Systematic Literature Study for Dimensional Classification of Success Factors Affecting Process Improvement in Global Software Development: Client-Vendor Perspective

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Abstract: Majority of the organizations are globalizing their software development activities by following the ideas of global software development (GSD). The motivation behind the adoption of GSD phenomena are the list of benefits gained by the software industry. However, there are different challenges face by the GSD organizations, particularly the issues related to Software Process Improvement (SPI). The aim of this study is the identification and classification into categories of the success factors that can impact SPI initiatives taken in GSD organizations. The Systematic Literature Review (SLR) method has been used to extract the success factors from the existing literature. The three core phases "planning, conducting and reporting the review" of SLR has been followed to perform this study. Total fifteen success factors were identified and classified into the six main categories. We have also reported the critical success factors of SPI i.e. management commitment, staff involvement, roles and responsibilities, communication and resources allocation. This article also reported the similarities and differences between the success factors classified on the bases of client-vendor organization and size of the organization. The identified success factors can contribute towards the implementation of SPI program in both client and vendor GSD organizations because these factors represent key areas of process improvement.

Keywords: Software Process Improvement, Global Software Development, Systematic Literature Review, Success Factors, Client, Vendor

1. Introduction

Different techniques and practices have been introduced in order to manage the software process but the most prominent approach is Software Process Improvement (SPI). The objective of process improvement is to assess and improve the activities involve in software development [1, 2]. There are different process improvement models and standards that assist to manage the software development activities. In particular, Capability Maturity Model Integration (CMMI) [3] is a software process improvement model that consist of organised and systematic practices for process evaluation and improvement. The International Organization for Standardization (ISO) has also developed various process improvement standards. ISO 9000 was developed for the quality assessment of the deployed software systems in an organization [4, 10]. The ISO/IEC 15504 was initiated under the umbrella of Software Process Improvement and Capability Determination (SPICE). The aim of SPICE was to assess and advertise SPI models and standards [5]. Different researchers highlighted that process improvement models can help a software development organization to develop a quality system, reduce development time and cost, as well as promote user satisfaction [6, 30]. The key issue of SPI is the unavailability of an operative and efficient technique to deploy SPI models and standards in the domain of GSD [6, 44].

SPI has a long tradition in the research areas of software engineering and information systems [2, 10]. The existing literature highlighted the importance of process improvement in the domain of single site (collocated) software development [9], but presently the majority of software firms are following the concept of GSD. GSD is carried out by teams positioned in different locations around the globe, developing commercially viable software systems [7, 8, 32]. The return on investment of GSD includes –but is not limited to– reduction of the development time and cost, high ratio of team productivity, improvement in workforce's skills and access to market [7].

Despite these significant benefits, only little consideration has been given to the following core question: "how to efficiently perform process improvement activities in the domain of GSD?" Particularly, team members working in the GSD environment operate beyond the geographical, cultural and temporal boundaries which make the SPI program much challenging [9, 38]. Furthermore, as highlighted by Richardson et al. [39], the deployment of SPI team members faces various challenges in the domain of GSD while developing the SPI practices, inter team

communication, managing the issue of time differences and mitigating the cultural conflicts. To effectively address these challenges, it is mandatory for the client-vendor GSD organizations to enhance the quality of their development practices and processes [10, 44, 45].

To summarize, the research presented here address the problem related to process improvement programs and activities in distributed environments by identifying and classifying success factors into particular categories with the aim of helping organizations to focus and rely on the factors to achieve their business goals.

In this study, we will answer the following research questions in order to address the reported research problem.

RQ1: What are the key categories to classify success factors for SPI programs in GSD?
RQ1.1: Are the identified success factors related to client or vendor organizations?
RQ2: What are the Critical Success Factors (CSFs) in each identified category?
RQ3: Do the identified success factors differ in the domain of organization size?

2. Motivation

Majority of the researchers focused to develop standards and techniques for the process assessment and improvement. These standards could assist to improve the development processes and capabilities of the organization [13] which include: CMM [12], CMMI [3] and ISO's SPICE [5]. However, regardless of the availability of various models and techniques, the success rate of process improvement programs is still very low [6, 27]. Ramasubbu [9] justify it by reporting that little attention has been given to manage the SPI programs.

Majority of firms have followed the concepts of GSD in order to increase business profit and it is significant for the team members to have complete knowledge and awareness of SPI implementation in GSD environment [9, 10]. This seems to be particularly true for client organizations working in developed countries which outsource the system components in developing countries because they offer cheaper services than onshore organizations [28, 44]. Similarly, the vendor teams could improve their skills using novel techniques to complete the client projects [29, 42]. However, both the client and vendor organizations working in GSD environment face the challenges of geographical, cultural and temporal distances [30, 44]. It has been observed that eight organizations out of ten, that have outsourced the system modules to offshore vendors have confronted various issues due to the inadequate planning and the poor management of SPI program [31].

However, the SPI challenges in the domain of GSD are different as compared to collocated development (single site) and these challenges should be seriously considered by both client and vendor organizations [10]. According to Ramasubbu [9], the existing literature does not highlight the distributed nature of SPI activities conducted in GSD organizations. No matter the type (client *versus* vendor), the deployment of SPI activities is more puzzling and demanding in GSD environment [9, 44].

Richardson et al. [39] argues that in GSD, the geographical distance brings physical separation among the team members, temporal distance decreases the direct communication opportunities and cultural distance bring cultural conflicts among the distributed teams. Therefore, GSD has experienced more complications as compared to collocated development [39]. Richardson et al. [39] mentioned that process models i.e. CMM, CMMI and ISO/IEC 15504 excellently operate in collocated environment but not addressing the challenges of SPI in distributed environment [10, 39]. O' Leary et al. [40] discussed that it is significant to manage the social challenges of the SPI program in GSD along the technical issues. A systematic mapping study of SPI in GSD conducted by Kuhrmann et al. [41] reported that various SPI proposals and experience reports have been discussed in the available literature, but very few studies highlighted it in the domain of GSD. The existing studies critically discussed the implementation of SPI standards and models like CMMI and ISO/IC 15504 in the context of GSD [10, 41].

In summary, little research work has been done to operate process improvement activities in GSD [9, 10, 38]. No study has been found, where the success factors categorised and reported in both client and vendor perspectives. Lately, Verner et al. [11] considered a tertiary mapping study by considering the published SLRs in GSD. They identified that current GSD SLRs do not differentiate the client and the vendor nature of organizations. This research gap is addressed here by discussing the success factors of the SPI program in both client and vendor organizations. We have adopted the approaches used by Koh et al. [37] and Niazi et al. [42] in order to report the client and vendor nature of the GSD studies.

Systematic Literature Review (SLR) technique was used to get deep understanding of the success factors and their categories that could positively impact the process improvement activities. The SLR assist us in evaluating and understanding the existing research [15] to identify and categorise the SPI success factors in client-vendor perspectives.

3. Systematic Literature Review

SLR is an approach for investigating, classifying, and assessing the existing literature related to a specific research field and questions of interest [15]. The main reason to follow the SLR technique is its rigorous process that could help to identify the research gap and provide a systematic way to extract the data [43]. The formal process of SLR makes the results more precise and scientific [43]. SLR approach assist to identify the research areas where more or less research is needed [43]. The SLR technique has been previously used in different other studies for the same nature of projects [22, 30, 35, 38, 45]. According to Kitchenham [15, 16], SLR involves the three key phases (i.e. plan the review, conduct the review and report the extracted results).

All the authors have participated in the SLR and contributed in the three main phases. In this study, the first author has executed the search strings and selected the 20 SLRs by applying the inclusion and exclusion criteria. The second and fourth authors (first author supervisors) have reviewed and reported the 20 SLR studies. The quality assessment process has been carried out by the third and fifth authors. The first author has reviewed and updated the quality assessment score for each selected SLR.

In this study we have considered the SLR studies published between 2004 and 2015. The time range is based on the deployment of SLR approach in the Software Engineering field [26]. We have also conducted the inter-rate reliability analysis in order to improve the review process and neutralize the inter-person bias [44]. The inter-rater reliability analysis results are given in section 3.2.2. The key phases of systematic review are briefly discussed in the following sections.

3.1. Phase 1: Planning the Review

We have developed the SLR protocol in the first phase of this study. First and third authors have participated in the development of the protocol. First author has selected the data sources and developed the search strings based on the research questions. The third author have reported the inclusion/exclusion criteria and the quality criteria for the selected studies. The protocol has been reviewed by the fourth author and updated based on his suggestions.

3.1.1. Research questions: The research questions are discussed in section 1:

3.1.2. Data sources: The selected data sources include:

- **Publisher's Site** publish research studies from their own repositories [17]. The selected publishers' sites are: "Wiley Inter Science", "IEEE Xplore", "Science Direct", "ACM Digital Library", "Business Source Premier" and "Springer Link".
- **Index Engines** consist of the articles reported in other publisher' sites [17]. The selected index engines are: "Inspec", "Cite Seer", "Compendex", "Google Scholar", "ISI Web of Science" and "Scopus".

The data sources were selected on the basis of our previous SLR experience and recommendations suggested by Chen et al. [17].

3.1.3: Search Strings: We used the keywords and their synonyms involved in the research questions to formulate the search strings. The keywords and their alternatives were based on the existing literature in the domain of SPI and GSD [7, 8, 22, 24, 25, 30].

Boolean "OR" and "AND" operators were used to construct the search strings by concatenating the keywords and their synonymous as shown in Table 1:

Table 1 Search Strings

Key Words	Alternatives
Category	("category" OR "classification" OR "grouping" OR "listing")
Factors	("factors" OR "aspects" OR "items" OR "elements" OR "variables")
Software Process Improvement	("Software Process Improvement" OR "SPI" OR "software process enhancement" OR "software process enrichment" OR "software process models" OR "software process standards" OR "software process frameworks" OR "software maturity models")
Global Software Development	("global software development" OR "GSD" OR "global software engineering" OR "distributed software development" OR "software outsourcing" OR "follow the sun approach" OR "Offshore software development")
Client	("client software development organizations" OR "client software development companies" OR "client analysis" OR "client perspective")
Vendor	("vendor software development organizations" OR "vendor software development companies" OR "vendor analysis" OR "vendor perspective")

3.1.4. Inclusion Criteria: Each selected primary study must be written in the English language. The articles must be journal, conferences or book chapters. The main focus was on those studies that have discussed the SPI activities in the domain of GSD. Additionally, we have emphasized on those articles that reported success factors along their categories and the client or vendor nature of the organizations.

3.1.5. Exclusion Criteria: Those studies were excluded which have not discussed the success factors of SPI. We have also excluded the articles that didn't provide the details of SPI standards and models. The duplicated papers and articles written in language other than English were also not considered.

3.1.6. Quality Criteria for studies selection: The quality assessment (QA) and data extraction processes were concurrently performed. We have developed a check list in order evaluate the quality of the selected primary studies. The guidelines provided by [18, 19] were followed in the design of checklist (Table 2).

Table 2 QA assessment check list

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?
QA3	Does the study report the categories in order to classify success factors for SPI in GSD?
QA4	Is the reported results are related to process improvement?
QA5	Do the results have addressed the research questions?

The assessment using the QA criteria was conducted as follows:

- Score=1 "studies which have explicitly answer to the checklist questions".
- Score=0.5" "studies which have partially answer to the checklist questions".
- Score=0 "studies containing no answer to the checklist questions".

3.2. Phase 2: Conducting the review

3.2.1. Primary studies selection:

The search process for the primary studies was conducted from September 2015 to December 2015. In the first phase, we have selected total 972 articles from the reported digital repositories using the given inclusion/exclusion criteria (sections 3.1.4 and 3.1.5 respectively) and search strings step (section 3.1.3). Then, the Tollgate approach [20] was adopted that led to a short list of the 20 remaining articles to consider

as the primary studies. The finally selected primary studies were evaluated against the QA criteria discussed in section 3.1.6.

As can be seen from Table 3, the tollgate approach consists of five phases P-1 to P-5:

- Phase 1 (P-1) "Explore using the search terms".
- Phase 2 (P-2) "Title and abstract based inclusion/exclusion".
- Phase 3 (P-3) "Introduction and conclusion based inclusion/exclusion".
- Phase 4 (P-4) "Full text-based inclusion/exclusion".
- Phase 5 (P-5) "Final list of the articles to be considered as primary studies".

Table 3 Tollgate Approach

Selected Sources	P-1	P-2	P-3	P-4	P-5
Wiley Inter Science	175	96	24	6	4
IEEE Xplore	220	84	31	9	3
Inspec and Compendex	95	25	9	5	0
Science Direct	135	65	27	13	5
Cite Seer	14	8	4	3	0
ACM Digital Library	75	20	12	7	1
Google Scholar	27	23	19	2	2
Springer Link	166	91	36	7	5
ISI Web of Science	30	19	16	9	0
Business Source Premier	35	21	8	4	0
Total	972	452	186	65	20

3.2.2. Data Extraction: The following data has been extracted from each selected primary study: paper title, vendor country, client country and organization size. The selected 20 primary study articles are provided on Appendix 1 and article tagged as (PS) which stands for primary study.

Inter-reliability analysis was performed to unbiased the inter-person selection process. We choose three external reviewers and each reviewer have selected ten papers from the "P-1" of tollgate approach and followed the selection process "P-2- P-5". They have also performed the quality assessment process by following the quality criteria discussed in (section 3.1.6). Kendall's coefficient of concordance (W) [33] statistical test was applied in order to analyses the inter-reliability agreement between the reviewers. 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. Because the calculated value of Kendall's coefficient of concordance was (W=0.80), which is positively close to 1.

3.2.3. Data Synthesis: The authors have extracted and reported the success factors discussed in the selected primary studies. The results extracted from all the selected articles were reported together and all the research questions were evaluated against these results as discussed in the forthcoming sections.

3.3. Phase 3: Reporting the Review

3.3.1. Quality Attributes: Each of the selected primary study assessed against the quality assessment questions discussed in section 3.1.6. The primary studies were assigned score for each QA question (QA1-QA5). We have assigned score 1, if the study explicitly answers to the check list question and score 0.5 if the question is partially answered. Those studies which have not answered the check list questions were assigned 0 points. The final QA score for each primary study was calculated by accumulating the scores for all the QA questions (Table 4).

The selected primary studies provided detail information regarding the process improvement success factors and therefore each article scored ≥50% against the quality assessment criteria (Table4).

Table 4 Quality Assessment scores of selected SLR studies

S. No	QA1	QA2	QA3	QA4	QA5	Final QA Score
PS1	1	0.5	0.5	0	1	3
PS2	0.5	1	0.5	1	0.5	3.5
PS3	0.5	0.5	0	1	0.5	2.5
PS4	0.5	1	0	1	0.5	3
PS5	0.5	0.5	0	1	0.5	2.5
PS6	1	1	0	1	1	4
PS7	1	1	0	1	1	4
PS8	0.5	0.5	0	1	0.5	2.5
PS9	1	0.5	0	1	0.5	3
PS10	1	1	0	1	1	4
PS11	0.5	1	0.5	1	0.5	3.5
PS12	0.5	1	0.5	1	0.5	3.5
PS13	1	1	0.5	1	1	4.5
PS14	0.5	1	0.5	1	0.5	3.5
PS15	0.5	1	0.5	1	1	4
PS16	0.5	0.5	0	1	0.5	2.5
PS17	1	1	0	1	1	4
PS18	1	0.5	0	0.5	1	3
PS19	1	0.5	0	0.5	1	3
PS20	1	1	0.5	1	0.5	4

3.3.2. Research Methods: The selected primary studies include six case studies, two mixed methods, two action research, five interviews and five questionnaire surveys. As can be seen from Figure 1, the research methods employed in the 20 SLR articles are distributed as follows: case study (CS) 30%, interview (IN) 25%, questionnaire survey (QS) 25%, mixed methods (MM) 10% and action research (AR) 10%.

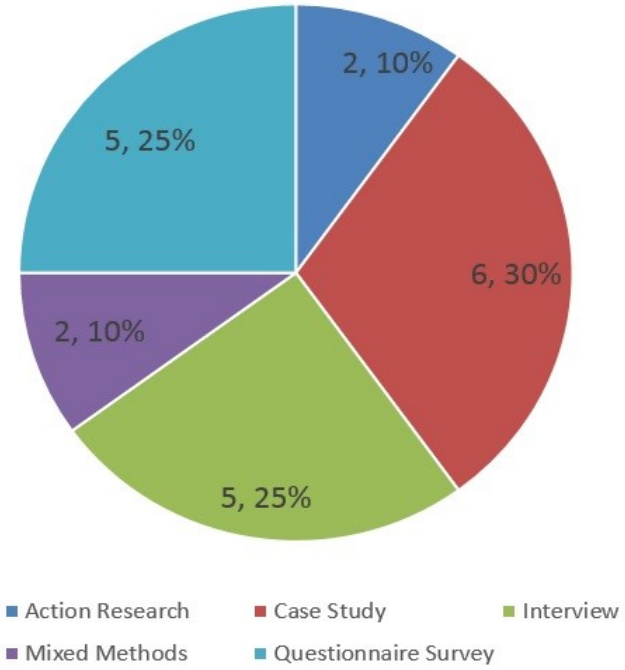

Fig. 1. *Research Methods of selected studies*

Figure 2 shows the frequency analysis of the primary studies based on the publication years and adopted research methodology. From year 1998-2003, 71% of the studies adopted case study research approach. Since 2003, there was a gradual increase in interview and questionnaire survey research methods. It shows that presently majority of the research studies are adopting survey techniques and interview approaches to conduct empirical studies related to SPI.

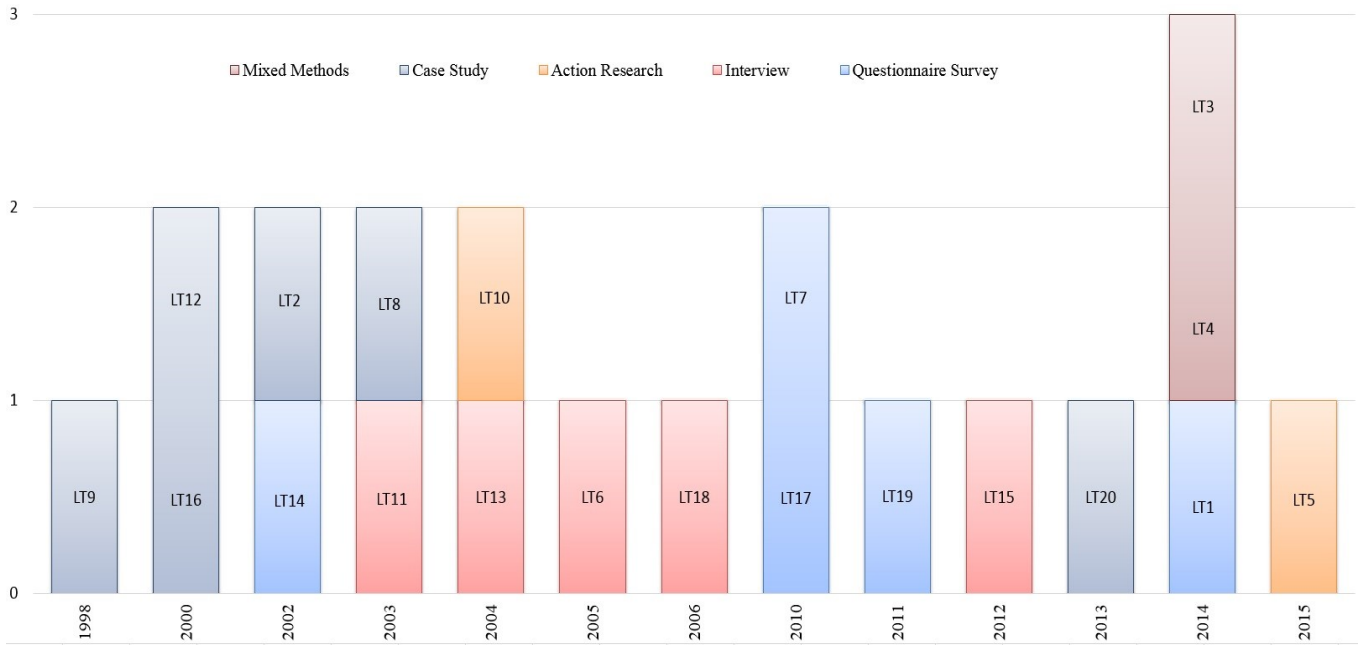

Fig.2. *Summary of the attributes of selected studies (year, frequency, research method)*

3.3.3. Publications Type: Figure 3 shows the distribution of the 20 SLR articles between journals or conferences as given in Appendix 1. Five articles (25%) were published in "*Journal of Software Process: Improvement and Practice*(SPIP)" which demonstrate that SPIP is the most common and active Journal to publish articles related to the success factors of SPI programs. Three articles (15%) were published in "*Information and Software Technology* (IST)" which indicated that IST is the second most influential journal. The rest of the SLR studies were fairly scattered among other journals and conferences. In the selected studies, "*Product-Focused Software Process Improvement* (PROFES)" is the most common conference, which has published (10%) of selected articles.

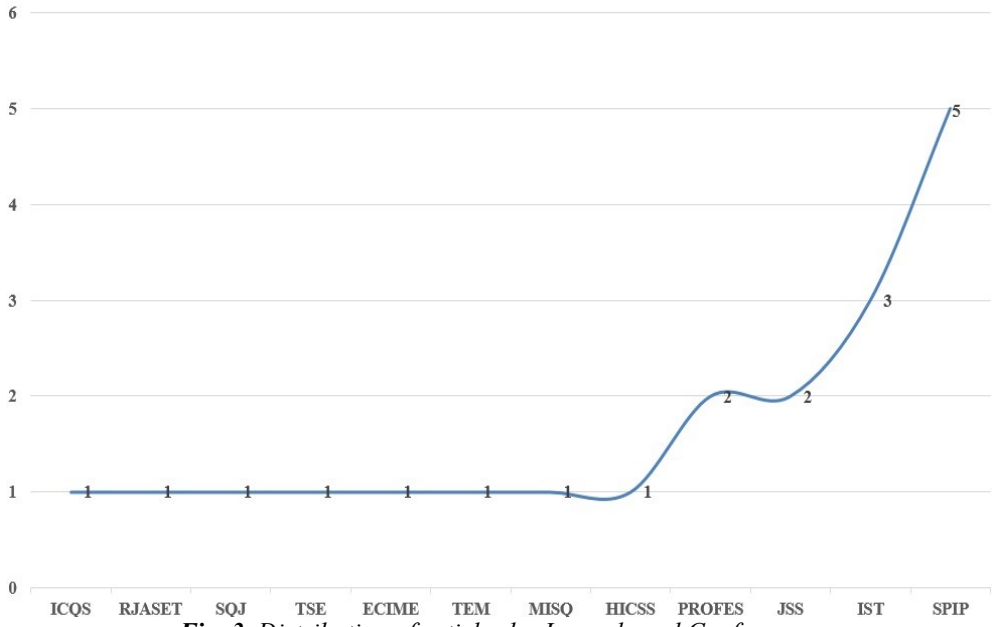

Fig. 3. *Distribution of articles by Journals and Conferences*

4. FINDINGS

The concept of the framework developed by Ramasubbu [9] has been used to classify the reported factors in different categorize. Ramasubbu [9] developed the framework to classify the issues of process improvement in the domain of GSD. He has organized the SPI activities in six different categories i.e. ("project administration, coordination, software methodology, human resources management, knowledge integration, and technology factors"). Due to the similar nature of this study to the Ramasubbu [9] framework, we have mapped the factors into the given six categories. The mapping process was informally done by all the authors and mapped each factor to a specific category based on their research experience and understanding. The same concept of categorization has been adopted in our previously published article [44].

In order to answer RQ1, the success factors and their respective categories are exhibited in Table 5, Figure 4 and briefly discussed thereafter.

4.1. SF1: "Management Commitment"

The existing literature have emphasised on the significance of top management support for process improvement programs [PS2]. Sulayman et al [PS3] define management commitment as "the degree to which the higher and lower level management in an organization financially support, realize and are involved in SPI activities". Hall et al [PS2] conducted an empirical study and highlighted the significance of top management commitment. They have particularly mentioned that when the organization have replaced the committed project manager with the one having low project interest than the previous process improvement effort was lost.

4.2. SF2: "Staff Involvement"

Staff involvement is the extent to which the team members contribute in the execution of the SPI activities [PS3]. Bayona et al [PS4] highlighted that it is important to involve the SPI practitioners during the process improvement initiation which could make them feel as part of the team. Ramasubbu [PS5] conducted an empirical study and analysed that the participation of the team members in process improvement program reduces the resistance to the implementation of new practices.

4.3. SF3: "Strong Relationship"

Strong relationship is the degree to which the team members in distributed environment could communicate and collaborate in order to execute the process improvement activities [PS6]. Strong relationship is a key factor to plan, initiate and implement the process improvement programs [PS17]. Furthermore, it guides to properly manage the team members, associated risks and staff coordination [PS17].

4.4. SF4: "Information Sharing"

Sulayman et al [PS3] define information sharing as "the degree to which the distributed team members coordinate and communicate to share the information involve in process improvement program". Ramasubbu [PS5] discussed that explicit information sharing among the team members working in GSD environment could assist in appropriate execution of the SPI activities. The team members can properly participate in the SPI program based on the knowledge sharing, information management and partnership [PS7].

4.5. SF5: "SPI Expertise"

Bayona et al [PS4] define SPI expertise as the "extent to which individuals can achieve specific SPI goals". Particularly, if the SPI team members have appropriate

expertise, skills and awareness then the chance of process improvement success and adoption is high.

Additionally, for the successful execution of process improvement program, it is mandatory that the organizational management have deep knowledge and understanding of SPI activities [PS20]. Otherwise, the organization might end the SPI program with frustration and failure [PS4].

4.6. SF6: "Roles and Responsibilities"

Bayona et al [PS4] highlighted the significance of roles and responsibilities by suggesting to assign right role and responsibility to right person. The roles and responsibilities of each team member should be clearly define in order to avoid confusion and misunderstanding during the execution of process improvement activities [PS4].

4.7. SF7: "SPI Leadership"

Hall et al [PS2] conducted an industrial empirical study and discussed that majority of the respondents highlighted the significance of top management leadership. They mentioned that for the successful execution of process improvement program, it is vital that the team management have proper leadership skills [PS2]. The organizational management should have the capabilities to encourage and support the team members in order to accomplish their goals [PS4].

4.8. SF8: "SPI Awareness"

Sulayman et al [PS3] explained SPI awareness as "the degree to which the top management takes the initiatives of SPI certification and provides training opportunities to the team members". Implementation of process improvement program is the practice of deployment of new techniques and procedures in an organization [PS6]. It is significant to conduct process improvement awareness workshops and seminars related to implementation of SPI activities.

4.9. SF9: "Communication"

Khan et al [PS1] define communication as "the process of knowledge transmission between the distributed team members and the mode of transfer they adopt to enhance this interaction". Strong communication channels make easy the job of coordination and control in GSD [PS2]. Proper communication across the distributed team members assist to effectively manage the process improvement activities [PS4].

4.10. SF10: "Resources allocation"

The significance and the possible problems related to the allocation of resources are discussed in [PS2]. Every process improvement project requires human resources, time, documentation, project planning, techniques and efficient budget estimation [PS6]. Organizations must commit for resource allocation [PS14], and long-term benefits of SPI programs require the proper allocation of all the required resources [PS17].

4.11. SF11: "Organizational Culture"

According to Khan et al [PS1], organizational culture is widely affected by the discussions of different people on certain issues and their reaction. It is vital to understand the organizational norms and values before the initiation of SPI program [PS4]. Cultural difference should be considered when the organization shows an intention towards the initiation of SPI implementation [PS4].

4.12. SF12: "Organizational Infrastructure"

Top management should show strong commitment towards the provision of resources and technological infrastructure as both a well etablish infrastructure and a stable environment are required for the effective implementation of process improvement activities [PS4].

4.13. SF13: "Setting SPI Goals"

Sulayman et al [PS3] define "setting SPI 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 SPI programs [PS19]. Setting realistic goals means that they might be achieve in the future by having the enough resources. As the implementation of SPI programs is expensive and spreads over time, it is important to clearly define the SPI goals and objectives [PS9].

4.14. SF14: "Pilot Implementation"

The pilot implementation of SPI program is necessary to evaluate how successful a given SPI program would be in a particular department. Both Kautz et al [PS12] and Niazi et al [PS13] emphasized on the significance of pilot implementation for team members in order to assess their skills and expertise regarding SPI. 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 [PS11].

4.15. SF15: "Evaluation"

Management should assess the SPI process in order to differentiate the proposed outcomes and those obtained after SPI implementation [PS2]. The performance of SPI implementations relies on the accurate estimation of quality, time and budget [PS20].

Table 5 Success factors (IDs, labels) sorted by categories

ID	Label	Frequency
	Category: Project Administration	
SF1	Management commitment	16
SF2	Staff involvement	14
SF10	Resources allocation	13
SF11	Organizational culture	10
	Category: Coordination	
SF3	Strong relationship	9
SF4	Information sharing	8
SF9	Communication	15
	Category: Human Resources Management	
SF5	SPI expertise	6
SF6	Roles and responsibilities	11
SF7	SPI leadership	10
	Category: Knowledge Integration	
SF8	SPI awareness	7
SF13	Setting SPI goals	8
	Category: Software Methodology	
SF14	Pilot implementation	4
SF15	Evaluation	5
	Category: Technology Factors	
SF12	Organizational infrastructure	4

Fig. 4. *Frequency analysis of identified factors*

5. Client-vendor based classification of the identified success factors

In order to answer RQ1.1, the client-vendor organizations were classified by reviewing the origin of each selected primary study. Total ten primary studies were conducted in client countries and ten in vendor countries as shown in Figure 5.

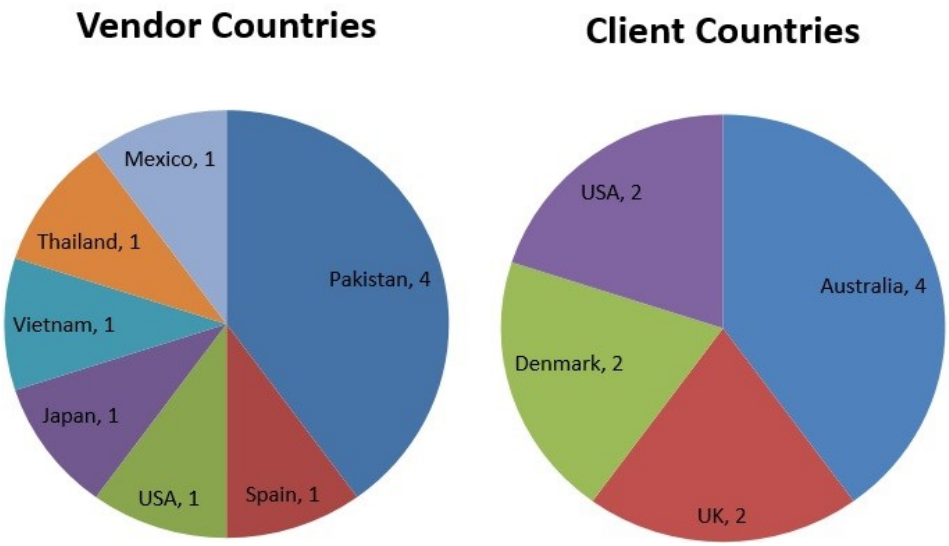

Fig. 5. *Country wise Classification of Client-Vendor Organizations*

Verner et al. [11] and Khan et al. [44] observed that in the available literature, most of the researchers focused on vendor organizations instead of client organizations. Therefore, we have adopted the frequency analysis technique which could use to compare the variables in the same group or across other groups [23]. The Fisher Exact test was applied in order to calculate the significance difference between the client and vendor organizations. The Fisher Exact test is appropriate for small sample size [14], that assist us to statistically evaluate the identified success factors reported in the 20 primary studies (Table 6) [14].

The results and analysis provided in Table 6 shows that the identified success factors have more similarities than differences in the domain of client-vendor organizations. As can be seen, *management commitment* (80% *versus* 80%), *communication* (80% *versus* 70%), *organizational culture* (60% *versus* 40%) and *SPI awareness* (30% *versus* 40%) are the most common success factors in both vendor and client organizations.

It is interesting to see that both vendor and client organizations consider *management commitment* as the most important success factor. This may be due to the fact that SPI is a long-standing approach and need proper top management commitment. Sulayman [24] conducted an empirical study and found that organizational management should assist the SPI teams in the development of SPI culture and take interest in process improvement activities. The second most important factor is *communication*. As can be seen from Figure 5, most of the vendor organizations are located in Asia, whereas client organizations spread across the West. Because of this difference, both client and vendor organizations face communication problems such as limited coordination, confusion among the distributed teams and delayed feedback on work products. As a consequence, messages are misinterpreted by team members, which lead towards the confusion between the client and vendor organizations [34]. Therefore, both vendor and client organizations consider *communication* as the second most important success factor for SPI implementation in GSD environment.

Table 6 Client-Vendor classification of identified success factors

Success Factors	**Vendor (n=10)**		**Client (n=10)**		**Fisher Exact Test α = 0.05**
	Frq.	**%**	**Frq.**	**%**	
Management Commitment	8	80	8	80	0.333
Staff Involvement	5	50	9	90	0.074
Strong Relationship	7	70	2	20	0.203
Information Sharing	6	60	2	20	0.380
SPI Expertise	3	30	3	30	0.178
Roles and Responsibilities	3	30	8	80	0.387
SPI leadership	**3**	**30**	**7**	**70**	**0.027**
SPI Awareness	3	30	4	40	0.376
Communication	8	80	7	70	0.648
Resources Allocation	**5**	**50**	**8**	**80**	**0.031**
Organizational Culture	6	60	4	40	1.000
Organizational Infrastructure	4	40	0	0	0.115
Setting SPI Goals	3	30	5	50	0.187
Pilot Implementation	4	40	0	0	0.115
Evaluation	4	40	1	10	0.360

The difference between client and vendor organizations is significant ($p < 0.05$) for two success factors: *SPI leadership* and *resources allocation* (Table 6). These factors get more attention in client organizations. Specifically, more client organizations than vendor (70% *versus* 30%, respectively) are aware of the importance of *SPI leadership*.

This result can be interpreted as most of the client organizations are located in the developed countries which emphasized on the criticality of *SPI leadership*. Similarly, more client organizations than vendor (80% *versus* 50%, respectively) are aware of the importance of *resource allocation*. This result suggests that majority of client organizations are financially stable, mature and consider *resources allocation* as important enough to formally execute the SPI program as a complete and robust project.

5.1. Critical Success Factors (CSFs)

The identified success factors were analysed and extracted the most critical factors. Those factors were considered as critical which have frequency ≥ 50% and the same criteria has been adopted in different other research studies [35, 36, 37, 38]. Total five factors: *management commitment*, *staff involvement*, *roles and responsibilities*, *communication* and *resources allocation* were rated as the most critical. These five factors are ranked as critical because their calculated frequency is ≥ 50% of all the other identified factors in both client and vendor organizations as shown in Figure 4.

6. Organizational Size based Comparison of Success factors

In order to address RQ3, the selected 20 SLR studies were classified according to the organization size (Table 7). As the data were of ordinal nature, therefore we used linear by linear association chi-square test in order to check any statistical difference between the success factors for specific type of organization [22, 23]. The linear by linear association chi-square test is ideal for ordinal type of variables and it is more influential than Pearson x^2 test [23, 35].

We have formulated the following hypotheses in order to measure the significant difference among the identified success factors based on different organization size.

- Null hypothesis (H0): the reported success factors have no statistical differences in the context of organization size.
- Alternative hypothesis (H1): the reported success factors have statistical differences in the context of organizational size.

The results of using the selected statistical test for comparison among the success factors are reported in Table 7. It is shown in the Table 7 that there are no statistical differences between the identified success factors in the context of organization size (small, medium, large). Therefore, the null hypothesis (H0) is accepted and rejected the alternate hypothesis (H1).

The results and analysis given in Table 7 demonstrate that *SF1 (management commitment, 71%)* has been mentioned as the most common factor for small size organizations. The commitment and involvement of the organizational management are vital in order to successfully execute the process improvement activities [SF5]. It is important for the top management to financially support, contribute and participate in the SPI activities [SF3]. For medium size organizations, the most common mentioned success factor is *SF9 (communication, 100%)*. It highlighted that due to lack of sufficient resources, the medium size organizations are not capable of establishing the technically rich infrastructure that could support the communication and coordination activities [SF1]. Majority of the small and medium size organizations adopt informal practices and methods to communicate and the main reason behind the adoption of informal techniques is the lack of sufficient resources [SF1]. *SF6 (roles and responsibilities, 66%)* has been considered as the most significant factor in the large organizations. It might be due to the reason that majority of the large size organizations are well established and follow formal processes; therefore, they consider success factor *SF6 (roles and responsibilities)* vital to formally execute the SPI activities across the organization.

Table 7 Factors classification based on Organization Size

Selected SLR studies types (N=20)				**X^2Test (linear-by-linear association) α = 0.05**		
Success Factors S. No	**Small (N= 7, 35 %)**	**Medium (N= 7, 35%)**	**Large (N=6, 30%)**	$X^2 = \sum_{i=1}^{n} \frac{(Oi - Ei)^2}{Ei}$	**Df**	**P**
SF1	5	6	3	0.590	1	0.442
SF2	4	6	3	0.040	1	0.842
SF3	4	2	1	2.264	1	0.132
SF4	0	3	2	1.981	1	0.159
SF5	3	1	2	0.171	1	0.679
SF6	2	5	4	0.660	1	0.416
SF7	2	5	3	0.660	1	0.416
SF8	2	4	1	0.136	1	0.712
SF9	4	7	3	0.031	1	0.859
SF10	4	5	3	0.049	1	0.825

SF11	4	6	0	3.595	1	0.058
SF12	2	2	0	1.486	1	0.223
SF13	2	4	2	0.049	1	0.825
SF14	3	1	0	3.595	1	0.583
SF15	3	2	0	2.959	1	0.085

N= Number of studies

In addition, it is shown in Table 7 that different other factors i.e. *SF2 (staff involvement, 57%), SF3 (strong relationship, 57%), SF9 (communication, 57%), SF10 (resources allocation, 57%)* and *SF11 (organizational culture, 57%)* are considered as the key success factors in small organizations. Similarly, other significant factors mentioned for medium size organizations are *SF1 (management commitment, 85%), SF2 (staff involvement, 85%)* and *SF11 (organizational culture, 85%)*. The other common factors for large size organizations are: *SF1 (management commitment), 50%), SF2 (staff involvement, 50%), SF7 (SPI leadership, 50%), SF9 (communication, 50%)* and *SF10 (resources allocation, 50%)*. This suggests that the above factors are the backbone of small, medium and large size organizations.

7. Discussion

Using the SLR technique, a total of 20 research articles were selected for this study to support the research questions. In order to answer RQ1, total fifteen success factors were identified which are further classified into six categories. The categories and their respective success factors are discussed in section 4. The project administration category has total four success factors: *management commitment, staff involvement, resources allocation* and *organizational culture*. Likewise, coordination category consists of three success factors that could positively impact the process improvement program. These factors are: *strong relationship, information sharing* and *communication*. The human resources category involves the success factors: *SPI expertise, roles* and *responsibilities and SPI leadership*. The next category is knowledge integration which has two success factors i.e. *SPI awareness* and *setting SPI goals*. The category of software methodology contains the success factors *pilot implementation* and *evaluation.* The last category is technology factors which consist of a single success factor i.e. *organizational infrastructure* (Table 8). These categories present some of the crucial areas, requiring further research attention.

In order to address RQ1.1, the results revealed that *management commitment (80% versus 80%)* and *communication (80% versus 70%)* are the most common factors in both vendor and client organizations respectively as shown in Table 6. The difference between client and vendor organizations was significant ($p<0.05$) for the following two success factors: *SPI leadership* and *resources allocation*. It is important to note that most of the client organizations (70%) focused on the importance of leadership for SPI teams as compared to vendor organizations (25%). It is worth mentioning that these results are consistent with previous work [9] regarding SPI
leadership. We found second significant difference between client and vendor organizations for *resources allocation*. It is important to notice that client organizations (80%) are aware of the significance of *resources allocation* than vendor organizations (50%). The lack of sufficient resources can undermine the successful execution of the SPI program in a distributed environment [10, 25].

To answer RQ2, total 15 success factors were extracted from the selected 20 primary studies. To analyse the importance of a particular factor, we have adopted the criteria of the factors having a frequency ≥ 50% as critical. By using the above criteria, five CSFs were identified: *management commitment, staff involvement, roles and responsibilities, communication* and *resources allocation*. The identified CSFs present the key areas where the SPI teams should give sufficient attention to achieve the specific objectives. The identified CSFs have more influence on process improvement programs as compared to the other identified success factors. The summary of the CSFs is provided in Table 8.

Table 8 Summary of findings

Research Question	Results
RQ1: What are the key categories to classify success factors for SPI programs in GSD?	• Project Administration • Coordination • Human Resources Management • Knowledge Integration • Software Methodology • Technology Factors
RQ1.1: Are the identified success factors related to client or vendor organizations?	• 'Management commitment' (80%, and 80%) and 'Communication' (80%, and 70%) are the most common factors in both vendor and client organizations respectively. • We have identified significant differences for two factors (i.e., SPI leadership, resources allocation) between the client and vendor organizations.
RQ2: What are the Critical Success Factors (CSFs) in each identified category?	• Project Administration (Management commitment, staff involvement, Resources Allocation) • Human Resources Management (Roles and Responsibilities) • Coordination (Communication)
RQ3: Do the identified success factors differ in the domain of organization size?	• We have not identified any significant differences between the success factors for organization size.

The key objective of RQ3 is to statistically investigate the significant differences among the identified success factors in the context of organization size [22, 23]. The main

reason behind the organization size-based comparison is because the success factors that have an impact on process improvement program in any specific type of organization should be seriously considered by that organization [10, 22, 38]. Finally, there was no statistical differences identified among the success factors in the domain of organization size. In addition, *management commitment*, *staff involvement* and *communication* were highly cited in all type of organizations. It shows that these three factors are equally critical for SPI team members working in different size organizations. The management of GSD organizations should show strong commitment to the SPI implementation and properly equip the SPI teams with different techniques and methods in order to successfully communicate and execute the process improvement activities.

7.1. Threats to Validity

The selected studies might not have reported the primary causes of the identified success factors and it could be a possible internal validity threat. The mitigation of this threat is challenging for us because the origin of the success factors was not formally identified in the selected primary studies.

One possible threat is that the sample size (N=20) of the selected primary studies is small and it might impact our results related to RQ1.1. However, we are certain that use of the selected statistical test (i.e. Fisher exact test) gives the satisfactory results as it is considered to be appropriate for any type of small sample size.

The authors of the selected primary studies might not have detail knowledge and understanding of the current trends of process improvement in GSD environment because majority of them are from academia. We will mitigate this treat by conducting industrial study in order to empirically validate the success factors.

We have addressed RQ1 by categorising the success factors based on the framework developed by Ramasubbu [9]. The categorization process was informally done by the authors. We were not able to formally validate the categorization process. However, all of the authors were involved in the informal mapping process.

In addition, there are numerous primary studies conducted for SPI and its possible that we might miss some related articles. However, this is not a systematic omission as in other published SLRs [21].

7.2. Research and Practical Implications

This SLR study reported a set of success factors classified in different categories which provides a conceptual framework for researchers as well industry practitioners. This study contributes to the academic research by providing a thorough overview of the existing literature in the domain of process improvement and GSD.

On the other hand, it provides relevant information to both client and vendor organizations about the success factors that play a significant role to efficiently execute the SPI activities in GSD context. Furthermore, the reported success factors in this study can assist the practitioners working in both the domain of client and vendor organizations to consider the critical success factors while taking SPI initiatives in GSD projects. In conclusion, this paper provided a consolidated knowledge-base of literature which has not been done before.

7.3. Future Work

The results and analysis discussed in this study could be used in relation to SPI and GSD. Five research avenues worthy of further investigation were identified.

- To validate the identified success factors and their categories in an industrial empirical study.
- To identify additional categories of success factors by conducting empirical study in GSD industry.
- To identify the best practices in order to address the reported success factors.
- To report the barriers that could hinder the implementation of process improvement program in GSD.
- To investigate the SPI standard and models adopted by the GSD organizations to address SPI challenges.
- To extend this study by considering the SLR studies published after 2015.

The ultimate objective of this study is to develop a model that could assist the GSD organizations to successfully execute the SPI activities. This model will help the practitioners to assess their existing capabilities of SPI implementation and provide the best practices for further improvement. The results highlighted is this study will contribute to the factors component of the proposed model. We believe that this research work could assist the researchers and practitioners to develop novel SPI practices in the context of GSD.

8. Conclusions

In this research work, the SLR research technique was followed in order to identify the success factors of SPI and their categories in the domain of GSD. Overall, 20 research articles were selected that have discussed the success factors of process improvement program.

Using SLR, fifteen success factors were identified and categorized into six main categories i.e. (“project administration, coordination, software methodology, human resources management, knowledge integration, and technology factors”) [9]. The framework proposed by Ramasubbu [9] and SLR technique [15, 16] gives an opportunity to categorize the identified success factors and rank the critical success factors for SPI activities. The reported categories and their success factors can act as a guide for GSD firms to consider in process improvement implementation program.

We classified the identified fifteen success factors on the basis of client-vendor organizations. The results show that based on client-vendor classification, the identified success factors have more similarities than differences. The aim of client-vendor classification is to provide a broad picture of the success factors of SPI programs that can assist process improvement activities in both client and vendor GSD organizations [44]. The identified factors should be considered by both client and vendor organizations in order to effectively execute the process improvement activities [44].

Total five factors were rated as CSFs for both client and vendor organizations. The identified CSFs are: management commitment, staff involvement, roles and responsibilities, communication and resources allocation.

The identified CSFs allow SPI teams to focus on the key process improvement areas in order to efficiently manage SPI activities. These factors represent key areas and both client and vendor organizations should have complete understanding of identified CSFs in order to successfully execute the SPI activities [30].

We also compared the identified success factors according to the organization size where the research took place. The aim of organizational size-based comparison was to provide adequate information regarding the identified success factors in the domain of organization size. We have not found any differences between the identified factors based on the organization size. Most of the articles have equally cited the success factors in the domain of small, medium and large size organizations.

The outcomes of this research work are a preliminary step towards the development of a taxonomy for the classification of success factors into categories in GSD context. We are confident that the results presented in this research study could possibly tackle the challenges related to the process improvement implementation, which is crucial for the success and progression of GSD firms.

9. References

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10. Appendix 1

See Table 9

Table 9: List of Selected primary studies using SLR

Primary Study	References
[PS1]	"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)" (Vendor Country: Pakistan; Client Country: Not mentioned, Size: Small)
[PS2]	"Hall, T., Rainer, A., Baddoo, N.: Implementing software process improvement: an empirical study. Software Process Improvement and Practice 7(1): 3-15 (2002)" (Vendor Country: Not mentioned; Client Country: UK, Size: Small)
[PS3]	"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)" (Vendor Country: Pakistan; Client Country: Not mentioned, Size: Small)
[PS4]	"Bayona-Oré, S., Calvo-Manzano, J. A., Cuevas, G., San-Feliu, T.: Critical success factors taxonomy for software process deployment. Software Quality Journal, vol. 22, pp. 21-48, (2014)" (Vendor Country: Spain; Client Country: Not mentioned, Size: Medium)
[PS5]	"Ramasubbu, N.: Governing Software Process Improvements in Globally Distributed Product Development. IEEE Transactions on Software Engineering, vol. 40, pp. 235-250 (2014)" (Vendor Country: USA; Client Country: Not mentioned, Size: Large)
[PS6]	"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)" (Vendor Country: Not mentioned; Client Country: Australia, Size: Large)
[PS7]	"Khan, U. S., Niazi, M., Ahmad, R.: Critical Success Factors for Offshore Software Development Outsourcing Vendors: An Empirical Study. Product-Focused Software Process Improvement, pp. 146-160 (2010)" (Vendor Country: Pakistan; Client Country: Not mentioned, Size: Medium)
[PS8]	"Ngwenyama O., Nielsen, P. A.: 'Competing values in software process improvement: an assumption analysis of CMM from an organizational culture perspective, IEEE Transactions on Engineering Management, vol. 50, pp. 100-112, (2003)" (Vendor Country: Not mentioned; Client Country: USA, Size: Large)
[PS9]	"Stelzer, D., Mellis. W.: Success factors of organizational change in software process improvement, Software Process: Improvement and Practice Vol. 4 (4), 227-250, (1998)" (Vendor Country: Not mentioned; Client Country: Germany, Size: Medium)
[PS10]	"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)" (Vendor Country: Not mentioned; Client Country: Denmark, Size: Large)
[PS11]	"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)" (Vendor Country: Not mentioned; Client Country: Australia, Size: Medium)
[PS12]	"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)" (Vendor Country: Not mentioned; Client Country: Denmark, Size: Small)
[PS13]	"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)" (Vendor Country: Not mentioned; Client Country: Australia, Size: Medium)
[PS14]	"Rainer, A., Hall, T.: Key success factors for implementing software process improvement: a maturity-based analysis. Journal of systems and software, Vol. 62(2), pp.71-84 (2002)" (Vendor Country: Not mentioned; Client Country: UK, Size: Large)
[PS15]	"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)" (Vendor Country: Pakistan; Client Country: Not mentioned, Size: Small)
[PS16]	"Komiyama, T., Sunazuka, T., Koyama, S.: Software process assessment and improvement in NEC–current status and future direction. Software Process: Improvement and Practice, Vol. 5 (1), pp.31-43. (2000)" (Vendor Country: Japan; Client Country: Not mentioned, Size: Large)
[PS17]	"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)" (Vendor Country: Vietnam; Client Country: Not mentioned, Size: Medium)
[PS18]	"Niazi, M., Wilson, D., Zowghi, D.: Critical success factors for software process improvement implementation: an empirical study. Software Process: Improvement and Practice, Vol. 11 (2). pp 193-211, (2006)" (Vendor Country: Not mentioned; Client Country: Australia, Size: Medium)

Table 9 Continued

Primary Study	References
[PS19]	"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)" (Vendor Country: Thailand; Client Country: Not mentioned, Size: Small)
[PS20]	"Espinosa. C., Edrein, I., Rodríguez-Jacobo, L., Fernández-Zepeda. A. J.: A framework for evaluation and control of the factors that influence the software process improvement in small organizations. Journal of software: Evolution and Process, Vol (25) 4, 393-406, (2013)" (Vendor Country: Mexico; Client Country: Not mentioned, Size: Small)