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Systematic review

Systematic review of organizational motivations for adopting CMM-based SPI

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Abstract

Background: Software Process Improvement (SPI) is intended to improve software engineering, but can only be effective if used. To improve SPI's uptake, we should understand why organizations adopt SPI. CMM-based SPI approaches are widely known and studied. *Objective:* We investigated why organizations adopt CMM-based SPI approaches, and how these motivations relate to organizations' size. *Method:* We performed a systematic review, examining reasons reported in more than forty primary studies. *Results:* Reasons usually related to product quality and project performance, and less commonly, to process. Organizations reported customer reasons infrequently and employee reasons very rarely. We could not show that reasons related to size. *Conclusion:* Despite its origins in helping to address customer-related issues for the USAF, CMM-based SPI has mostly been adopted to help organizations improve project performance and product quality issues. This reinforces a view that the goal of SPI is not to improve process per se, but instead to provide business benefits.

Keywords: CMM; CMMI; Capability Maturity Model; Software Process Improvement

1. Introduction

Software engineering researchers seek to improve the practice of software engineering. Software Process Improvement (SPI) approaches are intended to improve the practice of software engineering, but they can only be effective if they are used. To improve SPI, we should understand why organizations decide to adopt existing SPI approaches. This knowledge will help us to develop new or improved SPI approaches whose adoption will better match organizations' objectives.

CMM (Capability Maturity Model) is a long-standing, influential and often-studied approach to SPI. CMM, its successors (e.g., SW-CMM, CMMI), and other related models (e.g., SPICE/ISO 15504) describe practices and goals for software development process areas, and have frameworks for measuring the compliance of organizations with the goals and practices in these process areas. However, there have been concerns raised about its suitability for some organisations, especially Small and Medium Enterprises (SMEs). As part of a larger project about the adoption of CMMI by SMEs, we have previously reported on a study of why SMEs do not adopt CMMI [23]. To complement that study, we have also conducted a systematic review to investigate organizational motivations for adopting CMM-based SPI, which we describe in this paper.

A systematic review is a defined and methodical way of identifying, assessing, and analysing published primary studies in order to investigate a specific research question

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[13,22]. Systematic reviews differ from ordinary literature surveys in being formally planned and methodically executed. They are intended to be independently replicable, and so have a different type of scientific value than ordinary literature surveys. In finding, evaluating, and summarising all available evidence on a specific research question, a systematic review may provide a greater level of validity in its findings than might be possible in any one of the studies surveyed in the systematic review.

In this paper, we address the following research question: *Why do organizations embark on CMM-based SPI initiatives?* That is, what types of benefits are most frequently sought by organizations embarking on CMM-based SPI initiatives? We investigated these underlying motivations by examining the reasons or objectives most frequently reported by organizations for adopting CMM-based SPI. We have also tried to determine if motivations for adoption are related to the size of these organizations.

The nature and scope of our research question can be clarified by considering some alternative research questions [22] that we have not addressed in this study. These distinctions have proved important in defining inclusion criteria in our systematic review, as discussed in Section 2.1 below. We are not addressing the question: *What motivates individuals to support the adoption of CMM-based SPI in an organization?* The personal motivations of individuals have been studied by others [1]. We are also not addressing the question: *Why should organizations embark on CMM-based SPI initiatives?* In analysing the actual reasons reported for organizations, we are seeking descriptive, not normative, information about motivation. We are not addressing the question: *What reasons for embarking on CMM-based SPI are the most important to organizations?* Given the nature and quality of the publications we have analysed, we could only investigate the frequency of reported reasons. Frequency bears on the issue of importance, but does not completely answer it. We discuss this further in Sections 3.1 and 4.1.

This paper is organised as follows. In Section 2 we describe our research method. In Section 3 the results are presented. Section 4 discusses those results. The paper is concluded in Section 5.

2. Research method

This section describes the course of each step in the methodology used to carry out this systematic review study. A systematic review is a defined and methodical way to summarise the empirical evidence concerning a treatment or technology, to identify missing areas in current research or to provide background in order to justify new research. We followed Kitchenham's guidelines [13] for systematic reviews. In a separate paper [22], we have described our experiences using Kitchenham's guidelines.

A systematic review protocol was written to describe the plan for the review, and this protocol is described in detail in a technical report [18]. The major steps in our study were:

- Determine the search strategy (data sources and their search terms), then perform the search for relevant studies.
- Perform an initial selection of studies from all search results, based on information in titles and abstracts, then perform a final selection of studies from the initially selected studies, based on information in the bodies of the papers.
- Extract data and perform a quality assessment of the studies.
- Analyse the extracted data.

Details on the course of these steps are described in the following subsections.

2.1. Search strategy, and search

The search strategy for a systematic review is a plan for a search to identify and retrieve the smallest possible superset of publications that meet the eligibility criteria of the systematic review. Our selection criteria were: papers that contained an explicit statement that an organization had specific prior motivation(s) leading to their adoption of CMM-based SPI. We excluded papers that only provided expert opinion or anecdotes. As mentioned in the introduction we did not include papers solely because they contained a statement about possible or actual benefits of CMM-based SPI. Neither did we include papers solely because they reported that individual practioners within an organization had specific motivations for CMM-based SPI.

An initial scoping study was conducted to determine the resources to be searched, and the search terms to use for each resource. The searches were full-text searches, and the results included papers where the search terms occurred only in the body of the paper and not in the title or abstract. The scoping study used an initial list of resources, and an initial uniform search term. These were incrementally modified during the scoping study. Different resources required different concrete syntax for the search terms. Also, for general science resources we added a term "capability maturity" to limit the large number of publications returned from outside the software engineering field. In the scoping study, some papers that were already known to be relevant were used to check the inclusiveness of the search terms. The resources searched in the scoping study include databases, specific journals, and conference proceedings. In order to partly address selection bias, we also searched for "grey literature" (e.g., technical reports) from the website of SEI, the creators of CMM and CMMI. The final list of sources searched, their search terms, and the number of publications found for each resource (when conducted in early 2005) are listed in Table 1.

When we performed the search, we identified 591 publications (after removing duplicates). The search results were manually archived to a local computer in a tabular word processing document using the format shown in Table 2. Electronic versions of all publications were also stored by

Table 1
Data sources and search strategy

Resource	Search term	Number of publications
All Science Direct – all sources after 1989	(CMM OR CMMI) AND "capability maturity"	121
SpringerLink	(CMM OR CMMI)	9
Journal of Software Process Improvement and Practice	(CMM OR CMMI)	36
Empirical Software Engineering Journal	(CMM OR CMMI)	12
IEEE Xplore (IEEE Periodicals)	(CMM ⟨OR⟩ CMMI)⟨AND⟩ 'capability maturity'	26
IEEE Xplore (IEEE Conferences)	(CMM ⟨OR⟩ CMMI) ⟨AND⟩ 'capability maturity'	85
ACM Portal	(CMM OR CMMI) AND "capability maturity" -publisher:IEEE	200
ACM TOSEM	(CMM OR CMMI)	9
SEI PDF Documents (searched using Google)	(CMM OR CMMI) AND "capability maturity" -"people capability" site:sei.cmu.edu filetype:pdf	134
Other known published/unpublished papers		2
Total		634

Table 2
Template for search archive index

ID	Publication	Initial selection decision	Final selection decision
Resource = *resource name*			
Search Term = *search term*			
1	Title *Journal Title, Volume X, Issue Y1, Date, Pages N-M*Authors		

title in a file system directory for easy access during the systematic review.

2.2. Paper selection

The planned selection process had two parts: an initial selection from the search results of papers that could plausibly satisfy the selection criteria, based on a reading of the title and abstract of the papers; followed by a final selection from the initially selected list of papers that satisfy the selection criteria, based on a reading of the entire papers. To reduce potential bias, we performed the selection process with two researchers. In a first attempt, two researchers independently performed both the initial and final selection of papers, but did not achieve a reliable level of agreement. We jointly discussed and refined the selection criteria, combined the results of our initial selection into a list of 73 papers, and performed a second independent final selection, this time by physically highlighting quotes within each paper to justify its inclusion. Although this second attempt did not achieve reliable agreement, we considered each point of difference and reached joint agreement. We selected 46 publications, but three of these were later excluded in the data extraction phase, as described in Section 2.4.

2.3. Study quality assessment

During the data extraction phase (described in Section 2.4), the "quality" of each publication was assessed by one researcher. Following the guidelines [13], we marked each of the following three factors related to the "quality" of each publication YES or NO:

- Does the publication mention the possibility of selection, publication, or experimenter bias?
- Does the publication mention possible threats to internal validity?
- Does the publication mention possible threats to external validity?

These weak quality assessments were made solely on the basis of whether the publication explicitly mentioned the issues. We marked a factor as "YES" even if the publication did not use our terminology (e.g., "internal validity") – what was important was whether the publication explicitly considered the issue. Our assessments are not judgements about whether the publication had a "good" treatment of these issues. The results of the study quality assessment were not used to limit the selection of publications. Note that questions of external validity are not relevant to experience reports or case studies if they do not make claims about generalizing their results. So, we have not used the factor concerning external validity for such studies. We further discuss the use of our quality assessment data in Section 3.4.1.

2.4. Data extraction

In the data extraction phase, one researcher read every selected paper and extracted information structured according to the data model shown in Fig. 1. The data model consists of three types of entities: *Publications*, which report one or more *Studies*, which contain one or more *Quotes* about organizational motivations for adopting CMM-based SPI.

A *Publication* is a presentation, technical report, conference article, or journal article. We had selected 46 publications, we excluded three more publications during the data extraction phase. During this phase, we realised that indi-

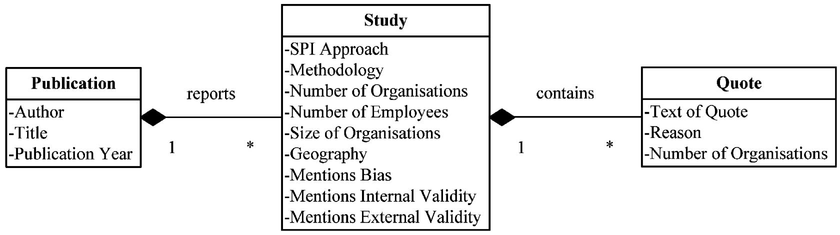

Fig. 1. Data model for information extraction.

vidual practioners' motivators for SPI are different in kind to (and have a different basis than) organizational motivations for SPI. We refined our selection criteria to exclude papers that only reported individual practioners' motivators for SPI, and so excluded two papers [1,2]. We also excluded a publication [9] that we realised was a duplicate of another selected publication [10]. So, we were left with 43 selected *Publications*. A list of these publications appears in Appendix A). For each *Publication* we extracted information about the attributes defined in Table 3. We also collected and analysed information about publication year, as described in more detail in [18].

A *Study* in a *Publication* describes an empirical investigation about organizations that have reported motivations for their adoption of CMM-based SPI. Of the 43 *Publications*, 40 contained a single relevant *Study*, but one *Publication* [8] contained two *Studies*, another [6] contained three *Studies*, and another [19] contained four *Studies*, making a total of 49 *Studies* in our systematic review. We recognise that in principle, "multiple case study" can be seen as a different methodology than "single case study", but in our analysis of papers containing a multiple case study, we have analysed each contributing case as a separate study. For each *Study* we extracted information about the attributes defined in Table 4. We also collected and analysed information about SPI approach and company location, as described in more detail in [18].

Table 3
Data for each Publication as a Whole

Attribute	Description
Authors	The authors of the publication
Title	The title of the publication

Of the 49 *Studies*, 45 were case studies or experience reports about single organizations, one was a series of interviews [17] with 29 organizations, one was an industrial trial [12] of 44 organizations, one was a survey [11] of 85 organizations, and one was a survey [6] of 161 organizations. The interview study [17] covered organizations using CMM-based SPI as well as other forms of SPI, but on request the study's author (also an author of this systematic review) was able to supply previously unpublished data on only those organizations (13 of the 29) that used CMM-based SPI. Thus the studies covered a total of 348 organizations. We believe that there is little significant threat from the possibility of "double counting" organizations among these studies.

From each *Study* we extracted a list of *Quotes*, where each *Quote* described an initial organizational motivation for the adoption of CMM-based SPI. Limited paraphrasing was performed, for example to separate single phrases containing lists of multiple separate reasons. We had a total of 198 *Quotes* extracted from the 49 *Studies*. For each *Quote*, we recorded information about the attributes described in Table 5.

The 49 *Studies* covered a total of 348 organizations, but two *Studies* [6,12] did not say how many organizations

Table 4
Data for each Study within a Publication

Attribute	Description
Methodology	The approach used to study the organization(s). It can be one of "Case study" (independently-reported study of one organization); "Experience Report" (self-reported study by one organization); "Industry Trials"; "Survey"; or "Interviews"
Number of Organizations	The number of organizations in the study (For "Case Study" and "Experience Report" studies, this will be 1.)
Number of Employees	The number of employees (and/or software developers) for the organizations in the study. When the *Number of Organizations* is greater than 1, this is left blank
Size of Organizations	"Small" (< 20 technical staff); "Medium" (20 to 200 technical staff); "Large" (> 200 technical staff); "Unknown"; "Various"; "Large?" or "Medium?"
Mentions Bias	"YES" or "NO" saying whether or not the paper makes any explicit reference to the possibility of selection, experimenter, or publication bias
Mentions Internal Validity	"YES" or "NO" saying whether or not the paper makes any explicit reference to the possibility of internal validity threats
Mentions External Validity	"YES" or "NO" saying whether or not the paper makes any explicit reference to the possibility of external validity threats

Table 5
Data for each Quote within a Study in a Publication

Attribute	Description
Text of Quote	The quote taken from the publication describing the reason (or paraphrased text, e.g., to separate multiple reasons given in a list)
Number of Organizations	The number of organizations who were associated with this reason in this study
Reason	The classification of the *Text of Quote* in terms of the reason categories defined in Table 6 below (Note that this classification was not performed during the data extraction phase, but instead in the data synthesis phase described in Section 2.5.)

were associated with each specific *Quote* (reason). Although we sent email inquiries to the authors of those papers, we did not receive enough information to let us complete this information. So, many of the summary analyses in this paper have excluded these two studies, leaving a total of 143 organizations. Nonetheless, we can make qualitative comparisons between our summary analyses and the high-level findings of those two studies, which we discuss in Section 4.1.

2.5. Data synthesis

At the end of the Data Extraction phase described in Section 2.4 we had extracted 198 *Quote* objects, each containing a *Text of Quote* attribute. Two researchers independently reviewed these in order to derive a list of categories to classify these motivations. Using these two lists as a starting point, the two researchers jointly agreed on a list of 22 categories, as shown in Table 6. The two researchers independently classified every *Quote* object into these categories. Although there was not initially a good level of inter-rater agreement, differences in opinion were discussed in a joint meeting, in some cases with a third researcher arbitrating. The final categories became the *Reason* attribute shown for *Quote* objects in Table 5.

In order to develop higher-level analyses, the two researchers also agreed on a grouping of the reason categories, as shown in Table 6.

To the question "Why did your organization adopt CMM-based SPI?", the rationale "SPI" (i.e., to change existing processes to seek improvement) is almost circular, and so perhaps should be included in the "N/A" reason

Table 6
Reasons for CMM-based SPI

Group	Reason	Description
N/A		*Non-reasons*
	N/A	A non-reason, e.g., a "circular" reason such as "CEO directive"
Customers		*Issues of gaining or retaining customers*
	Market advantage	Perception by an organization's target customers of the organization's competence and/or quality
	Customer demands	Satisfaction of an explicit customer request for the use of a specific development process or approach
	Customer satisfaction	Happiness of an organization's existing customers with the product and/or processes in the organization
People		*Issues related to the management of employees*
	Company knowledge	Accretion and dissemination of knowledge within an organization
	Leaders/Managers	The competency or enthusiasm of senior staff in an organization
	Motivate staff for SPI	The enthusiasm of individuals in the organization for Software Process Improvement
	Work environment	The physical and structural conditions intended to be conducive to work in an organization
Performance		*Issues of production*
	Predictability	The ability to create an estimate or schedule that is accurate
	Productivity	The rate of work for resources
	Project success	Meeting the goals of project stakeholders
	Development time	Overall duration required to deliver software
	Development cost	Overall cost required to deliver software
Process		*Issues related to the definition or management of the process*
	Process visibility	Ability for senior managers to monitor the status and progress of development activities
	Applicable SPI model	The model is applicable to the organization's characteristics (e.g., size, industry, technology, etc).
	Process quality	The extent to which an organization follows its defined processes
	Process consistency	Uniformity of processes across different development groups within the organization
	SPI	Software Process Improvement – changing existing processes to seek improvement
	Automation	Ability to have computer supported enactment or assistance for (parts of) the process
	Measure process	Ability to assess and rate the processes in the organization
Product		*Issues related to the product or service delivered to the customer*
	Service Quality	The fitness of the service delivered to the customer
	Software Quality	The fitness of the software delivered to the customer

group. Nonetheless, we have identified it as a "Process"-related reason, partly because it was such a popular reason! However, Section 3.3 provides a sensitivity analysis of our results where the "SPI" reason is excluded from consideration.

3. Results

This section describes the analyses of the data extracted from our selected studies. In Section 3.1, we first give an overall view of the frequency of reasons given in terms of number of organizations, and in Section 3.2 explore the relationships between these reasons and organizational size. We present in Section 3.3 a sensitivity analysis under the condition of excluding the reason "SPI". In a technical report [18], we provide more details about other analyses examining reasons related to SPI method, companies' geographical location, and the year of publication.

The guidelines for systematic review that we are following [13] suggest investigating the impact that the quality of studies has on our results. To this end, in Section 3.4 we investigate the relationship between reasons given and various characteristics of the studies.

3.1. Reasons reported for CMM-based SPI

We counted the frequency of reasons reported for the adoption of CMM-based SPI reported by organizations. For each Reason, we calculated an upper and a lower bound of the number of organizations who have given that Reason. These bounds are not identical because for some *Studies*, multiple *Quotes* have been classified into the same Reason category. The upper bound is calculated for each Reason category by summing the number of organizations reported for every *Quote* categorised with that Reason – even when there are two or more such *Quotes* in the same *Study*. The lower bound is calculated by summing only the *Quotes* within a *Study* that have the greatest number of organizations associated with that Reason in that *Study*. For example, if in a multiple-organization *Study* two *Quotes* were categorised into a single reason category, and the two *Quotes* were associated with *3* companies and *5* companies, then the contribution from that *Study* to the upper bound total would be $3 + 5 = 8$, but the contribution to the lower bound total would be $max(3,5) = 5$. The upper bound may over-state the true frequency, but the lower-bound may under-state the true frequency. We have not "weighted" the counting of reasons in inverse proportion to the number of reasons given by any organization, because we do not have a good basis for believing that a single reason reported for one organization is necessarily "stronger" than any of the multiple reasons reported for other organizations.

Table 7 shows the upper and lower bounds on the number (and percent) of organizations associated with each reason. "Software quality" is the most common reason (65% to 70%), with "Development time" and "Development cost" the next most common (around 55%), followed by "Productivity" (just over 40%) and "Process visibility" (around 30%). Next there are a group of three reasons ("Customer demands", "Market advantage", and "SPI") that are each cited somewhat often (around 20%), followed by 15 other infrequent reasons.

Table 7
Frequency of reasons reported for initial adoption of CMM-based SPI given by organizations

Reason	Percent (%)		Number (of 143)	
	More than	Less than	More than	Less than
Software quality	65.7	70.6	94	101
Development time	54.5	57.3	78	82
Development cost	54.5	55.9	78	80
Productivity	41.3	41.3	59	59
Process visibility	30.1	30.8	44	44
Customer demands	21.0	21.0	30	30
Market advantage	20.3	23.1	29	33
SPI	17.5	19.6	25	28
Measure software process	7.7	9.8	11	14
Customer satisfaction	5.6	6.3	8	9
Predictability	4.2	7.0	6	10
Applicable SPI model	3.5	3.5	5	5
Work environment	2.8	4.2	4	6
Internal process consistency	2.8	2.8	4	4
Automation	2.8	2.8	4	4
Process quality	2.1	2.8	3	4
Leaders/managers	1.4	2.8	2	4
Company knowledge	1.4	2.1	2	3
N/A	0.7	1.4	2	2
Service quality	1.4	1.4	2	2
Project success	0.7	1.4	1	2
IS performance	0.7	0.7	1	1
Motivate staff for SPI	0.7	0.7	1	1

In a Pareto analysis, over 80% of organizations are covered by one or more of the reasons "software quality", "development time", "development cost", "productivity", "process visibility", "customer demands", "market advantage", and "SPI".

As discussed in Section 2.4, two of the studies we found in our search were not included in the frequency and statistical analyses presented above, because they did not provide the number of organizations associated with each of reason. Here we compare our high-level findings with the findings of each of these two studies.

The first study [12] described industrial trials of the SPICE approach with 44 organizations, and asked respondents about their reasons for performing the SPICE software process assessments. Note that this question (about conducting assessments) is slightly different to our research question (about adopting an SPI approach). It is possible in principle to adopt CMM-based SPI without undergoing a formal software process assessment, and given that an organization has already adopted a specific SPI approach, the reasons for later undergoing an assessment may be quite different to the reasons for originally adopting the

Table 8
Comparison with [12] of rank-order of reasons for adoption

Our reasons	Our rank	12 rank	12 reasons
Software quality	1	9	Improve reliability of products
Development time	2	2	Improve efficiency
Development cost	3	2	Improve efficiency
Productivity	4	2	Improve efficiency
Process visibility	5	4	Establish project baselines and/or track projects/process improvement
Customer demands	6	6	Customer demand to improve process capability
Market advantage	7	(11)	Gain market advantage
Market advantage	7	(12)	Competitive/marketing pressure to demonstrate process capability
SPI	8	3	Establish best practices to guide organizational process improvement
Measure software process	(9)	1	Establish baseline and/or track the organization's process improvement
Customer satisfaction	(10)	(10)	Improve reliability of services in supporting products
Predictability	(11)		
Applicable SPI model	(12)		
Work environment	(13)		
Internal process consistency	(14)		
Automation	(15)		
Process quality	(16)		
Leaders/Managers	(17)	7	Generate management support and buy-in for SPI
Company knowledge	(18)		
Service quality	(19)	5	Improve customer service
Project success	(20)		
IS performance	(21)		
Motivate staff for SPI	(22)	8	Generate technical staff support and buy-in for SPI

Ranks in brackets indicate reasons outside the top 80% (our study) or indifferent/unimportant reasons [12].

SPI approach. Nonetheless, the questions are somewhat related.

Table 8 shows the reasons reported by [12] for organizations performing a software process assessment, and compares the rank order of their reasons with ours from Table 7. The significant reasons in common between their study and ours are "productivity", "SPI", "process visibility", "customer demands", and "software quality". We found that significant reasons also included "market advantage", which the SPICE trials found not to be significant. However, it is perhaps not surprising that industrial participants in a trial of an emerging standard are not (yet) motivated by "market advantage". Conversely, the SPICE trials found that significant reasons included "leaders/managers", "motivate staff for SPI", and "service quality", which we found not to be significant. We do not think that our study covered very many service-intensive software developing organizations, and so the fact that we did not find that "service quality" is significant may not be a meaningful difference. We believe that [12] may have found that the reasons of "leaders/managers" and "motivate staff for SPI" were significant because their question concerned the motivation for process assessment, and not for process improvement.

The sets of significant reasons are largely similar, but some reasons are in a different order between the two lists. We found that software quality was clearly the most frequent reason, but the SPICE trials list is as only their ninth-most important reason. As before, we believe that this is because their question concerned the motivation for process assessment, and not for process improvement. Process assessments do not assess or directly target product improvement, whereas process improvements can. However, the difference may be due to the SPICE trials investigating the "importance" of reasons, whereas we have investigated the "frequency" of reasons. Or else, the difference may be due to differences between SPICE and other forms of CMM-based SPI. We believe that this last reason explains the difference in rank order of the "market advantage" reason, because as an emerging standard, the market position of SPICE is certainly different to the CMM-based approaches from the SEI.

The second study [6] was a survey conducted before a SEI CMMI workshop of 161 respondent organizations, 43% of which had recently decided to adopt CMMI. Many (unspecified) of the respondent organizations had previously been using CMM-based SPI approaches, ISO9000, or other SPI approaches. In terms of our reason categories, the survey found that frequent reasons for "transitioning" to CMMI included:[1] "applicable SPI model", "customer demands", "market advantage", and "process quality."[2] This list is very different to ours, but we believe this is because their question concerns motivations for transition to CMMI from other SPI approaches. That is, their

[1] We have listed these reasons in the same order as appears in their paper, but it is not clear if their reasons were presented in frequency order.

[2] The reason we have classified as "process quality" came from a quote from the study "...matched a corporate emphasis on Total Quality Management (TQM) or other quality programs." It is perhaps unclear whether this refers to process quality or product quality, but on balance we decided that it meant the former.

research question is about the relative benefits of CMMI compared to these other approaches, whereas ours is about the entire (or absolute) benefits of CMM-based SPI. We believe that the first reason ("applicable SPI model") reflects SEI's early marketing message of CMMI being the integration of a plethora of earlier CMM models and thus having relatively increased suitability to a wider variety of development contexts.

To see a higher-level view of motivations for adopting CMM-based SPI, we have counted the frequency of grouped reasons (grouped according to the categories given in Table 6) reported by organizations. Again, we have calculated an upper and lower bound. These bounds are not equal firstly because, as discussed above, a single *Study* may have multiple *Quotes* that we associated with the same Reason, and secondly because each grouped reason contains multiple Reasons, and so a single *Study* may have multiple *Quotes* associated with the same grouped reason. As before, the upper bound is calculated for each grouped reason by summing the number of organizations reported for every *Quote* categorised with that grouped reason – even when there are two or more such *Quotes* in the same *Study*. The lower bound is calculated by summing only the *Quotes* within a *Study* that have the greatest number of organizations associated with that grouped reason in that *Study*. For example, if in a multiple-organization *Study* the reason "development time" had 4 companies and the reason "development cost" had 6 companies, then the contribution from that *Study* to the upper bound total would be $4 + 6 = 10$, but the contribution to the lower bound total would be $max(4,6) = 6$. As before, the upper bound will over-state the true frequency, but the lower-bound may under-state the true frequency. Table 9 shows the summary view of frequency of motivations for adopting CMM-based SPI. "Product" and "Performance"-related reasons are the most important (more than 60%), followed by reasons associated with "Process" (more than 50%), then "Customers" (more than 30%). Very few organizations cited "People"-related reasons (less than 10%).

Table 9
Frequency of grouped reasons reported for initial adoption of CMM-based SPI given by organizations

Reason group	Percent		Number (of 143)	
	More than	Less than	More than	Less than
Product	65.7	72.0	94	103
Performance[a]	63.6	162.9	91	233
Process	51.7	72.0	74	103
Customers	30.1	50.3	43	72
People	4.9	9.8	7	14
N/A	1.4	1.4	2	2

[a] While no more than 100% (143) of organizations will have given "Performance" reasons, we nonetheless show the higher number 162.9% (233) here as calculated by the "upper bound" method.

3.2. Relationship between organizational size and reported reason

SMEs may be faced with different business issues than larger enterprises, and so may have different motivations for SPI. Do the reasons for adopting CMM-based SPI tend to be different for different-sized organizations?

Fig. 2 shows the proportion of all reasons of different types given by organizations of different sizes. The size categories are described earlier in Table 4, and the summary numbers are calculated using the "lower bound" method described in Section 3.1. The chart suggests that different sized organizations may tend to give different reasons for adopting CMM-based SPI. In particular, "Small" organizations may be seeking proportionately fewer "Performance" benefits and more "People" and "Customer" benefits than "Medium" and "Large" organizations, while "Medium" organizations may be seeking fewer "Process" benefits and more "Product" benefits than "Large" organizations. However, these relationships are not statistically significant. To examine the relationship between size and reason, we first exclude "Various" and "Unknown" sized-companies, and then for each reason group use Fisher's exact test on the number of companies of each size giving those reasons. There is no statistically significant relationship with size for the "Product" ($p = 1.0$), "Performance" ($p = 0.79$), "Process" ($p = 0.58$), or "Customer" ($p = 0.15$) reason groups. Note that this does not mean that there is no relationship between reason and size, but rather only that we could not show that there is. In particular, the strength of our analysis is hampered by the small number of "Small" organizations in our sample.

3.3. Sensitivity of results to disregarding "SPI" as a reason

As mentioned in Section 2.5, the somewhat popular reason "SPI" might be regarded as being a non-reason because of circularity. That is, it could boil down to the rationale: "We did (CMM-based) SPI because we wanted to do SPI". This section presents a sensitivity analysis of previous results where the "SPI" reason is excluded from consideration.

Removing the reason "SPI" only minimally affects the Pareto analysis, as it is just replaced by the reason "measure software process". That is, over 80% of organizations are covered by one or more of the reasons "software quality", "development time", "development cost", "productivity", "process visibility", "customer demands", "market advantage", and "measure software process".

Removing "SPI" as a reason only affects the "Process" reason group. When excluding "SPI" the number of "Process" reasons is more than 63 (44%) and less than 75 (52%). (Compared to more than 74 (52%), and less than 103 (72%) as shown in Table 9.) However, the rank order of reason groups in Table 9 is not affected by removing "SPI" as a reason.

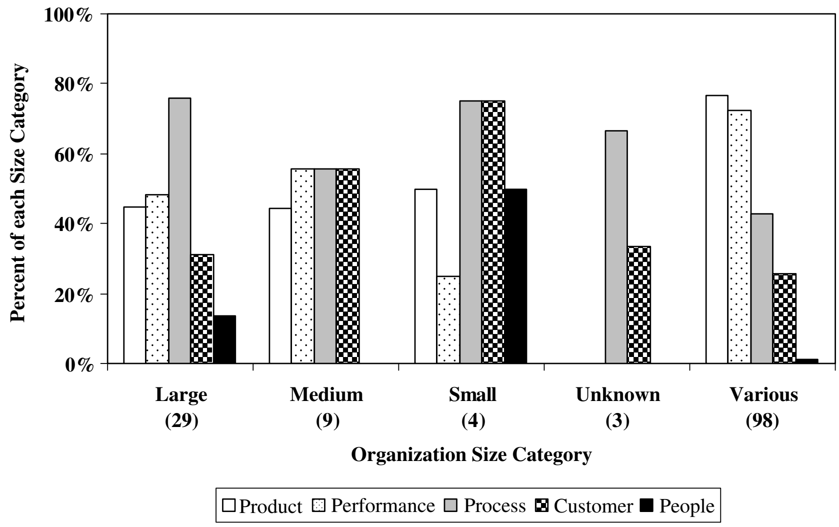

Fig. 2. Percent of organizations in each size category giving reasons in each reason group for adopting CMM-based SPI. (Number of organizations in each size category shown in brackets.)

Our previous finding of there being no significant relationship between "Process"-related reasons and size is not sensitive to excluding "SPI" as a reason ($p = 0.078$, Fisher's exact test). This is despite there being (when excluding "SPI") large percentage differences between "Small" (25%), "Medium" (33%), and "Large" (59%) organizations. As before, our analysis is hampered by the small number of "Small" organizations in our sample.

3.4. Sensitivity of results to study characteristics

The guidelines on systematic reviews we have followed [13] suggest that the quality of contributing studies should be evaluated to assess their validity considering bias, so that readers can make judgements about the reliability of the evidence included in the systematic review. This section describes our analysis of the nature of studies summarised in our systematic review. Section 3.4.1 describes the distribution of study quality attributes, and Section 3.4.2 discusses the difference in results between single-organization studies and multi-organization studies.

3.4.1. Study quality attributes

During the data extraction phase (described in Sections 2.3 and 2.4.), we extracted three attributes concerning the quality of studies: "Mentions Bias", "Mentions Internal Validity", and "Mentions External Validity". Each attribute could be scored "YES" or "NO", depending on whether the paper made any explicit reference to selection/experimenter/publication bias, internal validity threats, or external validity threats respectively. Note that this score does not reflect a value judgement about how well the studies address these potential biases or threats – merely if the studies acknowledged the possibility of these biases or threats.

Of the 49 studies, only seven scored "YES" to at least one of these attributes. Six of those scored "YES" for all relevant attributes, i.e., the survey [11], interviews [17], and industry trial [12] mentioned all potential quality issues, and three case studies [14,4,16] mentioned at least the internal validity and bias issues. One additional case study [5] mentioned only internal validity issues. So, even under this weak indicator of quality – much weaker than recommended by the guidelines [13] – we found a low number and proportion of potentially high quality studies. So, we did not perform a sensitivity analysis of our results with respect to the inclusion of only high quality studies. Instead, we have conducted a sensitivity analysis of our results with respect to the methodology employed by the studies, as discussed in the next Section 3.4.2.

3.4.2. Relationship between study methodology and reason

Of the 47 studies considered in Section 3.1 above, there are 45 single-organization studies (28 experience reports and 17 case studies) and 2 multiple-organization studies (a survey [11] and a series of interviews [17]). Is the methodology used by a study (case study, experience report, survey, or interviews) related to the reasons reported for organizations adopting CMM-based SPI?

Table 10 shows the frequency of grouped reasons in terms of number of studies. It is analogous to Table 9,

Table 10
Frequency of grouped reasons for adoption of CMM-based SPI in terms of number of studies

Reason group	Percent of Studies	Number of Studies (of 47)
Process	72.3	34
(excluding "SPI")	(53.2)	(25)
Performance	46.8	22
Product	44.7	21
Customers	42.6	20
People	14.9	7
N/A	4.3	2

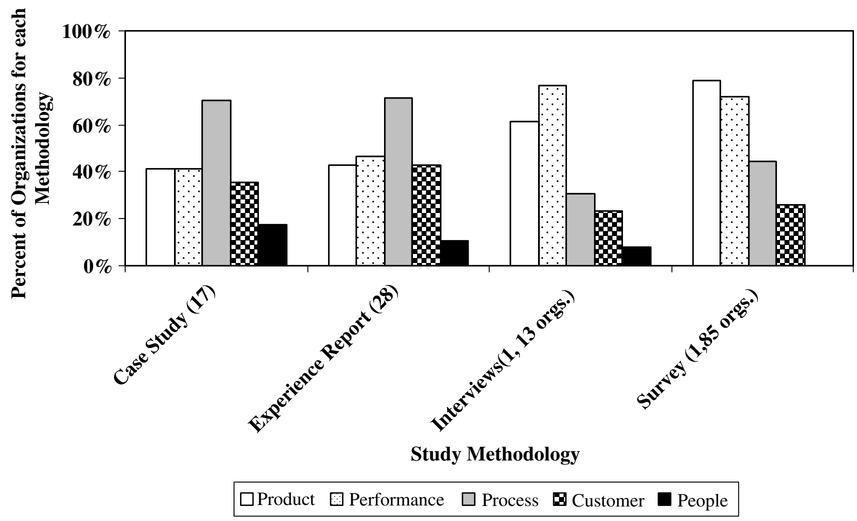

Fig. 3. Percent of organizations studied with each methodology giving reasons in each reason group for adopting CMM-based SPI. (Number of organizations studied with each methodology shown in brackets.)

which is in terms of number of organizations. Thus, Table 10 reduces the effect of the two multiple-organization studies. We see in Table 10 that the frequency order of the reason groups is different to that in Table 9 – "Process" (and perhaps "Customer" and "People") reasons are relatively more important, and "Product" and "Performance" reasons are both relatively less important. This difference in frequency order holds even when excluding the "SPI" reason in a sensitivity analysis (as per Section 3.3).

Reducing the impact of multiple-organization studies proportionately increases the importance of every "Process"-related reason (except for "Process visibility"), especially "SPI" and "Measure Software Process", and proportionately decreases both "Performance" issues ("Development time" and "Development cost"), and "Product" issues ("Software Quality").

Fig. 3 shows the proportions of grouped reasons in terms of number of organizations for each different kind of study methodology.

For "Product"-related reasons, there is a significant relationship between study methodology and reason ($p = 0.0004$, Fisher's exact test), with case studies at 41% and experience reports at 43%, compared to interviews at 62% and surveys at 79%.

For "Performance"-related reasons, there is a significant relationship between study methodology and reason ($p = 0.015$, Fisher's exact test), with case studies at 41% and experience reports at 46%, compared to interviews at 77% and surveys at 72%.

For "Process"-related reasons, there is a significant relationship between study methodology and reason ($p = 0.013$, Fisher's exact test), with case studies at 71% and experience reports at 71%, compared to interviews at 31% and surveys at 45%. However, this result of significance is sensitive to excluding "SPI" as a reason ($p = 0.74$, Fisher's exact test), as per Section 3.3.

For "Customer"-related reasons, we can not claim that there is a significant relationship between study methodology and reason ($p = 0.35$, Fisher's exact test).

The underlying strength of our significance analysis is somewhat limited because despite there being many organizations reported by the interviews and survey, there was only one interview and one survey [11,17]. Nonetheless, the results from the interview study and survey study are remarkably similar, despite being conducted in different countries.

4. Discussion

This section discusses what the results of Section 3 say about our research question: "Why do organizations embark on CMM-based SPI initiatives?" We summarise and discuss the importance of our findings, comment on their legitimacy and generalizability, and discuss a possible bias in the field towards "Process"-related motivations for adopting CMM-based SPI.

4.1. Motivations for adopting CMM-based SPI

The most common reasons given by organizations for adopting CMM-based SPI are indicated by our Pareto analysis, and the frequency order of Table 7 above. That is, 80% of organizations are covered by one of the reasons (in frequency order) "software quality" (66%), "development time" (55%), "development cost" (55%), "productivity" (41%), "process visibility" (30%), "customer demands" (21%), "market advantage" (20%), and "SPI" (18%)[3].

[3] If "SPI" is excluded from consideration, then "measure software process" (8%) replaces "SPI".

At a higher level of analysis, "Product" reasons (66%, e.g., software quality) and "Performance" reasons (64%, e.g., "development time", "development cost", and "productivity") are the most frequent, then "Process" reasons (52%[4], e.g., "process visibility", "SPI", and "process measurement"), and finally "Customer" reasons (30%, e.g., "customer demands", "market advantage", and "customer satisfaction"). "People"-related reasons (5%) were rarely given by organizations.

The rank-ordered list of reasons has some significance for SPI consultants and researchers. It confirms that software developing organizations are most commonly concerned with product quality and development productivity issues. This is perhaps unsurprising from a business perspective, but we feel the connection to these important issues is sometimes lost in the focus on process quality by SPI consultants and researchers. Process quality may be an important means by which SPI is implemented, but it is not the reason for implementing SPI. The two most common "Process"-related reasons we found were (ignoring "SPI"), to make processes more visible and measurable. We believe that these capabilities within an organization are important because of their support for the management of productivity, rather than because of their support for process quality.

In our study, we found "Customer"-related reasons were not a common reason for adopting CMM-based SPI. However, CMM-based SPI is sometimes seen as "organizational badge collecting" [15]. That is, the achievement of maturity level ratings is sometimes seen as being important for the assurance it can provide to customers. When mentioned in the popular media, it seems that the achievement of maturity level ratings almost always carries this message. However, our study suggests that this may be a kind of selection or publication bias in the popular media. Certainly, to the extent that CMM-based SPI has any marketing value, it must be generated through a marketing medium, which would encourage the emphasis and communication of this benefit in the popular media and in other inter-organizational communication channels.

We have not been able to provide evidence that there is a significant relationship between reasons given by organizations and their size. Our data seems suggestive of a relationship, but the small number of "Small" organizations in our study has limited the power of our analysis. We continue to believe that there is a relationship between reasons and size, but this could only be confirmed by later studies. The business problems faced by small companies certainly tend to be different to the problems faced by large organizations, and we would reasonably expect that this would impact their motivations for adopting SPI. For example, in another study [23] we found a significant relationship between size and the reasons given by organizations for not adopting CMMI.

[4] If "SPI" is excluded from consideration, then "Process" reasons were given by 44% of organizations.

In our introduction, we noted that our research question concerned the "frequency", not "importance" of reasons for organizations adopting CMM-based SPI. These are different but related questions. Arguably, knowing about importance is more useful for SPI consultants and researchers. The value of SPI derives from its ability to address the most important software engineering issues in organizations. Nonetheless, our findings about frequency of reasons can shed some light on the importance of these reasons. It would not be unreasonable to assume that when organizations report reasons for adoption, it is likely that their most important reasons are among them. Although it is possible that a very frequently reported reason may not be any company's most important reason, it is nonetheless a likely candidate as a very important reason across the industry. Our findings about the frequency of reasons can frame further studies about the importance of these reasons, and can in its own right provide direction to SPI consultants and researchers about how to better address organizational needs.

4.2. Internal validity: legitimacy of our findings

How legitimate are our findings of SPI motivation arising from the reasons we found reported in the literature? One possible threat to internal validity is that for any specific company, their reported reasons may not have in fact described underlying motivations. We have not been able to independently control this threat. However, we consider the likelihood of this threat to be fairly low. The authors of these studies were under no obligation to report the original reasons why companies adopted CMM-based SPI, and in fact many studies did not report these reasons. Authors could more easily not report reasons rather than falsely report them. Further, in order to partly address this threat, we have purposefully excluded studies that only report expert opinion and anecdote – we have only included a study when it claims that some original reason was linked to the decision to adopt CMM-based SPI.

However, bias is another possible threat to internal validity. It is possible that for studies which reported some reasons (and which we have included in our systematic review), there may have been a tendency for particular kinds of reasons to not be reported. Similarly, for the studies where no reasons were reported (and which we have not included in our systematic review), the underlying motivations may have been of a particular kind. Many of the contributing studies were self-reported experience reports (28) which may be subject to publication bias and experimenter bias, or case studies (17) which may be subject to publication bias. In Section 4.4, we specifically discuss the possibility of a systematic bias in the SPI literature favouring "Process"-related reasons.

4.3. External validity: generalizing from our findings

How safe is it to generalise these findings? Our sample contains many companies from many countries. However, our findings are not based on any studies that used a random sample of software-developing organizations in the world. We have few small (4) companies and medium (9) medium companies, and UK and Australian organizations are disproportionately represented. These issues are all points of caution in the generalization of our findings. However, we believe that in the investigation of our research question, our study is the most comprehensive to date. The issue of generalizing these findings can also be considered by comparing our findings with results from other related studies, as discussed in Section 4.1 above. There, we found that there were many similarities in the sets of reasons reported across both our study and the study by [12], and this provides some support for generalization.

4.4. Possible bias in SPI literature concerning motivations

In Section 3.4.2 we saw evidence that studies of multiple organizations reported more "Product" and "Performance" reasons and fewer "Process" reasons than studies of single organizations. We believe that there is a widespread bias within the SPI literature which tends to understate "Product" and "Performance"-related reasons, and to overstate "Process"-related reasons for organizations adopting CMM-based SPI. We have three arguments for claiming that bias exists: our results from Section 3.4.2; the likely motivations SPI researchers/experts; and quotes discovered in the SPI literature. These arguments are expanded in the subsections below.

If this bias exists, we do not know if it is a publication bias (that studies reporting "Process" motivations are in practice more likely to be initiated and/or reported within the SPI community), selection bias (that organizations with "Process" motivations are more likely to participate in SPI case studies or report their SPI experiences), and/or experimenter bias (that researchers' perhaps inadvertent personal bias affects results). We have also not been able to control for the individual respondent in our study – it could be that case studies or experience reports tend to be based on responses from different kinds of employee within organizations than surveys or interviews.

4.4.1. Argument from relationship between reasons and study methodology

To summarise Section 3.4.2, we found a significant relationship between study methodology and reasons reported in studies for "Product"-related reasons ($p = 0.0004$, Fisher's exact test), "Performance"-related reasons ($p = 0.0146$, Fisher's exact test), and "Process"-related reasons (0.0129, Fisher's exact test). Multi-organization studies reported "Product" and "Performance" reasons more often (and "Process" reasons less often) than single-organization studies. This is the main analytical result justifying our claim of bias, but some discussion is necessary.

There are 45 single-organization studies. Summary results from many studies are likely to reduce the impact of diverse bias. However, a widespread common bias will not be reduced by combining results from many studies – instead its relative importance will be magnified. Moreover, any bias in studies of single organizations may be disproportionately represented compared to the impact of any bias in a single study of many organizations. This is particularly likely for highly interpretive methodologies such as case studies or experience reports.

The distributions of reasons from the two multiple-organization studies are quite similar to each other. However, with only two multiple-organization studies, the power of our analysis is somewhat limited. Nonetheless the consistency of these studies, despite being conducted in different countries, is suggestive of broader external validity.

4.4.2. Argument from likely motivations

We claim that SPI researchers and SPI expert practioners in organizations (who are most likely to contribute experience reports about SPI to the literature) are naturally pre-disposed to focus on "Process" issues. When SPI is your "hammer", every problem looks like a "Process"-related "nail". If this predisposition did manifest as inadvertent bias in any of the studies we have summarised, then it would be in the direction of favouring "Process"-related reasons for adopting CMM-based SPI.

The predisposition of SPI researchers and SPI expert practioners toward "Process" issues is not likely to be shared as the primary focus of businesses. In economic theory (and in many cases, as a legal requirement), the primary driver for businesses is maximizing economic returns, e.g., by increasing revenue, decreasing costs, and gaining market share. Thus for software-developing businesses, software quality, productivity, development time, and customer confidence and/or satisfaction are important second-order drivers as they directly impact revenue, costs, and customer uptake. Process change is not a goal in itself, nor a second-order driver – for a business, a process is only "improved" if it makes a positive impact to increased revenue, decreased costs, or the second-order drivers important to the business.

4.4.3. Argument from quotations

For many SPI researchers and practioners a process is said to be "improved" if it is merely changed to incorporate more "best practices". The possibility of any positive impacts on the organization that implements the changed process is sometimes seen as a secondary contingent consideration. SPI researchers do often explicitly state the importance of tying "improvement" to business objectives, but there is nonetheless a tendency to consider process as the primary objective. The language that SPI researchers use reflects this – SPI researchers talk about the various "benefits" that can be gained from "process improvement", rather than talking instead about "process change" and saying that a changed process is "improved" only if it has the desired benefits. For example, the following quote provides some support for this observation:

...Maturity levels should be measuresof improvement, not goals of improvement [20].

SPI researchers have often warned about the dangers of adopting CMM for the "wrong" reasons. Specifically, seeking to adopt CMM merely in order to gain a rating is seen as corrupting:

"Standards" such as the CMM can help organizations improve their software process, but focussing on achieving a maturity level without addressing the underlying process can cause dysfunctional behaviour [21].

The following quote shows that in one instance, the SPI researchers actively discouraged the organization from adopting CMM for a "Customer" related reason:

It ... could not be ignored that achieving a level of the CMM has clear commercial/marketing value for S3 especially since customers were asking for their CMM rating. However, it was made clear the improvement was the goal, not certification to a level on the CMM for its own sake [19].

5. Conclusions

We have tried to discover why organizations adopt CMM-based SPI. We systematically searched for published reports that explicitly indicated the reasons why CMM-based SPI was adopted, and from almost 600 publications discussing CMM-based SPI, found 43 publications that did. Our results show that organizations adopted CMM-based SPI mainly to improve their product quality and project performance (e.g., development time, development cost, and productivity) but also to improve process management (e.g., process visibility, SPI, and process measurement). Satisfying customers (e.g., customer demands, market advantage) was not a very common reason for adopting CMM-based SPI, and organizations rarely adopted CMM-based SPI in order to improve their employees' capability, motivation, or work environment.

Our study investigated the frequency of reasons given for adopting CMM-based SPI. A common reason is not necessarily an important one, but common reasons would certainly be likely candidates for future investigation as important reasons. Similarly, uncommon reasons are likely to be unimportant reasons for SPI consultants and researchers. So, our findings about the frequency of reasons do shed some light on the importance of reasons for adopting CMM-based SPI, but further studies are required to precisely evaluate the importance of these reasons.

We could not show that there was a relationship between reasons for adoption and the size of the organization. The power of our study was limited by the small number of small organizations in our sample population. We still hold to our hypothesis that different sized organizations tend to have different in reasons for adoption, but this can only be (dis)confirmed statistically by later studies.

The primary focus of businesses is profitability, which is directly influenced by revenue and costs. Costs are directly influenced by productivity. Revenue is directly influenced by customer retention and acquisition, which are in turn influenced by product quality. So it should not be surprising that software developing organizations are commonly concerned with product quality and development productivity issues. Process change can impact on product quality and productivity. Process quality may be an important means by which SPI is implemented, but it is not a common reason for adopting SPI. The two most common process-related reasons we found were (ignoring the perhaps-circular reason "SPI"), to make processes more visible and measurable. We believe that these capabilities within an organization are important because of their support for the management of productivity, rather than because of their support for process quality.

CMM was originally created to address problems faced by the US Air Force stemming from unreliable delivery of software by its contracted suppliers. Providing assurance to customers about a developer's capability is the legitimate business goal that in part inspired the CMM. So, it is ironic that customer-related reasons are among those least frequently cited by organizations who adopt CMM-based SPI, and that SPI researchers actively advise organizations against seeking ratings for their own sake, to provide assurance to customers. There may be a popular perception that CMM-based SPI is adopted by organizations primarily for customer-related reasons, but we believe that this is a misperception driven by the operation of publication and selection bias in the popular media and inter-organizational communications. If market advantage is to be generated from the achievement of a rating, then the rating must be communicated to existing and potential customers. We believe that public or inter-organizational communications about CMM-based SPI will tend to promote this advantage.

For both researchers and practioners, we believe it is important to know why an SPI approach is to be adopted in organizations. In every case, the reasons for adoption should be clearly defined and relate to critical business issues that organization seeks to address. SPI practioners and researchers should accept that providing assurance to customers is a valid business goal. SPI researchers should continue to better understand the business issues facing software organizations, and so we would strongly recommend that all studies about the adoption or impact of SPI in organizations report the original motivations for adopting the SPI approach, and the number of organizations associated with each type of reason. Although understanding the initial organizational motivations for organizations adopting SPI (and the size of these organizations) is unlikely to answer the main research question in other studies of SPI, it will nonetheless help to set the context for almost any SPI research question.

The importance of the connection between business goals and SPI has been increasingly recognised by SPI researchers [7,8,24], and we encourage this trend. SPI researchers should also accumulate evidence that organizations who adopt SPI approach for specific reasons do in fact achieve the benefits they originally sought. Many SPI researchers have concerned themselves with the benefits to product quality and project performance resulting from the adoption of specific SPI approaches, and thus are addressing the two most commonly-cited organizational reasons for adopting CMM-based SPI.

Our study has also raised three important issues for the quality of SPI research: the existence of a bias towards process-related motivations, the overall poor quality of SPI publications, and the difficulty in obtaining data from previous studies. We conclude our paper by commenting on these issues below.

We found a significant difference between organizational motivations reported in single-organization studies (e.g., case studies, experience reports) compared to multi-organizational studies. The single-organization studies reported process-related reasons most frequently, compared to the product and performance reasons most frequently reported by multi-organizational studies. However, our finding is based on only two multi-organizational studies. We would strongly recommend that researchers conduct more multi-organization studies (e.g., surveys, multiple interview studies) that investigate original organizational motivations for adopting SPI.

We found that very few single-organization studies discussed or even recognised issues related to bias or empirical validity. We would call on reviewers of all publications in SPI research to demand that authors of experience reports and case studies recognise the possible weaknesses of their methodology or results, and discuss how these weaknesses have been mitigated in the study or could be mitigated in future studies by others.

We sought more detailed data about studies reported in two papers, but this data was not made available to us. If empirical research in software engineering is to be demonstrably reliable, then requests for data about previously-conducted studies must be answered. Otherwise a perception may form that the claims made in research papers have no more (perhaps less) credibility than the sales claims made by commercial organizations.

Acknowledgements

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Appendix A. List of the 43 selected papers

G. Anttoniol, S. Gradara, G. Venturi, Methodological issues in a CMM level 4 implementation, Software Process: Improvement and Practice 9 (1) (2004) 33–60.

R. Baskerville, J. Pries-Heje, Knowledge capability and maturity in software management, the DATA BASE for advances in information systems, Spring 30 (2) (1999) 26–43.

J. Batista, Dias de A. Figueiredo, SPI in a very small team: a case with CMM, Software Process: Improvement and Practice 5 (4) (2000) 243–250.

C. Boldyreef, M. Drost, D. Hinley, M. Morrell, A. Symons, A basis for process improvement in application management, Software Quality Journal, 6 (1997) 99–111.

C.D. Buchman, Software process improvement at AlliedSignal Aerospace, in: Proceedings of the 29th Hawaii International Conference on System Sciences, 1996, pp. 673–680.

K. Butler, W. Lipke, Software Process Achievement at Tinker Air Force Base, Oklahoma, Carnegie-Mellon University Software Engineering Institute Technical Report CMU/SEI-2000-TR-014, 2000.

L. Carter, C. Graettinger, M. Patrick, G. Wemyss, S. Zasadni, The Road to CMMI: Results of the First Technology Transition Workshop, Carnegie-Mellon University Software Engineering Institute Technical Report, CMU/SEI-2002-TR-007, 2002.

V. Casey, I. Richardson, A practical application of the IDEAL model, Software Process: Improvement and Practice, 9 (3) (2004) 123–132.

F. Cattaneo, A. Fuggetta, L. Lavazza, An experience in process assessment, in: Proceedings of the 17th International Conference on Software Engineering, 1995, pp. 115–121.

S. Cepeda, M.J. Staley, S. Garcia, G. Miluk, SE2 Workshop on Applying CMMI in Small Business Settings. Presentation. Available at: http://www.splc.net/ttp/presentations/sm-bus.pdf, 2004 (accessed 18.06.07).

A. Christie, L. Levine, E. Morris, D, Zubrow, T. Belton, L. Proctor, D. Cordelle, J.E. Ferotin, J.P. Solvay, Software Process Automation: Experiences from the Trenches, Carnegie-Mellon University Software Engineering Institute Technical Report CMU/SEI-96-TR-013, 1996.

T. Cromer, J. Horch, From the many to the one-one company's path to standardization, in: Proceedings of the 4th IEEE International Symposium and Forum on Software Engineering Standards, 1999, pp. 116–121.

C. Debou, A. Kuntzmann-Combelles, Linking software process improvement to business strategies: experiences from industry, Software Process: Improvement and Practice 5 (1) (2000) 55–64.

C. Ebert, Technical controlling and software process improvement, Journal of Systems and Software 46 (1) (1999) 25–39.

M.H. Fallah, Managing TQM in a large company, Technical Program Conference Record of Global Telecommunications Conference, 1993, pp. 510–513.

M. Frey-Pucko, R. Novak, C. Kandus, SEPAM-CMM implementation for developing telecommunications systems, in: Proceedings of the 27th Euromicro Conference, 2001, pp. 272–278.

F. Guerrero, Y. Eterovic, Adopting the SW-CMM in a small IT organization, IEEE Software 21 (4) (2004) 29–35.

T. Haley, B. Ireland, E. Wojtaszek, D. Nash, R. Don, Raytheon Electronic Systems Experience in Software Process Improvement, Carnegie-Mellon University Software Engineering Institute Technical Report CMU/SEI-95-TR-017, 1995.

T. Hall, A. Rainer, N. Baddoo, Implementing software process improvement: an empirical study, Software Process Improvement and Practice 7 (1) (2002) 3–15.

R. Hefner, A corporate approach to technology transition, in: Proceedings of the Thirty-second Annual Hawaii International Conference on System Sciences, 1999, pp. 7055–7059.

J. Herbsleb, A. Carleton, J. Rozum, J. Siegel, D. Zubrow, Benefits of CMM-Based Software Process Improvement: Initial Results, Carnegie-Mellon University Software Engineering Institute Technical Report CMU/SEI-94-TR-013, 1994.

C. Hollenbach, R. Young, A. Pflugrad, D. Smith, Combining quality and software improvement, Communications of the ACM 40 (6) (1997) 41–45.

K. Hyde, D. Wilson, Intangible benefits of CMM-based software process improvement, Software Process: Improvement and Practice 9 (4) (2004) 217–228.

P. Isacsson, G. Pedersen, S. Bang, Accelerating CMM-based improvement programs: the accelerator model and method with experiences. Software Process: Improvement and Practice 6 (1) (2001) 23–34.

H-W. Jung, R. Hunter, D.R. Goldenson, K. El-Emam, Findings from Phase 2 of the SPICE trials, Software Process: Improvement and Practice 6 (4) (2001) 205–242.

D.P. Kelly, B. Culleton, Process improvement for small organizations, Computer 32 (10) (1999) 41–47.

J.A. Lane, D. Zubrow, Integrating measurement with improvement: an action-oriented approach: experience report, in: Proceedings of the 19th International Conference on Software Engineering, 1997, pp. 380–389.

R.H. Lordahl, Starting a large scale software development project using the SEI CMM as the guiding vision, in: Proceedings of the 1994 Canadian Conference on Electrical and Computer Engineering, 1994, pp. 739–742.

F. McGarry, B. Decker, Attaining level 5 in CMM process maturity, IEEE Software 19 (6) (2002) 87–96.

E.G. McGuire, Initial effects of software process improvement on an experienced software development team, in: Proceedings of the 29th Hawaii International Conference on System Sciences, 1996, pp. 713–721.

M. Murugappan, G. Keeni, Blending CMM and six sigma to meet business goals, IEEE Software 20 (2) (2003) 42–48.

K.M. Nelson, M. Buche, H.J. Nelson, Structural change and change advocacy: a study in becoming a software engineering organization, in: Proceedings of the 34th Hawaii International Conference on System Sciences, 2001, pp. 8047–8055.

M. Niazi, A Framework for Assisting the Design of Effective Software Process Improvement Implementation Strategies, Ph.D. thesis, University of Technology Sydney, 2004.

F. O'Hara, European experiences with software process improvement, in: Proceedings of the 22nd International Conference on Software Engineering, 2000, pp. 635–640.

J. Payne, S. Griffith, Test software at Texas instruments: what SEI level is appropriate?, Conference Record of AUTOTESTCON'95, 1995, pp. 196–203.

S.K. Schaffner, K.S. White, Software engineering practices for control system reliability, in: Proceedings of the 1999 Particle Accelerator Conference, 1999, pp. 729–731.

G. Seshagiri, Continuous process improvement-why wait till Level 5?, in: Proceedings of the 29th Hawaii International Conference on System Sciences, 1996, pp. 681–692.

R.C. Smith, Software development process standards: challenges for process assurance, in: Proceedings of the 3rd International Software Engineering Standards Symposium, 1997, pp. 180–186.

J. Switzer, Integrating CMMI, TSP, and Change Management Principles to Accelerate Process Improvement, Presentation at National Defence Industrial Association 4th Annual CMMI Technology Conference and User Group. Available at: http://www.dtic.mil/ndia/2004cmmi/CMMIT5Thur/1151JulieSwitzer.pdf, 2004 (accessed 19.06.07).

G.C. Thomas, H.R. Smith, Using structured benchmarking to fast-track CMM process improvement, IEEE Software 18 (5) (2001) 48–52.

J. Williford, A. Chang, Modeling the FedEx IT division: a system dynamics approach to strategic IT planning, Journal of Systems and Software 46 (2) (1999) 203–211.

R. Willis, B. Rova, M. Scott, M. Johnson, J. Ryskowski, J. Moon, K. Shumate, T. Winfield, Hughes Aircraft's Widespread Deployment of a Continuously Improving Software Process, Carnegie-Mellon University Software Engineering Institute Technical Report CMU/SEI-98-TR-006, 1998.

H. Wohlwend, S. Rosenbaum, Software improvements in an international company, in: Proceedings of the

15th International Conference on Software Engineering, 1993, pp. 212–220.

References

[1] N. Baddoo, T. Hall, Motivators of software process improvement: an analysis of practitioner's views, J. Syst. Softw. 62 (2002) 85–96.
[2] N. Baddoo, T. Hall, De-Motivators of software process improvement: an analysis of practitioner's views, J. Syst. Softw. 66 (1) (2003) 23–33.
[4] R. Baskerville, J. Pries-Heje, Knowledge capability and maturity in software management, the DATA BASE for advances in information systems, Spring 30 (2) (1999) 26–43.
[5] C. Boldyreef, M. Drost, D. Hinley, M. Morrell, A. Symons, A basis for process improvement in application managementSoftware Quality Journal, vol. 6, Chapman & Hall, 1997, 99–111.
[6] L. Carter, C. Graettinger, M. Patrick, G. Wemyss, S. Zasadni, The road to CMMI: Results of the First Technology Transition Workshop, Carnegie-Mellon University Software Engineering Institute Technical Report. CMU/SEI-2002-TR-007, 2002
[7] V. Casey, I. Richardson, A practical application of the IDEAL Model, Softw. Process Improv. Pract. 9 (3) (2004) 123–132.
[8] C. Debou, A. Kuntzmann-Combelles, Linking software process improvement to business strategies: experiences from industry, Softw. Process Improv. Pract. 5 (2000) 55–64.
[9] C. Ebert, The quest for technical controlling, Softw. Process Improv. Pract. 4 (1) (1998) 21–31.
[10] C. Ebert, Technical controlling and software process improvement, J. Syst. Softw. 46 (1999) 25–39.
[11] T. Hall, A. Rainer, N. Baddoo, Implementing software process improvement: an empirical study, Softw. Process Improv. Pract. 7 (1) (2002) 3–15.
[12] H-W. Jung, R. Hunter, D.R. Goldenson, K. El-Emam, Findings from Phase 2 of the SPICE trials, Softw. Process Improv. Pract. 6 (4) (2001) 205–242.
[13] B. Kitchenham, Procedures for Performing Systematic Reviews, Keele University, Technical ReportTR/SE0401, 2004.
[14] E.G. McGuire, Initial effects of software process improvement on an experienced software development team, in: Proceedings of the 29th Hawaii International Conference on System Sciences, 1996, pp. 713–721.
[15] J.W. Moore, R. Rada, Organizational badge collecting, Commun. ACM 39 (8) (1996) 17–21.
[16] K.M. Nelson, M. Buche, H.J. Nelson, Structural change and change advocacy: a study in becoming a software engineering organization, in: Proceedings of the 34th Hawaii International Conference on System Sciences, 2001, pp. 8047–8055.
[17] N. Niazi, A Framework for Assisting the Design of Effective Software Process Improvement Implementation Strategies, PhD thesis, University of Technology Sydney, 2004.
[18] M. Niazi, M. Staples, Systematic Review of Organizational Motivations for Adopting CMM-based SPI. Technical Report. National ICT Australia, PA005957, 2005.
[19] F. O'Hara, European experiences with software process improvement, in: Proceedings of the 22nd International Conference on Software Engineering, 2000, pp. 635–640.
[20] M. Paulk, Using the Software CMM in small organizations, in: The Joint 1998 Proceedings of the Pacific Northwest Software Quality Conference and the Eighth International Conference on Software Quality, 1998, pp. 350–361.
[21] M. Paulk, Using the Software CMM with Good Judgment, ASQ Softw. Qual. Prof. 1 (3) (1999) 19–29.
[22] M. Staples, M. Niazi, Experiences using systematic review guidelines, J. Syst. Softw., 2007, in press for publication.
[23] M. Staples, M. Niazi, R. Jeffery, A. Abrahams, P. Byatt, R. Murphy, An exploratory study of why organizations do not adopt CMMI, J. Syst. Softw. 80 (2007) 883–893.
[24] J.J.M. Trienekens, R.J. Kusters, B. Rendering, K. Stokla, Business-oriented process improvement: practices and experiences at Thales Naval The Netherlands (TNNL), Inform. Softw. Technol. 47 (2005) 67–79.