Competing values in software process improvement: a study of cultural profiles

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Abstract

Purpose – The purpose of the article is to investigate the impact of organizational culture on software process improvement (SPI). Is cultural congruence between an organization and an adopted process model required? How can the level of congruence between an organizational culture and the values and assumptions underlying an adopted process model be assessed?

Design/methodology/approach – The competing values framework and its associated assessment instrument are used in a case study to establish an organizational culture profile of a software development business unit within the case company. The instrument is supplemented with a technique to produce culture profiles of texts such as process models like the Capability Maturity Model Integration (CMMI) and the case company’s quality management system. The different profiles are subsequently analyzed and compared.

Findings – The culture profile of the CMMI confirms previous research and depicts a result-oriented, formalized, and structured organization. A comparison with the company’s quality management system shows congruent culture profiles suggesting that the case company has succeeded in capturing underlying assumptions of the CMMI when updating the quality management system. The analysis also reveals the organizational culture profile of the business unit to be incongruent with the quality management system’s profile. This disconfirms previous research claiming that congruence is a prerequisite. Further analysis reveals that actions were taken by managers in the case company to address the cultural challenges and successfully implement new processes. It is, therefore, concluded that cultural incongruence is not an insurmountable barrier to SPI. By comparing cultural profiles, some SPI implementation challenges become evident and that in turn allows for effective SPI management action.

Research limitations/implications – The research is based on a single case study and that is sufficient to disconfirm existing research. Additional research is, however, needed to validate both the proposed text analysis technique as well as the proposed process for assessing and managing cultural challenges confronting SPI projects.

Practical implications – SPI managers are provided with a more complex view of organizational culture in which congruence is not a necessity. SPI managers can choose to compare culture profiles and decide how to address incongruences. To that end the text analysis technique is offered as a web service that allows for analysis of all text-based process models and standards, and of internal process documentation.

Originality/value – The proposed culture management process, including the text analysis technique, is a cost-efficient approach to analyzing and providing the basis for managing cultural challenges during SPI in a specific company. The process provides understanding and guidance in dealing with the specific challenges faced by software companies during SPI.

Keywords Capability Maturity Model Integration (CMMI), Competing values framework, Organizational culture, Culture profiles, Software process improvement, Values

Paper type Research paper
1. Introduction

Over the past two decades, researchers have made significant advances in developing models for software process improvement (SPI) (Niazi et al., 2005), including the capability maturity model (CMM) (Paulk et al., 1993), Bootstrap (Kuvaaja and Bicego, 1994), and SPICE (El Emam et al., 1998). Such models are designed to help managers improve software quality and reliability, employee satisfaction, and return on investment (Mathiassen et al., 2005). The capability maturity model integration (CMMI) (Capability Maturity Model Integration (CMMI) Product Team, 2010) is the most recent model targeting software and systems development organizations. Unfortunately, the level of success in implementing SPI is low (Kautz and Nielsen, 2004; Niazi et al., 2005; Pino et al., 2008; Rainer and Hall, 2003).

A substantial body of literature has investigated the challenges faced by SPI managers. Process implementation is a highly emergent and risk-prone activity, that is, both enabled and constrained by context (Allison and Merali, 2007; Iversen et al., 2004). Divergences between maturity models’ values and organizational culture threaten successful process implementation (Müller et al., 2009; Ngwenyama and Nielsen, 2003). Managers often focus on reaching particular maturity levels rather than improving current practices (Hardgrave and Armstrong, 2005). Effective diffusion of processes across individuals and organizational units requires a portfolio of knowledge management mechanisms (Slaughter and Kirsch, 2006). And, to be accepted, the prescriptions made by SPI models must be combined with key stakeholder perceptions and experiences (Napier et al., 2009). Finally, implementing software processes involves competing interests, values, and approaches, and may thus be influenced by organizational politics (Kautz et al., 2001; Nielsen and Nørbjerg, 2001; Stelzer and Mellis, 1998). Although all these perspectives are valid and highly relevant, we focus in this paper solely on organizational culture.

Previous studies have stressed the importance of organizational culture in SPI (Siakas and Georgiadou, 2002; Sharp et al., 1999; Schneider, 2002; Dangle et al., 2005). Stelzer and Mellis point to the necessity of “anchoring changes in the organization’s culture” (Stelzer and Mellis, 1998, p. 230); Fitzgerald and O’Kane emphasize a “strong and pervasive culture for software process improvement” as a critical success factor in SPI (Fitzgerald and O’Kane, 1999, p. 39); and Dybå argues that “if the new process is not aligned with the business strategy or does not match the organization’s culture, it will be rejected by the ‘organizational’ body” (Dybå, 2005, p. 418). SPI is not only influenced by organizational culture, SPI may itself have an impact on organizational culture. According to Dion, SPI is a catalyst for organizational culture change (Dion, 1993). For his part, Aaen states that “based on the software capability maturity model (CMM) and similar norms, SPI aims to build an infrastructure and culture that support effective methods, practices, and procedures and integrate into the ongoing way of doing business” (Aaen, 2003, p. 86). These studies have put organizational culture on the agenda among SPI managers and researchers.

Despite references to the importance of organizational culture, for example, as part of factor analyses (analyses of factors impacting SPI success), our review of the literature reveals that few studies have focussed explicitly on the topic. Four papers are notable exceptions. Boehm (2000) has found that the adoption of software process models promotes certain types of organizational cultures, implying a possible conflict between the maturity model being used and the culture of the organization. In line with Boehm, Dubé and Robey (1999) conclude that successful implementation and management of SPI depends on the fit between the values of various subgroups and the values underlying the new software process. Along the same line of reasoning,
Dube´ (1998) argues that alignment between the values underlying a software process and the organizational culture promotes implementation. Finally, Phongpaibul and Boehm (2005) emphasize that the cultural assumptions underlying process models like the CMM and CMMI are of western origin which necessitates adaptation to the national culture context of an organization. None of these studies has, however, investigated how organizational culture impacts SPI.

Despite these contributions to our knowledge about organizational culture in SPI, existing research has not sufficiently dealt with the consequences of cultural incongruence, i.e. the differences between organizational cultures and the value orientations underlying process models. Among other things, existing research does not adequately address the need for cultural congruence between SPI models and software organizations to achieve success. Against this backdrop, we contribute to state-of-the-art knowledge about SPI by investigating how to identify and cope with cultural incongruence based on a case study of SPI at Terma, a Danish high-tech company. Specifically, we establish and compare organizational culture profiles of one business unit, Integrated Systems (ISY), within Terma and the company’s CMMI-based standard operating procedures that were used as basis for SPI implementation. We analyze ISY’s ability to successfully implement new processes despite cultural incongruences based on the competing values framework (Cameron and Quinn, 2006) and we offer lessons learned from this analysis. We provide guidance to SPI managers by detailing how to assess and address the cultural challenges confronting SPI projects.

The competing values framework has previously been used in Ngwenyama and Nielsen (2003). They report from a theoretical study of the CMM models Software CMM (SW-CMM) and People CMM and claim that mismatching assumptions underlying the CMM models help explain implementation difficulties. The CMM models contain several major contradictions in terms of organizational culture – contradictions which may pose insurmountable challenges to an implementing organization. Based on a survey of Taiwanese companies, Shih and Huang (2010) conclude that organizational culture influences SPI deployment. Whereas a hierarchical culture facilitates SPI implementation, a clan culture creates the necessary conditions for skills development and SPI knowledge being shared during implementation (Shih and Huang, 2010). Following in the footsteps of Ngwenyama and Nielsen (2003), Müller et al. (2009) demonstrate how variations in culture across software organizations can have important implications for SPI outcomes. We extend this line of research by investigating whether cultural congruence between an organization and an adopted process model is required? In answering this research question, we demonstrate how the level of congruence between an organizational culture and the values and assumptions underlying an adopted process model can be assessed.

The paper is organized as follows. In the next section we present the competing values framework and its associated assessment instrument. Section 3 outlines the research approach based on the framework. In Section 4 we describe the case company and the SPI project. In Section 5 we make cultural diagnoses and identify (in-)congruence(s) between organizational culture profiles of the business unit and process documentation used for SPI purposes. In Section 6 we discuss the results, including how the incongruences were addressed, and in Section 7 we highlight the implications for both researchers and practitioners. Section 8 touches upon key limitations, and section 9 concludes the paper.

2. Competing values framework
Our primary focus is on understanding organizational culture and how an understanding of organizational culture can support SPI. Several theories of
organizational culture and change exist. Schein, for example, defines organizational culture as “a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems” (Schein, 2004, p. 17). In this paper, we subscribe to Schein’s definition but also to the view that organizational culture can be understood through organizational artifacts: visible organizational structures and processes; values and underlying assumptions; and symbols (Ngwenyama and Nielsen, 2003; Rafaeli and Worline, 2000; Schein, 1991).

For the purpose of understanding organizational culture, we have chosen the competing values framework (Quinn and Rohrbaugh, 1983; Quinn and Rohrbaugh, 1981; Quinn and McGrath, 1985; Cameron and Quinn, 2006) for the following reasons. First, the framework’s focus on understanding and changing organizational cultures which is relevant to SPI, because changing software processes is also about organizational change. Second, the framework contains four distinct perspectives on organizations through which we can analyze the underlying assumptions of the case company, its organizational artifacts, and its management challenges. Third, we are seeking to relate directly to and extend the results of Ngwenyama and Nielsen (2003) who applied the framework to SPI for the first time. Fourth, the framework is useful in offering clear conceptualizations of four culture types and it includes an instrument to establish organizational culture profiles (Cameron and Quinn, 2006, p. 16).

The competing values framework identifies two dimensions on which organizations differ (Cameron and Quinn, 2006). The two dimensions are: flexibility and discretion vs stability and control and external vs internal focus. The first dimension shows that some organizations are structured and act around the notion of stability, order, and control of human behavior while other organizations are structured and act with an emphasis on flexibility, dynamism, and trust in human judgment. The second dimension shows that some organizations are focussed on internal integration and unity while other organizations are focussed on external market differentiation, competition, and rivalry. These two dimensions delineate four types of organizational culture. The basic value orientations of these culture types are competing in the sense that they represent opposite assumptions.

The four culture types are labeled Clan, Adhocracy, Market, and Hierarchy (Cameron and Quinn, 2006). Each of the four culture types differs significantly from the others (cf. Figure 1). The Clan type is similar to a familytype organization with shared values and goals, internal cohesion, participation, and leaders acting as mentors; emphasis is on commitment, teamwork, and consensus. The Adhocracy type is an innovative organization pioneering new products; it emphasizes adaptation and flexibility in environments characterized by uncertainty and ambiguity. The Market type is oriented toward the external environment and it is often characterized by a decentralized structure. It focusses on strategic planning, competitiveness, and productivity. The Hierarchy type is governed by rules with an emphasis on efficiency, reliability, and predictability of production; both its environment and its activities are considered stable, making fine-tuning of procedures and control mechanisms possible.

The four culture types are theoretical constructs or ideal types, and most organizations contain elements of all of them (Cameron and Quinn, 2006). Only when viewed through the theoretical framework does an organizational culture appear as a mixture of culture types. In reality an organizational culture is unique and possesses very-specific characteristics. To assess the organizational culture profile, i.e. the mix of
culture types, Cameron and Quinn have developed an assessment instrument that has been validated and verified for reliability through several studies (Cameron and Quinn, 2006; Howard, 1998).

The assessment instrument uses a survey to establish a culture profile based on the four culture types. The instrument assesses the relative importance of elements of each culture type in an organization. For example, an organization might be dominated by the Clan culture type (45 percent), supported by elements of the Adhocracy culture type (35 percent), but only marginally influenced by the Hierarchy and Market culture types (10 percent), see Figure 2. In order to avoid attaching too much importance to the numerical value ascribed to each culture type, the percentage points should be interpreted as expressions of tendencies within the organization rather than facts (Cameron and Quinn, 2006).

The survey consists of six items or questions each having four alternative answers. For each question, the respondent divides 100 points among the alternatives. Percentages are calculated based on summary scores (see Appendix 1; Cameron and Quinn, 2006) and show the relative importance of each culture type. The percentage points are shown in a culture profile chart, cf. Figure 2. The chart corresponds to the two dimensions and four quadrants of the competing values framework, cf. Figure 1.

Two culture profiles are said to be congruent if the primary types are the same and if the differences between types are less than 10 percentage points.

The competing values framework has been used in several studies within IS research. Specifically, it has been used by Iivari and Huisman (2007) to explore the relationship between organizational culture and deployment of systems development methodologies; Shih and Huang (2010) have used it in a survey of the relationship between organizational culture and deployment of software processes; and Ngwenyama and Nielsen (2003) have relied on the framework in characterizing and analyzing the assumptions underlying the CMM models.
3. Research approach

The case study method is a well-established research approach within IS (Benbasat et al., 1987; Lee, 1989; Cavaye, 1996). In our case, we are investigating how organizational culture impacts SPI with the goal of understanding cultural profiles by using the competing values framework. It is an exploratory case study in which we utilize access to multiple sources of qualitative and quantitative data to gain a detailed understanding of how culture impacts SPI and can be managed to ensure successful implementation of new and improved processes.

The research was conducted at Terma, a Danish high-tech company that offers a wide range of mission critical off-the-shelf systems and products for civilian and military use. Terma consists of autonomous business units, one of which, ISY, is part of this study. The business units span a variety of application areas, including defense, aerospace, and surveillance. Within these areas, Terma develops "products and systems for a number of non-defense and defense applications, including command and control systems, radar systems, electronic warfare systems, space technology, and aeronautic structures for high-performance military aircraft" (www.terma.com). During the case study, Terma undertook a large internal project to improve its software processes and the goal was to reach CMMI level 2. Thus, the Terma case served our research objective well.

The case study reported here was part of a larger collaborative practice research project (Mathiassen, 2002) that ran from May 2005 to October 2008. The larger research project in which the lead author was a key participant provided the backdrop against which the case study was selected and our data collection and analysis activities were designed. His role in the SPI project at Terma was to contribute state-of-the-art knowledge and study the organizational consequences of implemented changes.

3.1. Data collection and analysis

The data collection and analysis were divided into two steps. During the first step, we collected data using the assessment instrument, cf. Section 2. Using the assessment...
The assessment instrument’s survey was translated from English to Danish, the native language of the respondents in ISY. The survey was digitized and the software tool Inquisite was used to support both data collection and data analysis. After the SPI project, the survey sent to the whole population of middle managers, project managers, and project participants in ISY having participated in the SPI project. All employees who were tasked with putting the new processes at CMMI level 2 into practice were included. This decision was made to focus directly on those involved and to minimize the disruption to the rest of the organization. Thirty-seven (85 percent) of the selected respondents completing the survey. After the data were collected, the data were aggregated and a culture profile was produced as described by Cameron and Quinn (2006, p. 59), cf. Section 2 and Appendix 1.

During the second step, we analyzed key documents used in the SPI project by means of a quantitative text analysis technique developed for that specific purpose. This technique was inspired by Ngwenyama and Nielsen (2003) and their qualitative analysis of the CMM. The literature shows that the culture profile of an organization or cultural artifact, e.g. internal documents, can be determined through qualitative data analysis (Marshall et al., 2003). Specifically, Ngwenyama and Nielsen (2003) argued – based on a qualitative content analysis – that the CMM is primarily grounded in the Market culture type and subsequently moves toward Hierarchy at higher maturity levels[2].

The text analysis technique that we have designed is also based on the competing values framework. Using the technique, we can produce culture profiles of the CMMI as a text and the company’s standard operating procedures known at Terma as the Terma Management System (TMS). All the policies and procedures that had been updated as part of the SPI project were identified and a culture profile was produced at an aggregate-level across TMS documents. The quantitative analysis technique applied on the texts describing the CMMI and in the TMS yielded culture profiles of the documents. With this technique we extend the line of research qualitative cultural analysis into a quantitative analysis.

The text analysis technique works in the following way. We searched the documents for words and phrases associated with each of the four organizational culture types. To that end, we used the software tool ATLAS.ti to perform word counts and frequency analyses of the documents. The search terms were derived from the detailed descriptions of the four culture types. The description of each culture type was scrutinized in search of words and phrases that describe the culture types (Cameron and Quinn, 2006, pp. 33-40). The selection of keywords and phrases was a collaborative process in which these culture codes were proposed and validated through discussion among the authors of this paper. The authors read the four culture type descriptions individually in search of key words and phrases and subsequently compared results revealing an estimated intercoder reliability (percentage of agreements between two authors coding the same transcript) of 80 percent (Miles and Huberman, 1994). During this process, some of the proposed culture codes were discarded while new ones surfaced. At first, some culture codes were too broad (e.g. risk) while others were too
specific (e.g. result orientation) to warrant a search for their occurrence. Afterwards, we searched for occurrences of the selected words and phrases in the CMMI and the TMS using ATLAS.ti. Since some of the words and phrases were ambiguous and not readily operable in such a search, it was necessary to modify some culture codes and include synonyms and various combinations of words. Arriving at these synonyms and word combinations involved defining, discussing, and redefining more than 250 culture codes.

Three examples illustrate the need for these synonyms and word combinations. First, the concept of “employee development” (Clan culture) is synonymous with “personal development,” and we wanted to make sure that our search included such synonyms. Consequently, in line with this example we established a list of synonyms for each word or phrase that was part of one of the four culture types. Second, the concept of “risk taking” (Adhocracy culture) may not only be expressed in numerous ways, e.g. “taking a risk” and “taking chances,” but may also be described as something undesirable which stands in contrast to its positive connotation in the Adhocracy culture type. We wanted to make sure that our search only included “risk taking” as desirable behavior. Therefore, we established a number of compound codes like “risk” not co-occurring in the same sentence with “avoid.” Third, different inflexions of the word “predictability” (Hierarchy culture) exist. It may, for example, appear as “predictable,” “predict,” etc. and we wanted to make sure that our search included such inflexions. Therefore, we used wildcards in our searches, i.e. “predict,*” to encompass all occurrences. Examples are shown in Appendix 2.

Having searched the documents in a systematic and exhaustive manner for words and phrases that describe the culture types, we performed weighed distribution analyses taking into account an uneven number of words and phrases for each culture type to determine the prevalence (in percentages) of the four culture types in each of the documents. See Appendix 3 for an example calculation. Based on the distribution analysis we established aggregate culture profiles of the CMMI and TMS documents.

In addition to using Cameron and Quinn’s (2006) assessment instrument and performing quantitative text analysis, we conducted post-project, qualitative interviews with key stakeholders to evaluate the impact and success of the SPI project. A total of eight semi-structured interviews were conducted.

4. Case description
ISY, one business unit at Terma, is a global provider of advanced defense technology. ISY specializes in various network and tactical systems, including air traffic management systems, naval command and control systems, and naval decoy systems. At the time of the case study, ISY was a project organization of 155 employees.

At the beginning of the millennium, many Terma projects experienced problems staying within schedule and budget, and several major customers were voicing concerns about the company’s ability to fulfill its contractual obligations. As a result, a SPI project was launched in 2005 with the goal of reaching CMMI level 2. CMMI level 2 is the level at which project management practices are stable and repeatable (CMMI Product Team, 2010). The project was divided into two phases: a process definition phase and an implementation phase. The first phase served to close the gaps between the CMMI requirements and the company’s standard operating procedures, i.e. the TMS, before executing an organization-wide implementation strategy during the second phase. During the first phase, small teams were tasked with making existing company policies and procedures compliant with the CMMI. These policies
and procedures were part of the TMS, a comprehensive ISO-9001-certified quality system containing more than 1,000 development and management processes. During the second phase, these policies and procedures were put into practice at the business unit level based on local implementation plans. A questionnaire-based self-assessment tool was used to assess implementation progress and software development projects’ compliance with CMMI level 2 (Müller et al., 2007).

Coinciding with the SPI project, ISY faced market demands for proof of process maturity. Management pointed to contract negotiations in which ISY’s lack of a CMMI appraisal had been a problem. As a consequence, they supported the project in words and deeds. Throughout the project, management’s involvement level was high and their implementation timetable was ambitious. The SPI implementation was planned and monitored like any other project. Corrective actions were initiated based on progress reports and assessments of available data. After evaluating implementation progress and problems – including lack of training and information about new processes – the ISY implementation manager and the ISY training manager modified the implementation plans. They identified a need for guidance and leadership, identified gaps between existing practices and new processes, and established solutions across all projects based on their formal authority to ensure compliance. The managers used maturity assessments to evaluate progress and plan corrective actions, and they immediately responded to unsatisfactory results. Confronted with confusion and uncertainty about how to implement processes into projects, they intervened and supported each project manager individually. Weekly and monthly meetings were also held to share knowledge and experience; the meetings helped drive process implementation forward. All signs of resistance were immediately identified and addressed by the ISY implementation and ISY training managers.

In the end, adopting the CMMI and rationally executing the SPI implementation left a strong impact on ISY projects. They made consistent improvements in process maturity throughout the project and achieved CMMI level 2 compliance. Out of seven projects that were selected for SPI participation, six projects demonstrated improvements from one maturity assessment to the next. Hence, in the end ISY accomplished the defined SPI goal.

5. Analysis
In this section we present the results of the text analyses of the CMMI and the TMS, the analysis of ISY based on the assessment instrument, and comparisons across the analyses.

5.1. Analysis of the CMMI
The culture profile shown in Figure 3 was produced by following the text analysis technique described in Section 3. The primary culture type is Hierarchy (36 percent) and the secondary type is Market (32 percent). With respect to the dimensions (cf. Section 2) on which organizations differ, the Hierarchy and Market culture types dominate the profile with their emphasis on stability and control. Conversely, the Adhocracy (7 percent) and Clan (25 percent) culture types – emphasizing flexibility and discretion – are less dominant as a group, especially the Adhocracy culture type with its emphasis on creativity, innovation, experimentation, and flexibility.

This result concurs with previous research (Ngwenyama and Nielsen, 2003; Rose et al., 2008). Ngwenyama and Nielsen concluded that “the core assumptions of the CMM paradigm are based on rational rule-governed organization structures that
are oriented toward stability, control, and productivity” (2003, p. 104). For their part, Rose et al. (2008) found that the organizational and managerial assumptions behind the CMM include process orientation, hierarchical management, standardization, and objective measurement. Based on our text analysis, we reach a similar conclusion in the sense that both the primary and secondary culture types are predisposed toward stability and control.

Both the qualitative analysis by Ngwenyama and Nielsen and our quantitative text analysis technique are based on the competing values framework, cf. Section 2. Based on a qualitative analysis of the SW-CMM documentation, Ngwenyama and Nielsen (2003) conclude that the SW-CMM is based on rational ideals, foster culture profiles dominated by the Market culture type, and shares many aspects of the Hierarchy culture type. The consistency between their and our findings not only lends support to our results but also to our text analysis technique.

The CMMI describes an evolutionary path for organizations to follow in improving software and systems development processes. The model focusses on different aspects at each maturity level: project management at level 2, process standardization at level 3, statistical process control at level 4, and continuous improvement at level 5 (CMMI Product Team, 2010). Based on their qualitative analysis, Ngwenyama and Nielsen (2003) also concluded that the lower maturity levels lean toward the Market culture type and the higher maturity levels toward the Hierarchy culture type. Expectations were, therefore, that an investigation of CMMI maturity level 2 (ML2) based on our text analysis technique would produce the same result. Figure 4 depicts a comparison between the profile of the CMMI in its entirety and CMMI ML2. It shows that both profiles are dominated by the Market and Hierarchy culture profiles, but it also shows that whereas Hierarchy is the primary culture type in the CMMI, Market is primary at ML2. Again, this is consistent with the qualitative analysis (Ngwenyama and Nielsen, 2003). Consequently, CMMI ML2 focusses on aspects associated with a result-oriented organization (Market) to a greater
Acknowledging the differences between the CMMI and CMMI ML2 has important implications for our study.

5.2. Analysis of the TMS
The TMS was updated to reflect the CMMI ML2 requirements as part of the SPI project. Hence, comparison between the CMMI ML2 and the TMS is appropriate. The TMS is text based and can therefore be subjected to our text analysis technique. The result of this analysis is illustrated in Figure 5.

Comparing the TMS and CMMI ML2, the culture profiles are overall congruent since the primary types are the same and the differences between culture types are less than 10 percentage points, cf. Section 2. Looking at the four culture types, Market is primary culture type in both the TMS and CMMI ML2, and only small differences exist between the culture profiles (1-4 percentage points for each of the culture types). In addition to being congruent, the almost identical culture profiles indicate that the teams tasked with updating the TMS were successful in making company policies and procedures compliant with the CMMI ML2.

5.3. Analysis of ISY
Based on the survey (cf. appendix 1), a culture profile of ISY was developed. Figure 6 illustrates the profile.

The analysis of the data from the survey in ISY reveals that the Hierarchy culture type is primary (33 percent) indicating that stability, efficiency, and structure take center stage. The Clan culture type is secondary (25 percent) which underscores the importance of internal orientation, integration, and unity. The primacy of the
Hierarchy culture type suggests that ISY is a very formalized place to work in which procedures govern what people do, including how they develop software. Furthermore, the Clan culture type adds the importance of teamwork to this characterization. Software is developed by empowered teams. Interestingly, all four culture types
5.4. Comparison of analyses

It is now possible to compare the culture embedded in the management system (the TMS) and the organizational culture of ISY. Figure 7 shows an overlay of the TMS and ISY culture profiles. It is worth noting that the figure juxtaposes culture profiles based on different data sources, i.e. the assessment instrument and our text analysis technique.

Two culture profiles are congruent if their primary types are the same and if differences between the same culture type are less than 10 percentage points, cf. Section 2. As Figure 7 illustrates, the two culture profiles differ in terms of primary culture type and differences exist between the profiles across two culture types. The primary culture type of the TMS is Market whereas Hierarchy is primary in ISY. The Market culture also accounts for the largest difference (13 percentage points) between the TMS and ISY. The Adhocracy culture is more prominent in ISY when compared to the TMS (an 8 percentage point difference). Again, it is important not to attach too much importance to the numerical value ascribed to each culture type but to interpret them as expressions of tendencies within the organization. However, the analysis suggests that the TMS is more result oriented than the people who are working by the new processes. The ISY culture profile indicates that the employees value creativity and innovation in their work life more than simply achieving measurable goals and winning market shares. Based on these observations, we conclude that the profiles are incongruent according to the guiding principles offered by Cameron and Quinn (2006).
6. Discussion
The analysis shows that the culture profiles of ISY and TMS differ in several respects and, most conspicuously, they are incongruent. In the face of cultural incongruence, Cameron and Quinn (2006) recommend initiating organizational culture change toward a desired future culture. If ISY had followed this recommendation, they would have initiated a culture change based on the TMS profile as the desired future culture and striven for cultural congruence. The TMS embodies a desired future culture in the sense that it represents the goal of SPI, i.e. it describes ideal practices that employees should strive for. According to Cameron and Quinn, cultural incongruence stimulates an awareness of the need to change the organizational culture to align the current with the desired culture profile, because incongruence signals ambiguity, lack of unity, and discrepancies between organizational behaviors and espoused values. However, while long-term cultural incongruence inhibits the organization’s ability to perform at high levels of effectiveness, temporary incongruence may be functional by highlighting uncomfortable aspects of the organization and motivating change (Cameron and Quinn, 2006, pp. 73-74).

Once the need for changing the organizational culture has been recognized, Cameron and Quinn (2006) suggest following a six-step process for designing and implementing the change. According to the six-step process, key stakeholders first need to reach consensus on the current culture based on analysis of a culture profile produced with the assessment instrument. Second, these key stakeholders have to reach consensus on the desired future culture through discussions revolving around a preferred culture profile. Third, the stakeholders determine the implications of culture change, and, fourth, agree on how to convey the desired values underlying the future organizational culture. Fifth, they identify behaviors that will be encouraged and discouraged, and, sixth, develop an implementation plan, including a timetable, benchmarks, and a communication strategy.

ISY did not follow the six-step process of organizational culture change. Nor did they deliberately pursue organizational culture change by other means. Yet they were able to successfully implement the new CMMI-based policies and procedures in the TMS. Consequently, ISY improved their organizational effectiveness despite the cultural incongruence between ISY and the TMS. The SPI implementation in ISY was successful for a number of reasons. First, subsequent assessments showed implementation progress and, eventually, that they had reached CMMI level 2. Second, the implementation also resulted in perceived improvements in the minds of the project managers. For example, a project manager described the new TMS templates as follows:

I honestly think the [new] templates are quite cool. In reality, they are a gift in disguise. I tried to use them on some small projects, and they were actually very useful.

Interviews with the other project managers in ISY reveal that they share the same sentiment. Another project manager praised the new project status meetings:

One of the things that unknowingly has become an excellent practice, and that the SPI project has imposed on us, is holding monthly status meetings – project status meetings. It is a matter of us doing it so often that we now can begin to call it a good habit.

ISY did not pursue organizational culture change; instead they handled the challenges of implementing new software processes directly and explicitly as SPI management issues. Each challenge was handled as it surfaced through active and deliberate management action. First, in response to growing skepticism among developers and
project managers, the ISY senior VP visibly stressed the need for improvements in an effort to instill a sense of urgency and to motivate the employees to participate in the SPI initiative. Having taken stock of the external environment and the competitive position of the company, the VP recognized and wanted to communicate the need for aggressive action to meet customers’ expectations and exceed competitors’ performance in the future. Second, the ISY implementation manager and the training manager who were responsible for software processes implementation and training in ISY recognized the need for supporting and guiding the project managers in interpreting and employing the new processes in practice. Third, the ISY implementation manager supported implementation by making expectations clear to the employees and assisting them in adapting the new processes to their work setting. Fourth, he also ensured that appropriate monitoring systems in the form of self-assessments were in place to keep process compliance under control. Fifth, he coordinated actions through weekly project meetings and monthly department meetings within ISY to ensure that knowledge was shared across projects and other organizational boundaries. Sixth, the training manager nurtured interpersonal relationships and provided supportive feedback to project managers on their performance by following up on assessment reports with the project managers. Seventh, she helped the project managers improve their performance by expanding their competencies to include knowledge of the CMMI through meetings to clarify the CMMI requirements in the context of ISY projects.

The management actions taken in ISY differ in several respects from the recommendations by Cameron and Quinn (2006) on organizational culture change. The TMS contains a desired future culture, that is, incongruent with the current culture in ISY (cf. Figure 7). A culture change process to align the ISY organizational culture with the culture profile of the TMS would result in different recommendations based on observed differences between the two culture profiles. From the perspective of the competing values framework the current culture in ISY should be aligned with the culture profile of the TMS and such an alignment would require different management actions than those in ISY. As previously noted, ISY is more Adhocracy oriented than the TMS but less Market oriented. The TMS has Market as its primary culture type whereas Hierarchy is primary in ISY. In addition, ISY is dominated by an internal focus (33 percent Hierarchy and 25 percent Clan) while the TMS, on the other hand, is dominated by stability and control (36 percent Market and 30 percent Hierarchy). A culture change in ISY toward greater Market orientation would entail pushing for an external focus on competitiveness and market share (cf. Figure 1). In a software developing company like ISY such a change would require developers and leaders to be sensitive to demands and trends in the market. In a Market culture standards and benchmarking techniques are used to improve performance vis-à-vis competitors. One way to accomplish this would be to change software development practices to accommodate users’ needs and shorten the time to market of the company’s software products, for example, by using rapid prototyping or similar software development methodologies. A change in ISY toward the TMS culture profile would also require deemphasizing the Adhocracy culture type which would entail sacrificing innovativeness and being a technology leader for the sake of capturing a larger market share. Software development in a Market culture is less focussed on experimentation and cutting-edge IT than using proven methods and mature technologies. However, ISY neither changed their overall software development methodology to cater more to users’ needs but remained with their software development methodology based on the waterfall model which is in keeping with Hierarchy as the
primary culture type (cf. Figure 3). Nor did ISY change its business strategy from niche to mass production to capture a larger market share. In effect, management practices were not changed in ISY to accommodate the cultural values underlying the TMS. The incongruence remained. However, the SPI project led to TMS adoption in ISY despite the cultural differences between ISY and the value orientations of the management system.

We thus conclude that ISY successfully implemented new software processes that were incongruent with the existing organizational culture without initiating or prompting an organizational culture change. This conclusion runs counter to existing SPI theory. First, while our research confirms the importance of considering organizational culture in SPI, it also challenges existing notions of cultural management. Existing research identifies organizational culture as an important factor influencing SPI (Siakas and Georgiadou, 2002; Sharp et al., 1999; Schneider, 2002; Dangle et al., 2005). Although our findings concur, little guidance is offered in the existing literature apart from emphasizing the need for alignment between envisioned changes and the organizational culture (Dyba®, 2005; Stelzer and Mellis, 1998). Such advice is, however, too broad to help us explain the ISY case. Second, contrary to Boehm’s call for a unifying culture between applied software development methodologies and the organization (Boehm, 2000) our research demonstrates the possibility of implementing software processes without embracing the underlying culture type of the processes. This finding goes beyond the identified incongruence between the TMS and ISY. Because the TMS is congruent with the CMMI, we infer that it is possible to adopt CMMI-based processes in a culture incongruent with the CMMI. Third, our findings question whether alignment between the organizational culture and the values underlying software processes is necessary for successful SPI implementation. As previously noted, alignment between the values embedded in development processes and the organizational culture has been linked to implementation success (Dubé, 1998; Dubé and Robey, 1999). Our case study shows that such alignment is not always a prerequisite for successful SPI implementation. This finding is also at odds with Ngwenyama and Nielsen (2003). Using the competing values framework, Ngwenyama and Nielsen (2003) reach the conclusion that misalignment between the cultural assumptions underlying the CMM and the culture of the adopting organization may jeopardize SPI implementation. Although our research does not indicate that implementation of software processes is easy and straightforward, it shows that cultural incongruence is not an insurmountable barrier to SPI. However, our analyses confirm that organizational culture influences how SPI should be managed and hence that it is important to understand the cultures of software developing organizations as well as software processes and methodologies (Dubé and Robey, 1999; Ngwenyama and Nielsen, 2003).

Within the research literature there has been a lively debate about the CMMI and its underlying assumptions. First, previous studies are skeptical of the management ideals underlying the CMMI and its predecessor the SW-CMM (Bach, 1994, 1995; Bollinger and McGowan, 1991; Johnson and Brodman, 2000). The CMM(I) is claimed to increase the bureaucracy of software development organizations. Our analysis supports this claim to some degree. Bureaucracy is a hallmark of the Hierarchy culture type which is also the dominant culture type in the CMMI (cf. Figure 3). Our analysis also shows the need for a more detailed analysis of the underlying culture types since the Market culture type is not only prominent in the model but also distinctly different from the Hierarchy culture type. In this regard, our study concurs with Ngwenyama and Nielsen (2003). We have, however, provided additional insights into the CMMI using the
competing values framework. Software development often requires creativity and innovation associated with the Clan and Adhocracy culture types which emphasize flexibility and discretion. The CMMI, on the other hand, is dominated by the opposite values, i.e. stability and control, associated with the Hierarchy and Market culture types, because these are also important to timely and efficient project or product completion. Our analysis highlights the low emphasis on Adhocracy culture elements in the CMMI. That, in turn, lends support to previous studies which show that the model pulls away from the organizational characteristics required in many aspects of software development and in many software companies (Rose et al., 2008; Aaen, 2003). However, some customers and projects, for example, the long-running projects in ISY paid for by military customers, require the kind of process stability induced by the CMMI (Guerrero and Eterovic, 2004).

Investigating the consequences, culturally and otherwise, of implementing changes to systems and software development invites an interesting discussion concerning the relationship between process and practice. Previous studies have shown that documented standard processes are either not used, because they do not capture the real-life complexity of software and systems development (Parnas and Clements, 1986), or adapted to the context in which they are used (Iivari and Maansaari, 1998). Consequently, simply updating process descriptions in a quality system like the TMS does not necessarily translate into changed work practices or cultural changes. However, processes impact practice through communication, training, quality assurance initiatives, and performance measurements (Müller et al., 2008). Therefore, processes have an educative effect through a variety of activities which in turn impact the organizational culture.

In summary, our diagnoses and subsequent discussion demonstrate the benefits of analyses based on the competing values framework. First, our text analysis technique provides an efficient and effective method of producing a quick overview and comparison of a SPI model and internal process documents. Such an analysis may be warranted, for example, when an organization has updated standard operating procedures to comply with process standards or requirements of maturity models as the ISY case has shown. A comparison of profiles reveals whether they are congruent and that, in turn, indicates success or failure in capturing underlying values and assumptions of the adopted process standard or model. In case of incongruence a more detailed analysis is needed. Second, a combination of our text analysis technique and the assessment instrument by Cameron and Quinn (2006) allows for an efficient and effective analysis of the congruence between an existing organizational culture and the culture underlying the SPI model or internal process documentation used for SPI implementation. Again, if incongruence is revealed, a more thorough analysis is required. The framework helps us pinpoint differences between culture profiles that need to be managed as part of a SPI project.

7. Implications
Our investigation of the impact of organizational culture on SPI has both practical and theoretical implications. In terms of practical implications, we propose a modified version of the six-step process (for designing and implementing organizational change) presented by Cameron and Quinn (2006). SPI managers should follow the revised process to assess and deal with the cultural challenges confronting their improvement efforts. Our four-step process for managing cultural SPI challenges is:

1. Establish as-is organizational culture profile using the assessment instrument;
2. establish to-be organizational culture profile using the text analysis technique;
(3) compare organizational culture profiles and analyze gap; and
(4) plan for culture management.

First, an as-is culture profile is established. By establishing an as-is culture profile the organization’s value orientations are revealed as a first step toward identifying potential SPI challenges. We recommend using the assessment instrument (Cameron and Quinn, 2006), because it is a non-intrusive and efficient way of identifying an organization’s current culture profile that has been validated in practice (e.g. Al-Khalifa and Aspinwall, 2001; Dastmalchian et al., 2000).

Second, a culture profile of the processes is established. A culture profile of the adopted SPI model (e.g. the CMMI) or process standard (e.g. ISO/IEC 15504 – SPICE) is produced. If internal process documentation (e.g. a company-specific quality system) is updated to reflect the requirements of the model or standard, a separate profile is established to verify process compliance, i.e. whether internal process documentation captures assumptions underlying the model or standard. As demonstrated by our case study, a text analysis can be used to evaluate internal process compliance with a SPI model. The culture profiles not only illustrate the future culture but also allow for analyses of the challenges confronting the SPI project. The text analysis is basically an algorithm and we have developed it into a web service that enables SPI practitioners to analyze and plan for the cultural challenges associated with SPI in a cost-efficient way. The web service follows the principles outlined in Section 3, but automates the cumbersome frequency and distribution analyses required to produce a culture profile of a text. As mentioned previously, the text analysis technique yields results that in the case study were validated against previous research (Ngwenyama and Nielsen, 2003). The web service is accessible at www.processinnovation.dk/octat.html.

Third, culture profiles are compared and analyzed. By comparing profiles, SPI practitioners can determine the gap (i.e. degree of congruence) between the organization and the processes in terms of culture and identify potential SPI implementation problems when taking the divergences between profiles into account. Although our case study benefits from hindsight, since the assessment instrument and text analyses were used after the SPI project had ended, the comparison can be performed at an earlier stage (e.g. during project planning). SPI practitioners who want to implement process improvements across departments, business units, or other organizational entities with their own subcultures are advised to use the assessment instrument and our text analysis technique as input to SPI planning and implementation. However, a word of caution is in order. Neither tool produces an exact measure of an organizational culture but reveals rough value orientations. Consequently, the numerical representations of each culture type should not be misinterpreted as facts but viewed as tendencies within an organization.

Fourth, management of the cultural challenges associated with SPI is planned. SPI management should decide how to address the identified potential problems. Is organizational culture change, for example, required or can the gap be bridged in another way? How can cultural incongruences be handled without following the process for designing and implementing organizational change (Cameron and Quinn, 2006)? Our case study shows that SPI implementation is possible despite cultural incongruence.

Cameron and Quinn suggest performing a “means-does not mean” analysis determining the implications of culture change (i.e. what the culture change means and does not mean for the organization) as part of a change process to align current...
and desired future cultures (Cameron and Quinn, 2006). Our research shows, however, that culture change is not always necessary or desirable in the face of cultural incongruence. Nonetheless, cultural incongruence challenges SPI implementation and requires management attention, and our case study describes how the challenges were overcome in ISY. Future research should focus more on culture management. Additional guidelines for culture-based SPI management are needed, e.g. how can insights from cultural analyses be used in managing SPI projects to successful completion? Future research should also focus on the long-term impact on organizational culture of process changes. Since the cultural changes are mediated by communication, training, quality assurance initiatives, and performance measurements, there is bound to be a time lag between process changes and cultural impact.

8. Limitations
This study is shaped and limited by our choice of analytical lens and approach to data collection and analysis. In terms of analytical lens our choice of the competing values framework has precluded other perspectives on organizational culture which might have provided additional insights. With regard to data collection, our decision to include only employees tasked with SPI implementation in the survey may have influenced the culture profile of ISY, since they may have been particularly motivated and have had a unique perception of the cultural climate due to their project involvement. However, the post-project interviews with some of these people, revealed significant variations in their motivations and perceptions of the organization. In terms of data analysis, the comparison of results based on two different methods, our quantitative text analysis technique and the assessment instrument associated with the competing values framework, makes it all the more important not to attach too much importance to the numerical value ascribed to each culture type of the profiles. Our analyses lead us to conclude that the organizational culture profile of ISY is incongruent with that of the TMS based on a 13 point difference between culture types. This conclusion is based on the premise that results can be compared across methods and that differences between culture profiles are not attributable to differences in how the profiles are established. Although it is not inconceivable that the use of disparate methods may impact results, the reliability of the methods used minimizes this risk.

9. Conclusion
In this paper we have reported on an investigation of the impact of organizational culture on SPI. The research is based on a case study of a SPI project in a high-tech company. Using the assessment instrument and a text analysis technique both based on the competing values framework (Cameron and Quinn, 2006) we established culture profiles of one business unit engaged in SPI as well as the adopted SPI model. Despite cultural incongruence between the organizational culture and the value orientations underlying the model, the business unit succeeded in implementing new CMMI-based policies and procedures. Our analyses lead us to conclude – contrary to existing research – that cultural congruence is not a prerequisite for SPI success. Consequently, cultural incongruence is not an insurmountable barrier to SPI. We discuss this result and describe how the cultural challenges associated with the SPI project were overcome. In so doing, we demonstrate the value in comparing and analyzing culture profiles for the purpose of cultural management. We suggest that SPI projects may benefit from cultural analyses but emphasize the need for future research focussing
on additional guidelines for culture-based SPI management. To assist others in establishing culture profiles in an efficient manner we have developed our text analysis technique into an easy-to-use web service. In addition, we offer guidance by suggesting a four-step process for managing cultural SPI challenges.

Notes
1. The competing values framework has been revised and updated over the years, yielding changes to names and descriptions of the four organizational culture types. For example, whereas Quinn and McGrath (1985) distinguish between Hierarchical, Rational, Consensual, and Developmental organizational culture forms, Cameron and Quinn describe and characterize them as Hierarchy, Market, Clan, and Adhocracy. In this article, we rely on the most recent version of the framework (Cameron and Quinn, 2006).

2. Although Ngwenyama and Nielsen draw on Quinn and McGrath (1985) who talk about a Rational rather than a Market culture type, these concepts are for the present purposes identical.

References


(The Appendix follows overleaf.)
Appendix 1
The following shows the survey, which is part of the assessment instrument (the Organizational Culture Assessment Instrument (OCAI)), as presented by Cameron and Quinn (2006, p. 26).

The OCAI consists of six categories each with four statements describing different scenarios. For each question, 100 points are divided among the statements depending on the extent to which each of them adequately describes the organization. Establishing the organizational culture profile is pure arithmetic. Calculating the current (“now”) and desired (“preferred”) profiles follow the same guidelines. All A responses are added together and divided by six to calculate the average score. Average scores for B, C, and D are calculated in a similar fashion. Each average score corresponds to an organizational culture type (A = Clan; B = Adhocracy; C = Market; D = Hierarchy). Percentage scores are calculated for the purpose of plotting the culture profile.

<table>
<thead>
<tr>
<th>Category</th>
<th>Now</th>
<th>Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dominant Characteristics</td>
<td>Total 100</td>
<td>A The organization is a very personal place. It is like an extended family. People seem to share a lot of themselves.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B The organization is a very dynamic and entrepreneurial place. People are willing to stick their necks out and take risks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C The organization is very results-oriented. A major concern is with getting the job done. People are very competitive and achievement-oriented.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D The organization is a very controlled and structured place. Formal procedures generally govern what people do.</td>
</tr>
<tr>
<td>2. Organizational Leadership</td>
<td>Total 100</td>
<td>A The leadership in the organization is generally considered to exemplify mentoring, facilitating, or nurturing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B The leadership in the organization is generally considered to exemplify entrepreneurship, innovation, or risk taking.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C The leadership in the organization is generally considered to exemplify a no-nonsense, aggressive, results-oriented focus.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D The leadership in the organization is generally considered to exemplify coordinating, organizing, or smooth-running efficiency.</td>
</tr>
<tr>
<td>3. Management of Employees</td>
<td>Total 100</td>
<td>A The management style in the organization is characterized by teamwork, consensus, and participation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B The management style in the organization is characterized by individual risk taking, innovation, freedom, and uniqueness.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C The management style in the organization is characterized by hard-driven competitiveness, high demands, and achievement.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D The management style in the organization is characterized by security of employment, conformity, predictability, and stability in relationships.</td>
</tr>
<tr>
<td>4. Organization Glue</td>
<td>Total 100</td>
<td>A The glue that holds the organization together is loyalty and mutual trust. Commitment to this organization runs high.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B The glue that holds the organization together is commitment to innovation and development. There is an emphasis on being on the cutting edge.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C The glue that holds the organization together is the emphasis on achievement and goal accomplishment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D The glue that holds the organization together is formal rules and policies. Maintaining a smooth-running organization is important.</td>
</tr>
<tr>
<td>5. Strategic Emphasis</td>
<td>Total 100</td>
<td>A The organization emphasizes human development. High trust, openness, and participation persist.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B The organization emphasizes acquiring new resources and creating new challenges. Trying new things and prospecting for opportunities are valued.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C The organization emphasizes competitive actions and achievements. Hitting stretch targets and winning in the marketplace are dominant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D The organization emphasizes permanence and stability. Efficiency, control, and smooth operations are important.</td>
</tr>
<tr>
<td>6. Criteria of Success</td>
<td>Total 100</td>
<td>A The organization defines success on the basis of the development of human resources, teamwork, employee commitment, and concern for people.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B The organization defines success on the basis of having the most unique or newest products. It is a product leader and innovator.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C The organization defines success on the basis of winning in the marketplace and outpacing the competition. Competitive market leadership is key.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D The organization defines success on the basis of efficiency. Dependable delivery, smooth scheduling, and low-cost production are critical.</td>
</tr>
</tbody>
</table>
Appendix 2
Table A1 displays examples of codes used in searching the TMS and the CMMI for evidence of the four culture types. The entire list of codes can be found at www.processinnovation.dk/OCTAT. Some of the search strings may return similar but unrelated words (e.g., the search expression “formal*” may return the words “formaldehyde” and “formalin”). Such unintentional hits were subsequently discarded. The compound search expressions, e.g., “Commitment* COOCCUR Employee*”, ensure that only sentences in which two or more keywords (in this example “Commitment*” and “Employee*”) occur simultaneously are found.

Appendix 3
The CMMI and TMS culture profiles were produced in the same way. First, the documents were searched for the culture codes as exemplified in Appendix 2 and the number of hits was calculated. For example, the word “Control” – which is associated with the Hierarchy culture type – was used 2,881 times in the TMS documents. Second, the total number of hits was calculated. For example, all keywords and phrases linked to the Hierarchy culture type were used 13,859 times across the TMS documents. Third, weighed distribution analyses were performed to determine how many hits (in percentages of all hits across culture types) were associated with each culture type. The uneven number of keywords and phrases was taken into account. For example, out of 50,547 hits 15,245 were associated with the Hierarchy culture type taking the 20 Hierarchy culture codes into account which amounts to 30 percent of all hits.

Table A2 shows the number of hits and culture codes for each culture type in the TMS culture profile calculation. The number of hits was normalized (based on the Adhocracy score). For example, the Hierarchy hits (cf. Table A2) were calculated as follows: 22/20 × 13,859 = 15,245. The normalized scores are listed in parentheses. The normalized scores were used for calculating the weighed distribution in percentages. In the above example, the calculation was performed as follows: 100/50,547 × 15,245 = 30.16 percent = 30 percent. For the purpose of plotting the culture profile (based on the percentage scores), decimal points were removed for the sake of simplification.

<table>
<thead>
<tr>
<th>Culture type</th>
<th>Adhocracy</th>
<th>Clan</th>
<th>Hierarchy</th>
<th>Market</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of hits</td>
<td>5,463</td>
<td>9,687 (11,840)</td>
<td>13,859 (15,245)</td>
<td>13,908 (17,999)</td>
<td>42,917 (50,547)</td>
</tr>
<tr>
<td>in percentages</td>
<td>10.81 (11)</td>
<td>23.42 (23)</td>
<td>30.16 (30)</td>
<td>35.61 (36)</td>
<td>100 (100)</td>
</tr>
<tr>
<td>Number of culture codes</td>
<td>22</td>
<td>18</td>
<td>20</td>
<td>17</td>
<td>77</td>
</tr>
</tbody>
</table>
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