The Impacts of Software Engineering Organization and CMMI Implementation: A study from an Organizational Culture Perspective

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Abstract

This paper presents two case studies to theorize how project team culture in software engineering organizations affects CMMI implementation from an organizational culture framework. We contend that CMMI implementation success is positively related to project team culture along the eight dimensions of organizational culture, such as orientation to change, control & coordination & responsibility, orientation to collaboration, basis of truth and rationality, motivation, orientation to work, orientation & focus, and nature of time horizon. The results indicate the extent of the impact of project team culture on CMMI implementation. In addition, we develop a cultural construction that shows the dimensions of culture that best facilitate a strong project team culture in CMMI implementation. Possible research questions on which future research can be based are also identified.

Keywords - Project team culture, software engineering organization, organizational culture, CMMI implementation

Managerial relevance statement

This paper proposed cultural construction and research model arising from data collected in our two case studies in practice extend theory about the impact upon CMMI implementation. They provide a theoretically grounded basis upon which future research can be built. Findings of this paper suggest that CMMI implementation project teams are influenced, but not necessarily bound by existing organizational culture. Moreover, CMMI is often implemented to support change in the fundamental structure of an organization, it can also require or bring about changes in the underlying organizational culture to support the integration in a software engineering organization. Furthermore, the requirements for the impact do not stop with the implementation. Therefore, rather than forming a sub-culture, the initiatives that CMMI implementation project teams pursue in order to conquer cultural
obstacles to the impact on the team during implementation may actually form the framework for changes in the broader organizational culture in a software engineering organization.
I. Introduction

Many organizations have become increasingly dependent on software and information systems (IS) and spend large amounts of funds on software development. However, the CHAOS [45] reports that 44% of such projects are challenged (late or over budget), while 24% failed (cancelled prior to completion or delivered and never used). Problems regarding project cost, timeliness, and quality of software products still exist.

In an effort to reduce costs, improve timeliness and provide better quality, many standards and models related to the development process have been defined, such as the Capability Maturity Model (CMM) [34], CMM Integration (CMMI) [41] [42], and ISO/IEC 15504 [23]. According to SEI [43], the adoption of CMM/CMMI by an organization brings good results with regard to delivery time and the reduction of defects and costs. CMMI delineates minimum requirements for system development and software engineering within different process areas (PAs) and at different maturity levels (from lowest maturity, 1, to highest maturity, 5). The model is used for three purposes: the first is for process improvement, the second is for benchmarking companies, and the third is for selecting suppliers, especially within the defense industry [4].

Due to widespread adoption, over the years, CMMI has become the standard for software development [8]. However, results are disappointing and the failure rate is high, despite the enormous amount of resources being spent on software development [20] [41] [42]. One reason may be that CMMI and similar maturity models lack applicability across various types of organizations and countries [33] [44] [47]. Other reasons relate to software development in general. Researchers have focused on a wide variety of problems and challenges confronting organizations that engage in software development [17] [29]. There is general agreement that software development is associated with considerable organizational changes, both in terms of scale and complexity, and software development success largely
depends on how change is perceived and managed [24] [25] [28] [33].

Insights from studies by Iivari et al. [22] and Cabrera et al. [6] reveal that organizational culture can be particularly helpful for improving complex processes. Organizational culture can be construed to cover almost everything in an organization: basic assumptions and beliefs, values, models of behavior, rituals, practices, symbols, heroes, artifacts, and technology [15] [21] [40]. However, our understanding of the impact on implementing CMMI and organizational culture in relation to software engineering organizational processes is limited. Existing studies indicate that culture is a factor to consider within software engineering organizations, such as those by Aaen [1], Muller et al. [30] and Ngwenyama et al. [32]. No research within software development literature explicitly explores the relationship between organizational culture and CMMI implementation.

The purpose of this study, therefore, is to understand the interactions between software engineering organizations, organizational culture and CMMI implementation. More specifically, this study has two objectives. First, it uses the organizational culture framework to explore the relationship between software engineering organizations and CMMI implementation. Second, this study uses two case studies of software engineering organizations that implemented CMMI maturity level-3 (ML-3). The rest of this study is organized as follows. The next section provides the research framework by describing the nature of organizational culture framework. Section III describes the methodology used in this study. In Section IV, a case analysis provides profiles of the two-case study and describes the impacts observed in these two case studies during CMMI implementation. Section V synthesizes the findings of this study. Finally, the last section discusses contributions of this study and directions for future research.

II. Theoretical background and research framework
CMMI implementation is influenced by many factors, and it is difficult to examine impacts separately from such factors [30]. These factors include managerial, environmental, and technical artifacts, and a major challenge in organization culture is managing the interactions among the various influences. However, it can be argued that these factors are all part of or are influenced by organizational culture. For example, managerial coordination and control influence are factors rooted in organizational culture [19] and influence the structure of decision making through that structure. The impact on implementing CMMI for a software engineering organization is embedded in the broader context of culture, and that culture influences the way organizational members share what they understand [1].

Our assessment of the impact on CMMI implementation is grounded in a framework proposed by Detert et al. [10]. Detert et al. derived the dimensions of culture in their framework from a content analysis of “a synthesis of what have repeatedly emerged as the components of culture” in other organizational culture research ([10], p. 851). One of their goals was to provide a basis upon which future theoretical and empirical work on organizational culture could be conducted. This framework supports an assessment of the dimensions of organizational culture and the practices or artifacts that arise out of those dimensions. It focuses on organizational culture as a system of shared values that define what is important and that guide organizational members’ attitudes and behaviors. We use the eight dimensions of culture included in Detert et al.’s theoretical framework to identify behaviors related to cultural values that underlie CMMI implementation in order to inform theory about the way these cultural dimensions mitigate or impede CMMI implementation. A model of our research framework is provided in Fig. 1 below.
A. Orientation to change (stability vs. change)

Some organizations are change-oriented and characterized by a focus on continuous improvement [14]. Change often becomes more widely accepted in some organizations because organizational members are accustomed to change and view it as positive [5]. Others are more stability-oriented and are characterized by the philosophy of “not rocking the boat” or “if it’s not broken, don’t fix it.” They may even seem to change without actually doing so [3] [13]. For example, an organization may adopt a policy of improved customer service, but the behaviors of organizational members may remain the same, or the organization may fail to change its infrastructure to actually improve customer service [3]. Change often requires organizational members to understand a new way of performing processes, as well as how and why their processes have changed [44].

B. Control, coordination, and responsibility (concentrated vs. autonomous decision making)
Organizations vary in the degree to which the structure of decision making is concentrated or shared. Where decision making is fairly concentrated, the rules of a few guides the behaviors and actions of the majority, and decision making is centralized [37]. In organizations where decision making is shared, organizational members are encouraged to be autonomous in their decision-making processes [35]. An overriding norm in many organizations is silo behavior, where individual divisions, units, or functional areas operate as silos or independent agents within the organization [7] [27].

C. Orientation to collaboration (isolation vs. collaboration)

Perceptions about the relative value of working alone or collaboratively are motivated by underlying beliefs about how work is best accomplished [10]. A culture that values individual efforts more than collaborative ones places greater emphasis on individual autonomy and believes that collaboration is inefficient [38]. On the other hand, organizations that believe collaboration is more efficient and effective than individual effort encourage teamwork and organize tasks around groups of people [37].

D. Basis of truth and rationality (hard evidence vs. personal experience)

In some organizations, truth is considered to be a product of systemic, scientific study; codified, hard evidence is vital to problem solving [39]. Central to this belief is that the phenomenon of interest about which decisions are made is too complex to be evident without such data collection and analysis. Many organizations take this a step further and focus on making what is already codified into hard evidence more readily available to the organization members [2] [26]. Furthermore, the norms of some organizations are such that if their “soft” or intuitive information is not already codified, then they believe it is either not worth doing or unable be done, and they do not attempt to capture this information [2] [26]. Other organizations view truth as a product of the sharing of unique, specialized information
possessed by individuals, and they gauge effectiveness through personal experience and intuition [10]. They are likely to agree with the estimation that an organizational information is experiential and intuitive [2] [26]. Beliefs about what is true may differ depending on which approach is used to determine truth. Degrees of both may also be seen in organizations.

E. Motivation (external vs. internal)

One view of motivation holds that people are intrinsically motivated to perform well; however, the processes or environments within which they work can thwart their motivational drive [16] [39]. If organizations believe people are internally motivated, they structure work environments to remove obstacles to effective work. These organizations address weaknesses in systems and processes in order to enhance performance [10]. Other views of motivation reflect the belief that individuals must be externally motivated to perform. Central to these views is choice of the appropriate type of reward systems. Organizations that assume people are externally motivated to perform will implement external rewards for performance.

F. Orientation to work (process vs. results)

Some organizations work from a results-based focus, where “the fundamental concern is on work accomplishment and productivity” ([10], p. 856). Others view work from more social or process-oriented foci. In these organizations, the focus is on achieving outcomes deemed important to stakeholders by the most effective methods [37]. Some organizations focus more prominently on improving the way in which jobs are completed and how results are achieved [26] [46]. They expect that favorable outcomes will follow when results are attained [9]. This view espouses that “organizations should focus only on process improvements and that by doing so results would follow” ([10], p. 856). However, more recent viewpoints are that organizations should focus on both process improvement and results to achieve their objectives.
G. Orientation and focus (internal vs. external)

Orientation and focus address the relationship between an organization and its environment. This includes ideas about the extent to which the firm is focused on its internal or external environment [37]. For example, many organizations assume that the key to organizational success is to focus on the processes and people within the organization, whereas others focus primarily on external constituents.

H. Nature of time horizon (short term vs. long term)

An idea about time horizon relates to whether organizational leaders adopt long-range plans or focus primarily on the short term [36] [37]. Some organizations with management in the former category are more likely to make investments that support their long-term missions. These include investments in information technologies that help organizations more effectively manage their information and better control their data and processes [44]. An organization with a greater short-term focus is more likely to make investments that support particular initiatives, applications, or functional processes.

A summary of these eight dimensions is provided in Table I. Using the eight dimensions of culture put forth by Detert et al. [10] as a theoretical lens, we investigate how these dimensions affect software engineering organizations during CMMI implementation.

Table I Dimensions of organizational culture

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<th>Dimension of culture</th>
<th>Definition</th>
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<tr>
<td>Orientation to change (stability vs. change)</td>
<td>Extent to which organizations have a propensity to maintain a stable level of performance that is “good enough” or a propensity to seek improvement through innovation and change.</td>
</tr>
<tr>
<td>Control, coordination, and responsibility (concentrated vs. distributed)</td>
<td>Extent to which organizations have decision-making structures centered on a few vs. decision-making distributed structures.</td>
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autonomous decision making) structures centered on dissemination of decision-making responsibilities throughout the organization.

Orientation to collaboration (isolation vs. collaboration) Extent to which organizations encourage collaboration among individuals and across tasks or encourage individual efforts over team-based efforts.

Basis of truth and rationality (hard evidence vs. personal experience) Extent to which organizations seek truth through systemic, scientific study using hard evidence or through personal experience and intuition.

Motivation (external vs. internal) Extent to which organizations deem that individuals are motivated by an internal desire to perform well or by external rewards and encouragement.

Orientation to work (process vs. results) Extent to which individuals in organizations focus on work as an end (results) or to which they focus on the process by which work is done as a means to achieve other ends.

Orientation and focus (internal vs. external) Extent to which organizational improvements are driven by a focus on internal process improvements or by external stakeholder desires.

Nature of time horizon (short term vs. long term) Extent to which organizations focus on the long term or the short term.

III. Research methodology

Data were collected using two case studies in the information service industry of organizations that had implemented CMMI ML-3. A single industry and the CMMI ML-3 were chosen to minimize bias that might be introduced because of differences across industries and across CMMI ML-3. Although ML-3 is not the first appraisal (ML-2 is the first) in implementing CMMI in the information service industry, ML-3 includes more PAs than other levels and also includes all PAs of CMMI ML-2. These PAs pertain to management and organizational process improvement and need more efforts to implement. Moreover, information service is the most representative industry of CMMI implementation among all industries [43] and attracts higher education alumni to work in Taiwan.

We also intend to understand the impact on a whole company and a single department in
CMMI implementation. Selection of the two organizations began with the researchers contacting the CIO or top IS executives of the two organizations in the information service industry to determine whether they had implemented or were in the process of implementing CMMI, and if so, whether they would agree to participate in this study. Of those who agreed to participate, we eliminated organizations that had implemented only one or two process areas (PAs) of CMMI ML-3, with no plans to implement additional PAs. We also eliminated organizations that had not implemented CMMI ML-3 across the organization or the specific division in which we were interested. Before the two organizations in this study had implemented CMMI ML-3, they all would have implemented PAs of CMMI ML-2, including PP (project planning), CM (configuration management), REQM (requirements management), PMC (project monitoring and control), SAM (supplier agreement management), PPQA (process and product quality assurance), and MA (measurement and analysis). The two organizations in this study implemented PAs of CMMI ML-3, including RD (requirement development), TS (technical solution), PI (product integration), VER (verification), VAL (validation), OPF (organizational process focus), OPD (organizational process definition), OT (organizational training), IPM (integrated project management), RSKM (risk management), and DAR (decision analysis and resolution). The dates when the two organizations began implementing their CMMI projects range from 2004 to 2010. Both of them used phased implementations rather than a so-called “big bang” approach. The first PA of implementation in the two organizations occurred three to fourth months after the project began. One of them completed their last PA of implementation after approximately two years; the other organization completed their last PA approximately six years. Data for this study were collected after all implementations had been completed.

The unit of analysis in this study is comprised of the project teams of the two information service organizations (e.g., software engineering organizations). The project teams at the two organizations were responsible for identifying and defining processes to be
included, configuration and design, testing, implementing, and training. Thus, each team was
like a unit for the implementation center, including assisting among team members and
between team members and other organizational members.

Due to the size of the project teams, interviewing a sample of key stakeholders was
deemed more manageable than attempting to interview each member. We asked the two top
IS executives to identify key members of their respective CMMI project teams. This is an
appropriate way to select respondents for case study research regarding causal mapping
because professionals in a field have been shown to be capable of nominating key respondents
who have a consistent set of attributes appropriate for a study, as indicated in the study by
Nelson et al. [31].

A series of semi-structured interviews were conducted with eight people across two
organizations. A written interview guide was used to guide the questions asked and to ensure
consistency between interviews (Appendix A). The interviews lasted between one and two
hours each and were conducted over a period of two months. In addition to in-person
interviews, we also preceded and followed the interviews with e-mail and telephone calls for
background information, clarification, and points not covered during the interviews.
Respondents in the two organizations included both information systems staff and
business/functional staff. Some had been members of the teams from the beginning, while
others had joined at various points in the project. Respondents in the two organizations
represented a variety of perspectives on CMMI, including some who were pleased with it,
some who hated it and others who were indifferent. They also represented a variety of
functional perspectives, including system analysis, system design, coding, testing and quality
control, and validation. Many were in managerial positions on the CMMI project teams, and
many came from various levels of management positions within the two organizations. Some
respondents remained in jobs related to CMMI after implementation, while others were given
either different or broader responsibilities. In addition, some individuals who were not employed in IT jobs prior to the CMMI project switched to IT positions during or after implementation.

Data analysis was conducted in two stages. First, the case analysis was performed in which responses were extracted for the two organizations and grouped into the eight dimensions of culture. Responses to questions designed to measure the impacts were also extracted. Examples of these measures include such things as: “How did your team learn from the rest of the organization about processes, needs, etc.?”; “How did you make sure that you had learned enough from the integration partner so that you could carry on after they left?”; and “How was transition of organizational members information managed when they left the team?” Examples of responses coded as the impacts (or no impact thereof) include phrases like: “we used checklists during transition off the team”; “I felt like I couldn’t express my concerns about that because they were process team things, and I was technical”; and “junior level people felt free to explain to senior level people how they thought the configuration should work.”

The two organizations were assessed in terms of where they fit in the cultural dimensions and for the impacts observed in CMMI implementation. The case analysis was then performed, where the impact upon CMMI implementation across the two organizations was compared in the context of the eight cultural dimensions. This method links cultural dimensions to organizational impacts in CMMI implementation and provides a logical and coherent understanding of the topic at hand.

In order to ensure the validity and reliability of the assessment, we established a case study protocol [48]. The protocol includes a case study database that consists of case study notes, case study documents, tabular materials, and a case study narrative. The case study database created in this study consists of the case study written notes and transcribed
interviews, any documents obtained from the respondents, tables of evidence by case site and construct of interest, and a narrative set of answers to each question asked in the interviews. It consists of approximately eight separate files and two legal pads of hardcopy notes. It reveals both the actual evidence and the circumstances under which the evidence was collected (e.g., time and place of interview, whether in-person or telephone interview, responses to questions).

IV. Case Analysis

This section presents an outline of the two cases and the impacts on organizational culture that occurred on CMMI implementation teams at the two organizations while implementing CMMI. The eight dimensions of culture developed by Detert et al. [10] are used to organize the presentation. The scope of CMMI implementation at the two organizations is summarized in Table II.

Table II Scope of CMMI implementation

<table>
<thead>
<tr>
<th>Case</th>
<th>Location</th>
<th>Time</th>
<th>Units</th>
<th>Number of users</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case A</td>
<td>Taiwan</td>
<td>2004. 3~ 2010. 3</td>
<td>ALL groups</td>
<td>180</td>
<td>ML-2, ML-3</td>
</tr>
<tr>
<td>Case B</td>
<td>Taiwan</td>
<td>2006. 3~ 2008. 6</td>
<td>One division</td>
<td>120</td>
<td>ML-2, ML-3</td>
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A. Case A

Case A was established in April 2000 by a group of industry leaders specializing in the fields of financial business and credit card information systems for decades. Case A provides services to financial institutions with the support of about 180 employees and the rich experience of its founders. Case A began its own CMMI project in the middle of March 2004 to improve internal software development procedures. For Case A, formulating comprehensive and suitable software development and a maintenance operation procedure
that suit its various business group operations and further improve products, service quality and efficiency through procedure standardization is the most important objective. After a collective effort from the entire Case A staff, both of Case A’s core business groups, the credit card core system development and maintenance division and the open system platform information solution division, achieved CMMI ML-3 in late March 2010 and have fully achieved comprehensive procedure establishment and execution.

a. The Impact

The CMMI implementation team in Case A was initially able to conquer some significant challenges to document management. However, over time, some of the key interventions unraveled, and as a result, document management became limited. At the time of embarking on CMMI implementation, Case A had an atmosphere of internal competition. The business groups viewed themselves as self-directing silos that competed for common resources, and each group set its distinct goals. This, along with an atmosphere of resistance to change in some divisions, made document editing and focusing on common processes difficult initially. Hard evidence was used to help divisions realize that their processes were not so different from those of other silos. For example, one major conflict at the start was that the upstream division did not want to switch to common processes at all. So, the team members from the two other groups mapped out the process in question and requested that upstream team members map out their processes. Then, they all met and compared the maps to identify commonalities. The upstream division eventually realized that many of the features they had believed were unique were in fact not, and upstream agreed to move to common processes. In this case, documenting actual processes and comparing them across silos were effective methods of implementation. During later team meetings, however, members discounted personal experiences or insights not based on hard evidence as invalid. This discouraged the sharing of softer personal experiences. One intervention to mitigate the impact (i.e., the
discouragement) that initially proved successful later deteriorated. This was eliminating seniority and functional distinctions among team members. Initially, this enhanced document management in the form of formal and informal discussions, as well as shared documents and emails. Lower level employees felt free to provide their input. However, over time, senior team members began to resent the lower level members, and the degree of experience sharing significantly slowed and began to shut down. So, what began as a difficult but successful attempt at sharing experiences deteriorated to limited sharing.

b. Orientation to change: stability and change

Some groups within Case A had experienced more change than others in the past, and these groups were more willing to embrace software process improvement (SPI)-based change. The more stable groups did not respond as readily. As one team member said, "different streams (groups) have adapted differently." For example, the sales and distribution operations function was the most complex to implement, and the group responsible for it had experienced the least change in the past. Thus, this group’s member had the greatest difficulty adapting to the integrated, common process. The implementation project team had to spend more time training and working with the people in this group than they had originally anticipated. As one team member indicated, "They adapted very poorly early on. We’ve worked with them and now, one year later, they are doing fine. They believe the data and are comfortable with it." On the other hand, the open system platform information solution group was accustomed to change because it operates in an “acquisition and consultancy environment." Thus, this group’s members had few difficulties adapting. As described, “upstream is primarily accounting-based, so with the sharing economy they grew used to change” and have adapted to PAs (e.g., SAM, REQM, RD, PI) of CMMI ML-2 & ML-3 more readily.

c. Control, coordination, and responsibility: Autonomous decision making
At the time of CMMI implementation, Case A’s business groups were operating as highly autonomous silos that optimized their own goals, resulting in internal competition. As one manager described it, "We are really good at competing with each other, but we have not been as good at competing with external competitors.” The culture was one in which groups were essentially pitted against each other. Each sought to optimize its own goals, with little awareness of whether it was accomplishing overall organizational goals. Autonomous decision making not only abounded, but was viewed by the groups as necessary for their own survival. Therefore, the cross-divisional collaboration required in CMMI implementation was quite counter to the mindset of those on the team.

d. Orientation to collaboration: isolation

Prior to software process improvement (SPI), working in a project team had a negative connotation, and consequently, people did not like to work in teams. "Once someone is on the project, they are always destined to be a person of the project.” It is difficult for a person to return to his previous job once he is removed for the project. Teams sometimes, although not always, were used as a dumping ground for weak employees. The culture was one where isolation was more valued than collaboration. Although they were able to successfully mitigate the impact in the implementation team at first, they were not able to conquer the culture of isolation and, in the long run, experience on the CMMI project team eventually broke down.

e. Basis of truth and rationality: Hard evidence

Hard evidence for decision-making or problem-solving tasks was required, and the impact, in terms of personal experience and opinions, was discouraged. As one person described it, 'If someone said we can’t do it this way, we said, ‘Why can’t you? Is it really unique?’ We’d get them to list what they do and to look at what others have listed, and
identify the commonalities." Although this is a useful tool for mitigating the impact, Case A’s requirements to codify experience before any analysis was done may have reduced the sharing of information that was difficult to codify or to support with hard evidence. The rigid requirement for hard evidence may have also inhibited people from expressing ideas based on information about what might or might not work, thereby limiting information.

f. Motivation: Internal

The impact was internally motivated on the implementation project team by eliminating seniority and functional distinctions. External rewards were not addressed. Senior people worked alongside hourly workers on the team, and if the lower level employees had an idea or wanted to try something, the senior people listened to them and, in some cases, took direction from them. “In the old culture a lower level person wouldn’t say what they thought in front of a more senior person.” This worked well in the beginning, but as the project progressed, senior people began to resent that junior people knew more than they did about both the processes and the PAs of CMMI ML-2 & ML-3. Eventually, the attitudes of the senior people created an environment in which the freedom to express ideas was inhibited.

g. Orientation to work: Results

There were “tremendous pushes from senior management to meet time deadlines.” Rather than delaying the project to gather more information, senior management provided more money and resources, going over budget, to ensure the project was not delayed.

h. Orientation and focus: Internal

When implementing CMMI, the orientation at Case A was internally focused in that they wanted to improve their organizational environment while promoting quality.
i. Nature of time horizon: Long term

Case A understood from the outset that implementing the PAs of CMMI ML-2 & ML-3 would require a long-term commitment to the project.

B. Case B

Case B involves the application integration division of an international information service company. The parent company of Case B ranks No. 2 for total PCs and notebooks and its product range includes PC notebooks and desktops, servers and storage systems, monitors, peripheral devices, digital devices, LCD TVs and e-business solutions for business, government, education and home users. It employs 7,000 people worldwide. Revenue for 2009 was US$17.9 billion. Case B leads in system integration with services in hardware, software, network, and specialty counseling in Taiwan. Case B began its CMMI ML-2 project in March 2006 and finished CMMI ML-3 in the end of June 2008. Case B employs approximately 120 users in CMMI implementation.

a. The Impact

The CMMI implementation project team at Case B utilized strong systems, like a document management system, for their implementation. Extensive communication regarding CMMI plans, work process changes, and the importance of CMMI implementation took place among team members and between the team and the rest of the organization. The project team managers implemented team-based bonuses so the entire team was rewarded upon the successful completion of milestones. This facilitated sharing information among the team members because it minimized the benefits usually associated with information hoarding. Team members were willing to share information with one another, both on a formal and an informal basis. Both hard evidence, such as current written policies, reports, and other analyses, were shared along with soft data, such as previous experiences or personal insights.
Team members were also encouraged by the project manager and each other to seek out additional expertise, if the requisite information was not in existence within the team. Thus, Case B generated a considerable amount of useful information throughout the CMMI implementation.

b. Orientation to change: Change

Processes were changed as a result of CMMI implementation. "Our business processes have become much more well-defined and understood." "A lot people are aware of the integration and dependencies among processes.” For example, inviting the tendering process is now uniform throughout all the units (i.e., service or product department). To help achieve this, the units worked together to change their nomenclature for parts, creating a common master file of parts across units. This was a major hurdle to surmount because of the vast number of parts involved. Case B’s implementation project team explicitly focused on activities that helped to prepare the organization for change. “We had never worked so hard on cultural readiness," one person said. “We had decision makers from every functional group in the units in each design and implementation, which went a long way toward the cultural readiness on which change management was focused.”

c. Control, coordination, and responsibility: Concentrated decision making

While the style of decision making was highly concentrated, Case B also ensured extensive information sharing, which contradicts what theory predicts about the role of concentrated decision making during times of extensive organizational change. Theory indicates that autonomous decision making allows for the freedom of thinking and idea generation necessary for extensive change to occur. Yet, this was not the case at Case B. One explanation for this may be that CMMI tends to consolidate decision making by integrating processes across intra-organizational boundaries. As Case B’s decision-making style more
closely matched that required by CMMI, perhaps this match was more conducive to the
document management for sharing information required by CMMI implementation.

d. Orientation to collaboration: Collaboration

Prior to CMMI ML-2, efforts were in place to create a culture that promoted teamwork,
where "people are encouraged to share their ideas across functions." To help foster this
culture, many facilities moved away from the use of traditional titles that imply a hierarchy.
As no single individual on the CMMI team possessed all the knowledge necessary to
complete the project, "everyone on the team had to rely on everyone else." Thus, extensive
efficiency occurred.

e. Basis of truth and rationality: Personal experience

After the first PA (i.e., PP) was implemented, the team realized that it did not have the
right sequence to adequately model how the processes worked. The team members believed
that this was partly because they did not have the right people involved in the implementation,
and that they were missing experiential methods. Therefore, they restructured their approach
to document management and data gathering, even though the new approach required more
time for the implementation.

f. Motivation: External and internal

Team members were internally motivated and externally rewarded. The division
organized teams by process rather than by function to create an environment in which
information sharing was internally motivated. This required team members to gain diverse
information and to understand processes beyond their own functional areas. As a result, they
worked in an environment in which information sharing was built into the implementation
because neither individuals nor functional areas could proceed without it.
In addition, external motivation was provided for the team with a bonus program. Each team member received the same bonus at the end of a PA implementation, regardless of rank in the organization. The bonus was based on the team’s quality of work. This was done to remove competition among individuals that might exist to “get there first” or to be “lone rangers” in the implementation. Providing the same bonus helped to focus team members on accomplishing the common goal of implementing a system that would most benefit the organization as a whole. The project manager said that the “core of the things I always tell my members that implementing CMMI is a team activity. If you don’t play as a team you can’t win.” Equalizing bonuses also helped to minimize hierarchical and seniority distinctions on the team, so that everyone could feel freer to be an equal contributor. As one person described it, “we had a foxhole mentality”, whereby team members were united around a common cause. Thus, team members were both internally motivated and externally rewarded to share information to accomplish a common goal. It should be noted, however, that the team-based bonus system was counter to the way employees had been rewarded in the past and was not easy to implement. The project managers had to work diligently to convince top management in the parent company to allow them to implement it.

g. Orientation to work: Process

The division had a process rather than a results orientation to work. They reorganized their entire approach to information gathering after their first PA implementation in order to provide a system that facilitated document (e.g., information) acquisition. At the start of the project, they followed their integration partner’s model, in which they met with one or two key people at each unit, such as engineers and “folks who knew unit processes and were going to make decisions on who was going to do what.” However, “the users were not involved in the actual understanding of how we were building this system, what they were going to see, and what they were going to get.” In the first PA implementation, the team
members realized that the users not only did not understand how the processes worked in CMMI, they “didn’t really even know what the real process was.” They only knew their piece of the process. Thus, relying on a few people for process-wide information was not sufficient. In subsequent implementations, the implementation team involved more key business people from across various units in the implementation, although this required more time. Achieving a strong outcome was more important than meeting a deadline with a weaker product.

h. Orientation and focus: Internal

Case B was primarily internally focused in terms of its CMMI implementation. Implementing CMMI was seen as a way to promote quality internally by making internal processes more efficient.

i. Nature of time horizon: Long term

Management was well aware that implementing CMMI was not a “quick fix.” They were willing to embark on a multi-month effort to implement a PA of CMMI successfully.

V. Synthesis of findings

In this section, we synthesize our findings and present our extension of theory through a cultural construction that illustrates which dimensions of culture best mitigate the impact upon CMMI implementation. We also discuss obstacles to the impact and propose a model that discusses obstacles to the impact on a project team that arise out of existing cultural dimensions, and which suggests that they can be minimized by taking initiatives that alter the culture within the project team itself. External forces, such as consultants or integrators, can also potentially affect project team culture. This model further posits that the project team culture may be a key driver of the impact on the team, regardless of broader organizational cultural factors.
A. Extent of the impact

It is useful to first assess which organizations mitigated the impact in their CMMI implementations. Based on the above case analyses, it appears that Case B encouraged mitigation of the impact throughout the entire implementation. Case A’s impact began strongly, but broke down later in the implementation stage. Table III provides a summary of the cultural dimensions for these two cases. Case B exhibited the most documentation. Analyzing the differences and similarities between the organizations that exhibited the most the documentation vs. those that exhibited the least yields a construction of the cultural dimensions that best mitigates the impact in CMMI implementation for an organization. These differences and similarities are discussed in the section below. Table IV provides a summary of the resulting cultural construction.

Table III Summary of dimensions of culture in the two case sites

<table>
<thead>
<tr>
<th>Dimensions of culture</th>
<th>Case A</th>
<th>Case B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation to change</td>
<td>Stability &amp; change</td>
<td>Change</td>
</tr>
<tr>
<td>Control, coordination, responsibility</td>
<td>Autonomous</td>
<td>Concentrated</td>
</tr>
<tr>
<td>Orientation to collaboration</td>
<td>Isolation</td>
<td>Collaboration in pockets</td>
</tr>
<tr>
<td>Basis of truth and rationality</td>
<td>Hard evidence</td>
<td>Hard evidence &amp; personal experience</td>
</tr>
<tr>
<td>Motivation</td>
<td>Primarily internal</td>
<td>External and internal</td>
</tr>
<tr>
<td>Orientation to work</td>
<td>Results &amp; process</td>
<td>Primarily process</td>
</tr>
<tr>
<td>Orientation to focus</td>
<td>Primarily internal</td>
<td>Primarily internal</td>
</tr>
<tr>
<td>Nature of time horizon</td>
<td>Long-term</td>
<td>Long-term</td>
</tr>
</tbody>
</table>

Table IV Cultural constructions for the impact upon the CMMI implementation project team

<table>
<thead>
<tr>
<th>Dimensions of culture</th>
<th>Cultural construction value</th>
<th>The impact upon project team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation to change</td>
<td>Change</td>
<td>CMMI requires change in organizations. Implementation project teams must be change-oriented in order to share the information required for change to occur.</td>
</tr>
<tr>
<td>Control, coordination, and responsibility</td>
<td>Consistency in either concentrated</td>
<td>CMMI centralizes data and information while simultaneously pushing decision making throughout the organization. Implementation project teams must share information in order for this to occur, regardless of the prior decision-making style.</td>
</tr>
<tr>
<td>Orientation to collaboration</td>
<td>Collaboration</td>
<td>Collaboration is a key to the impact on implementation project teams. Teams must focus on facilitating</td>
</tr>
</tbody>
</table>
For Peer Review

collaboration throughout the project, regardless of prior orientation in the organization.

<table>
<thead>
<tr>
<th>Basis of truth and rationality</th>
<th>Hard evidence and personal experience</th>
<th>Implementation project teams should rely on document management in the form of both personal experience and hard evidence.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td>Internal and team-based external motivation</td>
<td>Implementation project team members can be motivated to share information if obstacles to sharing are removed and initiatives to share are enacted.</td>
</tr>
<tr>
<td>Orientation to work</td>
<td>Process</td>
<td>The results of CMMI implementation are achieved by focusing on the process of gathering information throughout the implementation.</td>
</tr>
</tbody>
</table>

B. Cultural construction

Case B differed from Case A on two dimensions: orientation to change and the basis of truth and rationality. First, in terms of orientation to change, the two organizations investigated operate in a relatively innovative industry and are thus willing to orient to change. However, Case B had the least difficulty changing processes after implementation, whereas Case A encountered a significant amount of resistance. Although Case A made efforts to change, it seemed unable to sufficiently conquer its orientation to stability to do so. The differences in this orientation between the two organizations offer further insight into the differences in the impact between the two organizations. Organizations that are more stability-oriented may wish to maintain the status quo and thus are reluctant to engage in the impact required for the extensive changes that CMMI necessitates. Furthermore, companies that are more change-oriented may not only be more willing to change, but because they desire breakthrough, they may better understand what it takes to do so. As the impact upon the organizational process is part of what is required, they may be better at or more aggressive about facilitating the impact. Thus, the cultural construction value on this dimension that best mitigates the impact is an orientation toward change.

Case B also differed from Case A in its basis of truth and rationality. The teams in Case
B emphasized personal experience in addition to hard evidence, whereas the teams in Case A relied primarily on hard evidence, often discouraging members from sharing "softer" information. This suggests that, although sharing hard evidence is important, this alone is not sufficient for the type of impact for sharing that is needed to establish an information institution of an organization, such as CMMI. Thus, the cultural construction value is hard evidence plus personal experience.

Interestingly, Case B differed from Case A on two other dimensions of culture. It differed on control, coordination, and responsibility and motivation. Case B was largely centralized, with concentrated decision making. Case B’s extensive information sharing is counter to what theory indicates about the role of autonomous decision making in times of organizational change. Theory indicates that decentralization promotes efficiency for the organizational process because it allows information to flow more freely throughout the organization and fosters the sharing of ideas [11]. One explanation for the impact at Case B is that because CMMI centralizes control through convergent data and integrated processes, a concentrated decision making structure may more closely match CMMI ML-3” (e.g., IPM, DAR), and thus also provide an atmosphere conducive to mitigating the impact during implementation. On the other hand, while CMMI centralizes data and processes, it simultaneously pushes decision making throughout the levels of the organization. Thus, an organization that lies on this dimension may not substantively influence the impact on CMMI implementation because CMMI requires both convergent and divergent decision making. Hence, this dimension should be considered within the context of other dimensions.

Case A was moving from decentralized silos to a more centralized locus of control, coordination, and responsibility. It had begun these changes prior to the CMMI implementation, but was still evolving during the implementation. In Case B, this dimension had been relatively stable. In Case A, the shift away from decentralized silos may have caused
people to feel unsettled or unsure of what was expected of them. Team members may have clung, either consciously or subconsciously, to autonomous behaviors that the prior control structure had enabled, and thus were not as willing or able to share their information. Thus, consistency in either concentrated or autonomous control, coordination, and even responsibility may be more important to the impact than the actual position within the dimension. Case B also differed from Case A in terms of the motivation dimension. Case B was the only firm in which project managers focused on external motivational factors. There is no specific evidence for how much of Case B’s impact is attributable to the external bonus plan. However, it is likely that because the external bonus plan was team-based, motivating individuals to maximize team performance rather than individual performance, the bonus plan created an environment in which individuals felt encouraged to share information or removed obstacles in the environment that may have precluded the impact. Thus, we have included team-based external motivation in the cultural construction.

While Case B relied on internal motivation, the relationship of internal motivation to the impact is not straightforward. Although orientation to collaboration is important to the impact, as evidenced in Case B, our findings suggest that a culture oriented toward collaboration alone is also not sufficient to mitigate the impact upon CMMI implementation. For example, even though Case B’s culture was one of collaboration and the implementation team members were accustomed to working in teams prior to the implementation, they found the impact during CMMI implementation more difficult because the environment of the CMMI implementation team was not conducive to the impact. Thus, a prior orientation to collaboration does not ensure that the impact will occur in any given new context. The environment of the team must be addressed and managed from the beginning of the implementation.

In addition, our data show that prior orientation to isolation does not necessarily impede
the impact on CMMI implementation. For example, Case A mitigated the impact early in the implementation, even though its existing culture valued isolation more than collaboration. It did so by structuring the team so that obstacles to collaboration such as seniority and functional distinctions were removed. This structure helped to create an environment of collaboration. Teams can take proactive steps or initiatives to conquer the isolation orientation that is rooted in the broader organizational culture. Thus, team environment and structure can conquer a culture of isolation. However, it is important to note that the impact broke down in Case A as the project progressed. Senior people began to resent the experience that junior people had gained and the power the environment provided the junior people. They began to retreat to the old culture of isolation by not listening to or valuing the input of the junior people on the team. Although the project managers had implemented successful interventions at the beginning of the project to mitigate the impact, they did nothing to reestablish an environment of collaboration when it broke down, even though they recognized that the breakdown had occurred. One possible explanation may be found in the influence of the traditional culture of isolation; perhaps the intervention was viewed as an effort to conquer an orientation to isolation, and the breakdown was viewed as evidence that this dimension of the culture could not be conquered. Although traditional orientation to isolation is not sufficient to impede the impact, the interventions to conquer this must be carefully managed and monitored throughout the project to maintain organizational processes. As the two organizations that exhibited the most documentation were highly collaborative, the cultural construction value for this dimension is collaboration.

Our data also suggest that an orientation to work that is focused on process rather than on deadlines and results is generally more conducive to a positive organization environment. Case B had a process-based orientation, but so did Case A. However, the impact of this dimension at Case A may have been minimized by factors within other dimensions discussed above. Thus, the impact of orientation to work on the impact may be contingent upon the
presence or lack of other factors, such as external change agents, in the organizational environment.

None of the two organizations differed on the orientation and focus or on the nature of time horizon dimensions of culture. In the two organizations, the aim was to cut costs and to improve operations by leveraging common processes. With regard to CMMI, there was an internal focus in the two organizations. Furthermore, the two organizations in this study spent approximately six or two years implementing CMMI ML-2 & ML-3, and both spent many months afterwards to achieve a "steady-state" of operations so organizational members understand how to use general goal (GG) and general practice (GP) of CMMI ML-2 & ML-3 effectively. Their commitments to implement CMMI were all long-range. Thus, there is insufficient variability among the organizations to assess the impact on the basis of these dimensions.

C. Summary and cultural construction

Through examining the dimensions of culture, it is apparent that there are complex interrelationships between the dimensions. However, two dimensions of culture unique to the two organizations that exhibited the most impact are orientation to change and the basis of truth and rationality. Case B had an orientation toward change, whereas Case A exhibited significant resistance to change. This highlights the importance of change management in CMMI implementation to prepare the organization and the project team for the impact. The second dimension, basis of truth and rationality, underscores the importance of sharing personal experiences in addition to hard evidence. This supports the document-based view of the organization, which asserts that employee information, experiences, and know-how are critical resources. While these two dimensions are necessary, the two case studies have demonstrated that each dimension must be supportive of the others, forming a cultural construction that is conducive to the impact upon CMMI implementation.
D. Obstacles to CMMI implementation

Applying the insights of cultural dimensions to the impact on CMMI implementation has allowed for a more thorough perspective of the link between culture and the impact. When analyzing the case data, it became evident that certain cultural obstacles impeded document management (e.g., information sharing) in CMMI implementation. For example, at Case A, organizational hierarchy distinctions carried over to the CMMI project team. This was an obstacle to document management because the more highly ranked members were unwilling to listen to members who ranked below them in the organization. This obstacle arose out of the organizational cultural norms for how superiors and subordinates interact (control, coordination, and responsibility dimension).

Although these obstacles existed, there is evidence that, at least sometimes, CMMI project teams were able to apply initiatives to conquer cultural obstacles. For example, Case A and Case B used formal and informal team-building exercises to help team members become accustomed to sharing and accepting both hard evidence and personal experience (basis of truth and rationality dimension). These initiatives were focused at the team level and therefore affected team culture, but not the broader organizational culture. Table V provides examples of obstacles and initiatives identified in this study, the dimensions they address, and how they helped conquer cultural obstacles.

The data suggest that elements of an organizational culture may act as obstacles to CMMI implementation teams. The project team may enact initiatives to conquer cultural obstacles, enabling the development of a project team subculture. External forces, such as the presence of an external integrator, may also influence team culture. This highlights the importance of understanding the norms, values, and modes of operation of external consultants or integrators prior to their selection. The resulting team culture, then, is a direct determinant of the extent to which information is shared within the implementation team. These relationships are shown in the proposed model in Fig. 2.
Table V Examples of initiatives to conquer obstacles to CMMI implementation

<table>
<thead>
<tr>
<th>Culture dimension</th>
<th>Obstacle</th>
<th>Initiative</th>
<th>Impact on CMMI implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation to change</td>
<td>Organizational propensity to maintain status quo carried over to the project team through functional organization of the team</td>
<td>Organized the team around processes rather than around functions</td>
<td>Mitigated the integration of documentation across processes, which helps to mitigate the integration of the processes themselves</td>
</tr>
<tr>
<td>Control, coordination, and responsibility</td>
<td>Organizational hierarchy distinctions carried over to team</td>
<td>Eliminated seniority and functional distinctions on the team</td>
<td>Encouraged junior people to share ideas without fear of reprisal or disapproval from senior people; Helped eliminate silo behavior between functional areas</td>
</tr>
<tr>
<td>Orientation to collaboration</td>
<td>Team members more likely to share information among those with whom they are already familiar</td>
<td>Structured the team</td>
<td>Brought team members from a diversity of perspectives and locations in proximity of one another; Eliminated physical distance to place team members in a situation where the impact was more likely to occur</td>
</tr>
<tr>
<td>Basis of truth and rationality</td>
<td>Team members prone to discourage the sharing of information</td>
<td>Used formal and informal team-building exercises</td>
<td>Helped orient team members toward both a willingness to share information and to listen to others, for hard evidence data and personal experience</td>
</tr>
<tr>
<td>Motivation</td>
<td>Team members prone to compete with one another for bonuses in the organization</td>
<td>Provided equal bonuses for all team members</td>
<td>Reduced tendency to hoard experience for personal gain or recognition</td>
</tr>
<tr>
<td>Orientation to work</td>
<td>Organization put pressure on the team to finish by a given deadline</td>
<td>Allowed team to rethink situations that do not seem to be working; Extended deadlines and reorganized document gathering where necessary</td>
<td>Placed focus on gathering the appropriate data</td>
</tr>
</tbody>
</table>
VI. Contributions and future research

The proposed cultural construction and research model arising from data collected in our two case studies extend theory about the impact upon CMMI implementation. They provide a theoretically grounded basis upon which future research can be built. Findings suggest that CMMI implementation project teams are influenced, but not necessarily bound by existing organizational culture. Although theories exist that support the idea of subcultures within an organization [12], these findings extend these theories specifically for the IS discipline. Because CMMI is often implemented to support change in the fundamental structure of an organization, it can also require or bring about changes in the underlying organizational culture to support the integration in a software engineering organization. Furthermore, the requirements for the impact do not stop with the implementation [30] [32]. Therefore, rather than forming a sub-culture, the initiatives that CMMI implementation project teams pursue in order to conquer cultural obstacles to the impact on the team during implementation may actually form the framework for changes in the broader organizational culture in a software engineering organization.

The research model and cultural construction can also be used as a foundation for
investigating further the nuances of the impact on implementing CMMI in software engineering organizations. While we examined the impact from a pragmatic perspective in this study, future research should also investigate the impact from a tacit and explicit knowledge perspective. This may yield additional insight on the way cultural obstacles affect the sharing of these specific types of knowledge. Organizations can use the examples of cultural obstacles to the impact as a basis to identify their own obstacles and to link those obstacles to specific aspects of culture. In addition, they can assess whether the obstacles are organizationally based issues, or whether they arise from within the team itself. This assessment is useful so that organizations can also determine the level at which an initiative is required. It is important that organizations monitor these initiatives and make adjustments as needed.

Our data show that clearly, the impact does not “just happen.” Understanding how these cultural dimensions influence organizational environment is important for practitioners engaged in CMMI implementation. It is crucial to recognize that other factors, such as leadership, technology, organizational change, evaluation and administration, may also influence the organizational environment in CMMI implementation. However, it could be argued that these all occur within the broader context of organizational culture. Thus, these findings provide insight into specific aspects of an organizational culture that may be built upon to mitigate the impact and to help identify cultural issues that may need to be addressed. Actions such as team-building activities, team bonus programs, relocation of team members and encouragement of members to contribute both "hard evidence" and "soft knowledge" to discussions are examples of changes that could be implemented to mitigate the impact upon CMMI implementation.

Appendix A

1. Orientation to Change (stability vs. change)
1.1. Do you believe that the organization is different now than before CMMI implementation? If not, why; if so, how?
1.2. Have the processes changed, or are they being changed because of CMMI?
1.3. How has CMMI changed the way you think about your job or the company?
1.4. What are some things that you learned about the business processes at the company that you didn’t know before the CMMI implementation?

2. Control, Coordination, and Responsibility (autonomous vs. concentrated decision making)

2.1. How easy or difficult is it to gain access to people or resources in other units that might be helpful for projects in your own unit?
2.2. Are employees encouraged to be ‘free thinkers’ and to find new and creative ways to complete their jobs?
2.3. To what extent do rules and procedures govern your daily work activities?
2.4. How would you describe the structure of the organization (e.g., is it primarily decentralized or centralized)?

3. Orientation to Collaboration (isolation vs. collaboration)

3.1. Do you usually work on a project team or do you primarily work alone on projects?
3.2. Do you think you are more rewarded for individual activities or for work on teams? How important is project teamwork to your company?
3.3. Are teams primarily made up of people from the same functional areas or from across functions?
3.4. How would you describe the culture of the firm?
3.5. How did your team seek input from others in the company on areas where you were uncertain?
3.6. How did your team seek to keep others in the company informed about company goals and progress on CMMI?
3.7. Do you think this was ever seen as simply another IT project?

4. Basis of Truth and Rationality (hard evidence vs. personal experience)

4.1. During CMMI project team meetings, were people encouraged to express their ideas, even if they weren’t fully formed yet? And did they express these ideas?
4.2. Was there ever anything in the implementation process you felt just wasn’t right, but couldn’t exactly explain why? If so, did you express this? Why or why not?
4.3. Was there anything you assumed to be true about CMMI that you later changed your mind about?

5. Motivation (external vs. internal)

5.1. How were the CMMI project team members selected?
5.2. How were differences in perspectives melded together?
5.3. Was this easy or difficult?
5.4. Was there ever a time when differences couldn’t be resolved? (If so, how was that handled?)
5.5. How were team members rewarded for work?

6. Orientation to Work (process vs. results)
6.1. How much focus was there on meeting deadlines and finishing the project under budget?
6.2. How well were deadlines met?
6.3. When deadlines weren’t met, what was the reason?
6.4. How did your team determine whether the goals were valid and being met?

7. Orientation and Focus (external vs. internal)

7.1. How did your team learn about opportunities CMMI could provide your firm?
7.2. Do you think this learning process occurred throughout the implementation?
7.3. How much did your group rely on outside consultant expertise?

8. Nature of Time Horizon (short term vs. long term)

8.1. What was the timeline for your CMMI implementation?
8.2. How long did you spend planning for CMMI prior to beginning the implementation?
8.3. Is the CMMI implementation part of an organizational effort?
8.4. What are the goals for CMMI?
8.5. What are the primary benefits your organization wants to realize from CMMI?

References


[41] SEI, *Capability Maturity Model Integration (CMMISM), Version 1.1*. CMMISM for


