activities.	
P5-CB5	Strategy should be developed so that SPI activities will not disturb the everyday schedule of the team members.	