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Examining the impacts of organizational culture and top management support of knowledge sharing on the success of software process improvement

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ABSTRACT

Although numerous studies have discussed the importance of the relationship between knowledge management and software process improvement (SPI), a research gap still exists in relation to how the specific role of knowledge sharing influences successful SPI implementation. This study advances our knowledge by developing an innovative model for exploring the impact of knowledge sharing on SPI success, the impact of knowledge sharing in specific organizational cultures, and how the support of top management specifically influences the path to SPI success. To empirically test the model, this study adopts the statistical technique of partial least squares (PLS) to analyze 118 samples collected from SPI-certified Taiwanese organizations. The results suggest that clan-type organizational culture has a stronger association with knowledge sharing than hierarchy-type in the context of SPI success. SPI knowledge sharing is found to be a mediator of both clan culture and top management support in the context of SPI success. The findings also include the implication to improve our knowledge about how organizational culture and top management support drive effective knowledge sharing on the way to SPI success.

1. Introduction

The fundamental goals of software process improvement (SPI) are to develop better-quality and more reliable software, to increase customer satisfaction, and to increase returns on investment. SPI may be the dominant approach used by software firms and organizations to improve their competitive market position (Niazi, Babar, & Verner, 2010). SPI was developed in response to the need for managing and improving the quality of software development (Samalikova, Kusters, Trienekens, & Weijters, 2014). Specifically, SPI emphasizes improvements in resolving various issues arising from ad-hoc software processes and aims to obtain optimal solutions for process issues throughout the planning, development, and production cycles, as well as to resolve organizational and management issues. To provide guidance for implementing SPI, a number of theoretical process reference models have been developed, such as the ISO9000 series of standards, the Capability Maturity Model Integration (CMMI), the Quality Improvement Program (QIP), and the Software Process Improvement and Capability dEtermination (SPICE) process.

As SPI is a highly knowledge-intensive activity (Dyba, 2005; Mathiassen & Pourkomeylian, 2003), the theory of knowledge management (Alavi, Kayworth, & Leidner, 2005; Alavi & Leidner, 2001; Baskerville & Dulipovici, 2006; Schultze & Leidner, 2002) is used as the theoretical base of this study. Knowledge management regards knowledge as the foundation of a firm's performance (Small & Sage, 2005). Knowledge management is the process of acquiring, storing, sharing, creating, and using knowledge (Nonaka, Toyama, & Konno, 2000). In the SPI context, the improvement of software processes involves intensive teamwork and produces significant amounts of knowledge, making the effective sharing of knowledge among individuals essential (Slaughter & Kirsch, 2006). In the process of software development, knowledge sharing helps to avoid the same mistakes, reducing dependency on a few employees who own critical knowledge, increasing integration of individual competencies (including knowledge, experiences, and skills), and improving decision-making (Meehan & Richardson, 2002). Through sharing, employees can effectively increase their understanding of identifying and fulfilling potential improvement

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needs of the processes for achieving ad-hoc SPI goals and increasing the overall performance (Rus & Lindvall, 2002).

In previous studies, the contribution of knowledge management to the effective execution of software processes and to the increase of employees' competencies and skills related to software development has been described (Feher & Gabor, 2006; Meehan & Richardson, 2002; Rus & Lindvall, 2002). However, these studies were mostly case-based observations of individual firms. There is currently no significant empirical and quantitative evidence for understanding comprehensively the impact of knowledge management practices on the implementation of SPI and on SPI success. Therefore, in this study, we attempt further examination of how knowledge sharing influences SPI success. Moreover, according to knowledge-management literature, two organizational antecedents—organizational culture and top management support—may critically determine employees' knowledge-sharing activities (Jones, Cline, & Ryan, 2006; Lin, 2007b). From previous SPI studies, little is known about how organizational culture and top management support may affect knowledge sharing in the context of SPI success.

Organizational culture is considered to be a significant environmental factor in SPI implementation (Muller, Kraemmergaard, & Mathiassen, 2009; Muller & Nielsen, 2013; Ngwenyama & Nielsen, 2003; Niazi et al., 2010; Passo et al., 2012; Shih & Huang, 2010). Organizational culture influences the way in which employees think, act, and respond to process improvement missions (Passos, Dias-Neto, & da Silva Barreto, 2012b). Hyde and Wilson (2004) stated that organization culture affects the extent of collaboration of the SPI among employees while the work of improvement is being carried out. In addition, culture influences employees' willingness and behavior in terms of knowledge sharing: cultural effects may encourage or impede employees' knowledge-sharing activities (De Long & Fahey, 2000; Jones et al., 2006). Shih and Huang (2010) argued that the significant effect of organizational culture on SPI makes it necessary to investigate how culture influences the development of knowledge during SPI implementation. Nevertheless, there has as yet been no study investigating the impact of organizational culture on knowledge sharing in the SPI context. Therefore, in this study, we investigate how culture can encourage employees to participate in knowledge sharing that may be critical to SPI success.

Another factor that could exert a significant influence on SPI success is more individualized. Top management may be an individual or a small group of critical individuals who influence employees' perceptions and willingness to engage in tasks. Top management support has been demonstrated to promote the success of technological implementations (Jones & Price, 2004; Jones et al., 2006; Shao, Feng, & Liu, 2012). However, the current SPI literature does not empirically address the mechanisms by which top management support facilitates knowledge sharing in relationship to SPI success, and thereby how it helps to sustain the success of SPI (Dyba, 2005; Niazi, Wilson, & Zowghi, 2006; Rainer & Hall, 2002; Sulayman, Urquhart, Mendes, & Seidel, 2012; Wilson, Hall, & Baddoo, 2001). Previous knowledge-management studies have documented how supportive behavior by top management is essential to nurture a conducive climate and workplace in which employees are encouraged to apply their knowledge in their work. Moreover, top management support enhances the level and quality of knowledge sharing and exchange through influencing employee commitment (Wang & Noe, 2010). Top management support with proper employee incentive mechanisms facilitates knowledge sharing and stimulates employees to share their knowledge, which in turn may contribute to organizational success. In the SPI context, where there is a high demand for knowledge sharing, top management support may also affect knowledge sharing through their influence on the norms and climate of the employees' workplaces. Therefore, in this study, we examine the relationships among top management support, knowledge sharing, and SPI success.

Based on the background knowledge described above, several research questions are addressed in this study. (1) What is the relationship between knowledge sharing and SPI success? (2) Which aspects of organizational culture are most important in terms of SPI knowledge sharing? (3) Does top management support influence and facilitate SPI knowledge sharing and SPI success? To answer these questions, this study proposes a research model that adopts the statistical technique of partial least squares (PLS) and uses samples collected from SPI-certified Taiwanese organizations to model the relationships among organizational culture, top management support, SPI knowledge sharing, and SPI success. When collecting our sample, we focused on a specific SPI program, which is capability maturity model integration (CMMI) (SEI, 2010). By addressing the proposed research questions, from the theoretical aspect, this study not only contributes to the extant SPI literature regarding the role of knowledge sharing in SPI success but also extends the understanding of how specific organizational culture and top management support can influence the way to SPI success. From the practical aspect, this study offers information to the discussion on how, by combining knowledge management and software process management, as well as how digital tools may help foster knowledge sharing and build a knowledge-oriented culture within an organization in the context of SPI.

The paper is organized as follows. Section 2 reviews relevant research to show the foundations for the hypotheses and the research model. Section 3 describes the methodology. Section 4 presents the statistical analyses. Section 5 discusses the findings and implications. Section 6 describes the limitations of the study and outlines directions for future studies.

2. Research model and hypotheses development

The research model was developed to enable consideration of the relationships among organizational culture types, top management support, SPI knowledge sharing, and SPI success, as shown in Fig. 1. The organizational culture types used in this study are those that were defined in the competing values framework (CVF) (Cameron & Quinn, 2006).

The theoretical basis of the model was developed by reviewing and surveying the literature. The literature that suggests relationships among organizational culture types, top management support, SPI knowledge sharing, and SPI success is described in the following sections.

2.1. SPI success

SPI has been proven to provide benefits for firms. It can improve product quality, shorten the time to get products to market, increase productivity, reduce costs, and more. To realize these benefits, the effective implementation of SPI requires time, careful scheduling, resources, and knowledge (Mathiassen & Pourkomeylian, 2003; Meehan & Richardson, 2002; Niazi et al., 2006). Decisions about SPI implementation are influenced by organizational factors, and several studies have analyzed the critical success factors involved in SPI success (Dyba, 2005; Montoni & Rocha, 2007; Niazi et al., 2006; Rainer & Hall, 2002; Sulayman, Mendes, Urquhart, Riaz, & Tempero, 2014; Sulayman et al., 2012; Wilson et al., 2001).

Dyba (2005) validated a theoretical model of SPI success factors and proposed an operational definition of the variables of SPI success. The study suggested that SPI success is defined by two indicators: improved organizational performance and the

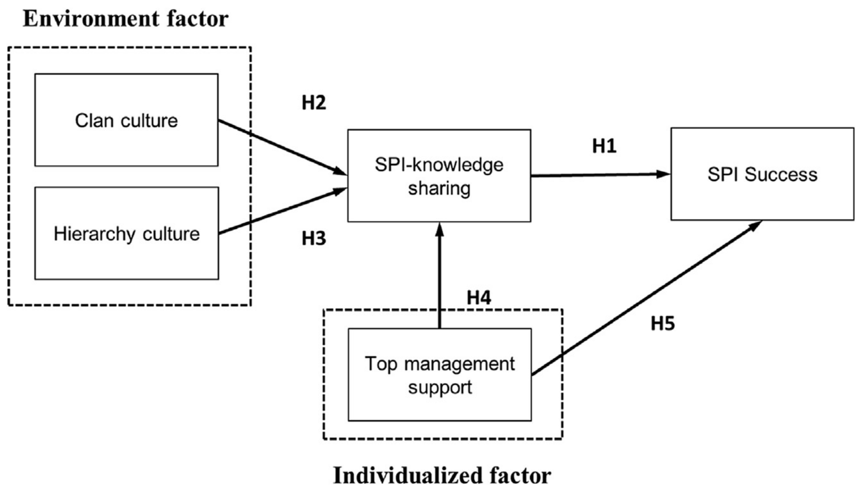

Fig. 1. The proposed research model.

perceived level of SPI success, which includes cost reduction, decreased cycle time, and increased customer satisfaction (Dyba, 2005). Dyba's theoretical model of SPI success factors has been applied in various other studies. For example, Sulayman et al. (2014) used Dyba's work to develop a specialized framework of SPI success factors for small Web companies. Winter and Ronkko (2010) investigated product usability metrics by adopting Dyba's (2005) SPI success factors. Egorova, Torchiano, and Morisio (2009) evaluated the effect of software engineering practices for industrial projects based on Dyba's (2005) work. In this study, we adopt Dyba's (2005) definition of SPI success as the dependent variable in the proposed model.

2.2. Knowledge sharing and SPI success

Knowledge is considered as a mixture of information, experience, value standards and norms, which by this definition could be evidenced in documentation, information, technical reports, professionalism and know-how (Koriat & Gelbard, 2014; Lin, Wu, & Lu, 2012; Nonaka et al., 2000; Ruggles, 1998). In organizations, a key objective of management is systematic and organized application of tools for the development of new knowledge. Organizations use formal and informal methods to obtain useful experiences, knowledge, and expertise to help improve organizational performance and to increase customer value and satisfaction. In today's highly competitive environment, the most important activity for firms is to create, utilize, and apply knowledge to gain a sustainable competitive advantage (Nonaka et al., 2000; Yu, Hao, Dong, & Khalifa, 2013). Knowledge management is essential for modern firms because it contributes to sustainable organizational growth, organizational learning, innovation, and success.

Theoretically, knowledge management comprises the creation, acquisition, sharing, and management of knowledge (Jones et al., 2006). Specifically, knowledge sharing can be viewed as a critical activity for improving organizational capabilities, including absorptive capacity (Liao, Fei, & Chen, 2007), innovation, problem-solving, and profitability (Foss, Husted, & Michailova, 2010; Nonaka et al., 2000). Knowledge sharing typically takes place on both the organizational level (including teams, groups, and units) and the individual level (Sabherwal & Becerra-Fernandez, 2003). Bartol and Srivastava (2002) described knowledge sharing as employees diffusing relevant information and knowledge across the organization. Van den Hooff and De Ridder (2004) considered knowledge sharing to be individuals' transferring or mutually exchanging their explicit and tacit knowledge, and consequently cooperatively creating new knowledge. Lin (2007a) defined knowledge sharing as a social interaction culture, referring to individuals exchanging knowledge, experiences, and skills within organizations. Wang and Noe (2010) defined the process of knowledge sharing as providing task information and know-how to cooperate to solve problems, develop new ideas, and implement policies or procedures.

SPI is a complex and knowledge-intensive activity that is composed of domain-specific knowledge and experiences. Firms need to systematically manage software process knowledge for the employees to gain the ability to learn, utilize, and adapt process knowledge to achieve SPI goals (e.g., reducing cost and time required for software development and increasing customer satisfaction). Firms often rely on SPI-related knowledge, skills, and experiences to deal with challenges that arise in SPI implementation (Dyba, 2005; Meehan & Richardson, 2002; Rus & Lindvall, 2002; Slaughter & Kirsch, 2006). Scholars have believed that knowledge management is particularly relevant to manage and support software processes. For instance, Meehan and Richardson (2002) investigated the four knowledge management categories of creation, storing, sharing, and leverage in three small software development companies. Their findings indicate that software process knowledge has to be formally and informally shared to make software processes more effective. Rus and Lindvall (2002) suggested that firms should encourage a knowledge-sharing organizational culture and form numerous communities to help employees share SPI-based knowledge. Feher and Gabor (2006) noted that knowledge leverage (share and transfer) activities are essential to decrease dependency on employees who are single owners of critical knowledge. Therefore, it seems that SPI knowledge sharing activities are crucial for employees to gladly share their own knowledge, which consequently helps organizations achieve expected SPI goals. Based on this, the following hypothesis is proposed:

H1. SPI knowledge sharing has a positive influence on SPI success.

2.3. Organizational culture

Organizational culture is made up of the symbols, language, ideology, beliefs, rituals, and myths of an organization. Culture is ubiquitous, and covers all areas of organizational life (Schein, 1990). Cameron and Quinn (2006) considered culture to refer to the core values, assumptions, interpretations, and approaches that characterize an organization. Prior SPI literature has demonstrated a significant relationship between organizational culture and SPI implementation (Dyba, 2005; Muller et al., 2009; Muller & Nielsen, 2013; Ngwenyama & Nielsen, 2003; Shih & Huang, 2010). Passos, Dias-Neto, and da Silva Barreto (2012a) noted that organizational culture impacts SPI success by influencing employees' behavior, motivations, and productivity, as well as their satisfaction with the organization itself. Dyba (2005) considered that improved software processes must continually align with organizations' business strategies and goals, and should match an organization's culture. In this regard, SPI theory and practice cannot ignore the body of knowledge about organizational culture.

Organizational culture may be used to help understand successful SPI implementation. In the knowledge management literature, it is widely believed that organizational culture is a critical factor for effective knowledge sharing (Alavi et al., 2005; De Long & Fahey, 2000; Oliver & Kandadi, 2006; Schein, 1990). Although organizational culture is regarded as an antecedent of knowledge sharing activities, De Long and Fahey (2000) argued that different organizational cultures may impact members' willingness to share their knowledge. McDermott and O'dell (2001) also noted that firms should further identify what culture better supports knowledge sharing as a natural activity in employees' daily work. Seemingly, the above arguments may serve as a basis for us to further explore the relationship between different culture types and effective knowledge sharing, which might lead to SPI success.

To understand organizational culture, Cameron and Quinn (2006) proposed a theoretical typology of organizational culture, called the Competing Value Framework (CVF), shown in Fig. 2. The CVF identifies four dominant organizational culture types: clan, adhocracy, hierarchy, and market. They are defined along two major axes: (1) internal versus external organizational focus and (2) flexibility and discretion versus stability and control.

According to Cameron and Quinn (2006), clan culture focuses on maintaining its stability. This means that an organization focuses on shared values, tradition, teamwork, loyalty, common goals, commitment, and participation by the organization's members. Adhocracy culture is externally oriented and focuses on innovation, growth, dynamism, and creation. In this type of culture, the organization presents opportunities to its members to self-develop. Hierarchy culture refers to an organization with a formalized or structured construction. This culture emphasizes order, procedures, stability, and the predictability of settings, therefore increasing productivity, efficiency, and the reliability of products. Finally, market culture focuses on the organization's transactions in the external environment. Members of market cultures are success and customer oriented. The priorities in a market culture are efficacy and achievement.

Scholars have indicated that CVF has the following advantages in terms of understanding the effects of organizational culture on SPI implementation. First, CVF is a nonintrusive and inexpensive way to understand an organization's culture, and it provides clear conceptualizations of the distinct culture types (Muller et al., 2009; Muller & Nielsen, 2013). Second, CVF has been widely and substantially validated in numerous organizations by both practitioners and researchers (Cameron & Quinn, 2006; Muller et al., 2009). Third, CVF has been chosen in many studies that analyze interactions between organizational culture and SPI (Muller et al., 2009; Muller & Nielsen, 2013; Ngwenyama & Nielsen, 2003; Shih & Huang, 2010). Fourth, SPI is considered to be an organizational change since it modifies, improves, and recreates existing software processes inside organization. Similarly, the CVF aims to understand and change organizational culture (Muller & Nielsen, 2013).

2.4. Organizational culture and SPI knowledge sharing

Previous studies have indicated that, of the four types of CVF, specific cultures can be selected for thorough investigation by focusing on the objective and context of the research (Kim, 2014; Richard, McMillan-Capehart, Bhuian, & Taylor, 2009; Tseng, 2010). For example, market and adhocracy culture, with their external focus, encourage competitiveness between employees (Cameron & Quinn, 2006; Dwyer, Richard, & Chadwick, 2003; Wiewiora, Trigunarsyah, Murphy, & Coffey, 2013). Under such competitive conditions, knowledge becomes a proxy for power and “destabilishes” knowledge sharing (Suppiah & Sandhu, 2011). As a result, there is less knowledge shared among employees in organizations that have market or adhocracy cultures (Al Murawwi, Behery, Papanastassiou, & Ajmal, 2014). Wiewiora et al. (2013) noted that market-type values, such as competitiveness and achievement, are associated with evidence of hesitancy to share knowledge. In contrast, empirical evidence in related domains has been used to propose that the characteristics of clan culture and hierarchy culture have positive impacts on knowledge sharing (Alavi et al., 2005; Shao et al., 2012).

As an objective of our theoretical model is to determine how culture fosters and promotes knowledge sharing, in this study, we focus on clan and hierarchy cultures. Emphasizing the significance

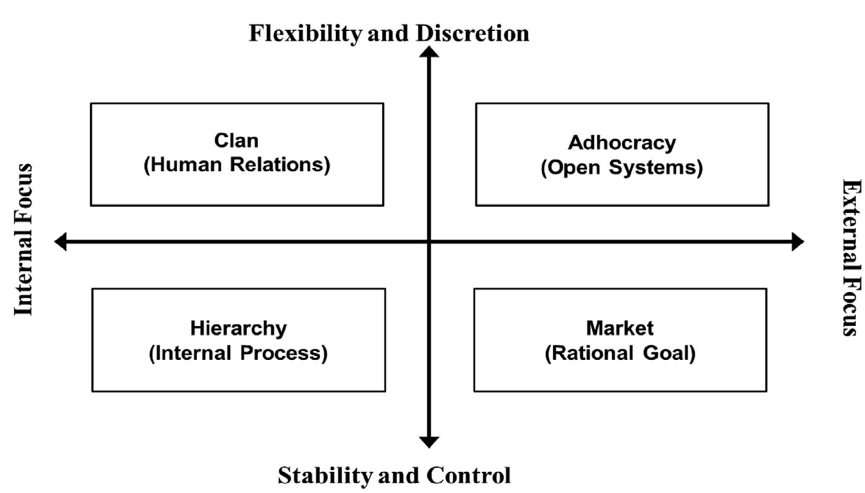

Fig. 2. CVF of organizational culture.

of culture on knowledge sharing reduces the complexity of the analysis suggested by Tseng (2010). Therefore, the effects of the two culture types that have positive influences on knowledge sharing in the context of SPI success are examined.

Clan culture emphasizes flexibility and an internal focus, and the typical characteristics of clan culture are teamwork, trust, employee involvement and participation, and high organizational commitment to employees (Cameron & Quinn, 2006). Kim and Lee (2006) found that knowledge sharing capabilities require employees to collaborate, interact, and disseminate individual employees' work experiences. Scholars also indicate that a workplace with high trust levels enhances knowledge communication and promotes active knowledge sharing behavior (Bock, Zmud, Kim, & Lee, 2005; Kim & Lee, 2006; Nonaka et al., 2000; Suppiah & Sandhu, 2011). Moreover, clan-type organizations with fine knowledge communication and interactions can produce higher levels of social networks, which facilitate employees' knowledge sharing activities (Kim & Lee, 2006).

Since SPI is an organizational learning process (Dyba, 2005; Mathiassen & Pourkomeylian, 2003) and a group activity (Rus & Lindvall, 2002), it often requires employees to communicate and coordinate their SPI-related knowledge, experiences, and skills to collaboratively enhance the entire organization's learning ability in relation to SPI (Rus & Lindvall, 2002). The clan culture characteristics of trust and cohesion encourage employees to share their SPI-related experiences, skills, and knowledge during SPI implementation (Feher & Gabor, 2006; Rus & Lindvall, 2002). Furthermore, high levels of participation may lead to better SPI knowledge sharing and the use of mutual knowledge and experience to decide, act, and take responsibility for successful SPI implementation (Dyba, 2005; Montoni & Rocha, 2007; Niazi et al., 2006; Rainer & Hall, 2002). Thus, we hypothesize:

H2. Clan culture is positively related to SPI knowledge sharing.

Hierarchy culture is control oriented and internally focused. It is characterized by formalized and hierarchical structures, regulations, and standard operating procedures (Cameron & Quinn, 2006). Hierarchy culture governs how employees develop software processes within organizations (Muller & Nielsen, 2013). SPI is dominated by stability and control (Muller & Nielsen, 2013; Ngwenyama & Nielsen, 2003; Shih & Huang, 2010), and therefore, hierarchical cultures facilitate successful SPI implementation (Shih & Huang, 2010). In knowledge management of SPI, SPI implementation is essential for timely and efficient project or product completion (Muller & Nielsen, 2013). A standardized structure facilitates teams to adopt for their projects, to monitor the development of improvement step by step, and to streamline knowledge management procedures (Alavi et al., 2005, p.210). On the other hand, hierarchy cultures also emphasize efficiency, uniformity, and coordination; they can help employees accommodate the adoption of new processes and motivate employees to share knowledge and resolve any misfit that arises during information systems (IS) implementation (Shao et al., 2012). We conclude that hierarchies may be beneficial for SPI implementation and could increase employees' motivation to share their SPI-related knowledge, experience, and skills. We hypothesize:

H3. Hierarchy culture is positively related to SPI-knowledge sharing.

2.5. Top management support

Top management support is considered a prerequisite for successful information technology (IT) and IS implementation and adoption. Akkermans and van Helden (2002) led a case study that ranked top management support as one of the most critical success factors in enterprise resource planning (ERP) implementation (Law & Ngai, 2007; Nah, Zuckweiler, & Lau, 2003). Kim, Lee, & Gosain (2005) described top management as vital for developing and promoting a vision to shape the implementation of IT infrastructures and ERP systems. Ke and Wei (2008) argued that top management's role modeling is able to foster a learning atmosphere that is a determinant of ERP implementation success. Nah et al. (2003) conducted a survey of chief information officers and identified top management support as the most critical success factor influencing ERP implementation success. Law and Ngai (2007) proposed a research model to examine the success of ERP system adoption. The results demonstrated that top management support is positively related to ERP success. Chen and Popovich (2003) indicated that top management support is a key success factor relating to customer relationship management (CRM) implementation. Lee and Lim (2005) argued that top management support affects internal and external diffusion of electronic data interchange (EDI), which is related to EDI implementation success.

In the SPI context, numerous previous studies have analyzed and identified top management support as a key factor (Goldenson & Herbsleb, 1995; El-Emam, Goldenson, McCurley, & Herbsleb, 2001; Rainer & Hall, 2002; Dyba, 2005; Niazi et al., 2006; Montoni & Rocha, 2007; Sulayman et al., 2012). Support from top management indicates their interest in SPI and the extent to which organizational resources are granted by top management for SPI implementation (Goldenson & Herbsleb, 1995; Stelzer & Mellis, 1998; El-Emam et al., 2001). Higher levels of top management support can overcome organizational changes and guarantee that improved processes will be conducted smoothly during SPI implementation (Stelzer & Mellis, 1998). Therefore, top management is expected to commit to and participate in SPI implementation (Dyba, 2005). In spite of this, however, in previous SPI literature, there is little or no research examining how top management supports and facilitates knowledge sharing in SPI (Dyba, 2005). In knowledge-intensive SPI, success can be achieved by particular employees' capabilities and experiences, because of the support and rewards provided by top management. However, the sustainability of this success depends almost entirely on whether knowledge can be shared and donated. Since the main objective of this study is to explore the role of SPI knowledge sharing on SPI success, we define top management support in terms of the degree of support provided to encourage employees to share their knowledge. Accordingly, we propose the following hypotheses:

H4. Top management support has a positive influence on SPI knowledge sharing.

H5. Top management support has a positive influence on SPI success.

3. Research methodology

3.1. Data collection and sample

To investigate the questions, we adopted a survey research approach. As this study was conducted in Taiwan, the questionnaire was written in traditional Chinese and a backward-translation procedure was used to ensure consistency between the Chinese and English versions (Jiacheng, Lu, & Francesco, 2010). A group of experts, including two professors and two industrial specialists in SPI, participated in the development of the questionnaire for the survey. To ensure content validity, all the experts examined the items relevant to the SPI domain and checked that the survey items were clear, meaningful, and understandable. The constructive comments suggested by these experts led to several minor modifications (such as formatting and wording) to the preliminary questionnaire. Ten respondents from two different firms pilot-tested the questionnaire. The respondents were requested to provide suggestions regarding the overall presentation of the questionnaire and the wording of the items, especially problems with ambiguity and comprehensibility. After minor changes to the formatting and typesetting were carried out, the pilot-testing process produced the finalized formal questionnaire.

In this study, to increase validity, 56 firms that adopted the CMMI-based SPI program and have received official certification in Taiwan participated in the survey. All CMMI-certified organizations are recognized and cited by the published appraisal results of the CMMI institute (see https://sas.cmmiinstitute.com/pars/pars.aspx). The managers and practitioners of CMMI-certified firms were chosen because they were directly involved in their organizations' implementation of CMMI. They were first contacted by telephone to ensure that they understood the purpose of this study and agreed to participate. A total of 350 questionnaires were sent in 56 CMMI-certified firms, and 118 usable questionnaires were returned for analysis (2 invalid questionnaires were returned), with a response rate of 33.7%. Table 1 shows the demographics of the respondents and organizations.

3.2. Measures

In this study, constructs were adopted from previously-developed constructs that had been validated in prior studies. All of the variables were measured based on a seven point Likert-type scale, ranging from strongly disagree to strongly agree. The

Table 1
Characteristics of the samples (N = 118).

Characteristics of the respondents' organizations		
Industry types	Frequency	Percentage
Information technology	50	42.4%
Manufacturing	43	36.4%
Research institute	8	6.8%
Finance	7	5.9%
Education	5	4.2%
Health care	3	2.5%
others	2	1.7%
Number of employees		
Below 50	28	23.7%
50–100	35	29.7%
100–500	32	27.1%
500–1000	10	8.5%
Above 1000	13	11.0%
Maturity level of CMMI		
Maturity level 5	2	1.7%
Maturity level 4	5	4.2%
Maturity level 3	45	38.1%
Maturity level 2	66	55.9%
Characteristics of the respondents		
Job position		
CEO	3	2.5%
Vice/assistant president	4	3.4%
General manager	30	25.4%
Manager	41	34.7%
Staff	40	33.9%
Education		
Bachelor	42	35.6%
Master	71	60.2%
Doctor	5	4.2%
Work experience		
1–5 years	16	13.6%
6–10 years	56	47.5%
11–15 years	32	27.1%
16–20 years	9	7.6%
Above 21 years	5	4.2%

measurement items for the constructs are listed in Appendix 1. The following are descriptions of all the variables.

Both clan and hierarchy cultures were assessed using the Organizational Culture Assessment Instrument (OCAI) from the competing values framework developed by Cameron and Quinn (2006). Clan culture emphasizes flexibility and is internally oriented; the characteristics of clan-type firms are teamwork, high commitment and employee involvement. Hierarchy culture emphasizes control, but is internally oriented. An organization with a hierarchy culture is characterized by a formalized and structured work place. The core values of a hierarchy culture are efficiency, coordination, regulation and predictability. In this study, clan culture was measured in terms of three reflective items respectively, and hierarchy culture was measured in terms of four reflective items.

SPI success was operationalized as a second-order reflective construct formed by two first-order reflective constructs, derived from Dyba (2005). The two first-order reflective constructs consist of the perceived level of SPI success and organizational performance. The perceived level of SPI success was measured using two items: (1) SPI is able to substantially increase a firm's software engineering competence; and (2) SPI improves a firm's overall performance. Organizational performance was measured using three items: SPI is able to contribute to (1) a firm's cost reduction; (2) a firm's cycle time reduction of software development; and (3) a firm's increased customer satisfaction.

In this study, the variables of SPI-knowledge sharing and top management were modified in order to more appropriately measure the variables related to successful SPI implementation. SPI-knowledge sharing was operationalized as a second-order reflective construct. This variable was estimated using the degree of SPI-related "knowledge donating" with five reflective items, and SPI-related knowledge collection with five reflective items, developed by Van den Hooff and De Ridder (2004). SPI-Knowledge donating means that employees are willing to share personal intellectual capital to others during SPI implementation. SPI-knowledge collecting refers to the willingness of consulting colleagues to accept this intellectual capital. Top management support was measured using four reflective items adopted by Lin (2007b). These measurements evaluate the level at which employees perceive the support and encouragement of SPI-related knowledge-sharing from top management during SPI implementation.

Measurement reliability was assessed prior to data analysis. To assess the reliability of the measures, the Cronbach alpha coefficient was used. As shown in Table 2, the results showed that all the constructs had Cronbach alpha values greater than 0.7, indicating an acceptable level of measurement reliability (Nunnally, 1978). As the results of the test were satisfactory, all the items were retained for the survey.

4. Data analysis and results

PLS is a component-based approach that is widely adopted in the IS field, and has several advantages: PLS is able to deal with reflective and formative constructs, and latent constructs under

Table 2
Measurement reliability tests.

Constructs	Cronbach's alpha
Knowledge donating	0.91
Knowledge collecting	0.87
Top management support	0.86
Level of perceived SPI success	0.75
Organizational performance	0.73
Clan culture	0.73
Hierarchy culture	0.78

non-normal conditions, it is also able to handle more minimal demands on sample size than other methods (Urbach & Ahlemann, 2010). Therefore, PLS is appropriate for the analysis of our survey samples (N = 118). In the data analysis section, the first step examined the measurement model in order to check the reliability and validity of the constructs, and the second step attempted to test the relationship between the latent constructs and hypotheses. In this study, SmartPLS 2.0 M3 software (Ringle, Wende, & Will, 2005) was used in order to assess both the measurement model and the structural model.

4.1. Measurement model

In order to validate the measurement model, internal consistency reliability, and the validity of convergent validity and discriminant validity were assessed. Internal consistency reliability was examined using composite reliability (CR) values. As shown in Table 3, all of the composite reliability values were above 0.7, ranging between 0.77 and 0.96, which satisfies the commonly acceptable level, as recommended by Fornell and Larcker (1981). The results showed that all CR values were reliable.

Convergent validity was assessed using two criteria (Fornell & Larcker, 1981; Hair, Black, Babin, & Anderson, 2010): (1) all factor loadings should be significant and greater than 0.5 (Wixom & Watson, 2001), and (2) average variance extracted (AVE) from each construct should exceed the threshold value of 0.5, as this indicates that 50% or more of the variance is explained by the indicators of the latent variable (Chin, 1998). As shown in Table 3, all factor loadings exceed 0.6, the AVE values ranged between 0.54 and 0.83, and all values were above the acceptable level of 0.5. All the factor loadings and AVEs support the convergent validity of the constructs.

Table 3
Measurement model results.

Construct	Factor loadings	AVE	CR
Knowledge donating (KD)		0.83	0.96
KD1	0.90		
KD2	0.92		
KD3	0.93		
KD4	0.91		
KD5	0.89		
Knowledge collecting (KC)		0.70	0.92
KC1	0.89		
KC2	0.85		
KC3	0.89		
KC4	0.82		
KC5	0.74		
Top management support		0.75	0.92
TO1	0.88		
TO2	0.85		
TO3	0.83		
TO4	0.90		
Level of perceived SPI success (PS)		0.69	0.82
PS1	0.85		
PS2	0.81		
Organizational performance (OP)		0.54	0.78
OP1	0.77		
OP2	0.82		
OP3	0.61		
Clan culture (CL)		0.54	0.77
CL1	0.66		
CL2	0.84		
CL3	0.68		
Hierarchy culture (HI)		0.54	0.82
HI1	0.77		
HI2	0.73		
HI3	0.80		
HI4	0.63		

In order to confirm discriminant validity, two criteria were assessed. First, as shown in Table 4, when the loading of each measurement item on its assigned construct is larger than its loading on any other construct, it is considered to have good discriminant validity (Chin, 1998). Second, the square root of the AVEs of a construct should be greater than the correlations between the construct and other constructs in the model (Fornell & Larcker, 1981), as shown in Table 5. Overall, as shown in Tables 4 and 5, convergent and discriminant validity are empirically supported, demonstrating the sufficient construct validity of the scales.

The survey data were collected via self-report. Therefore common method bias (CMB) problem may have occurred. Following the recommendation of Podsakoff, MacKenzie, Lee, and Podsakoff (2003) and the analytical procedure proposed by Liang, Saraf, Hu, and Xue (2007), a common method factor was added to the PLS model. The indicators for all the constructs were reflectively associated with the method factor. The results showed that the variance was explained by the construct and by method factor (bias). As shown in Appendix 2, the results demonstrate that the method factor loadings were insignificant and the indicators' substantive variances were substantially greater than the method variances (Liang et al., 2007). The average substantively explained the variance of the indicators at 0.72, while the average method based variance was 0.002. The ratio of the substantive variance to the method variance was 360:1. Given this, the results implied that the potential concern of CMB was not significant in this study (Liang et al., 2007). We also checked variance inflation factor (VIF) values for all of the constructs, and the results were less than 2.2 which was below the rule-of-thumb cut-off of 10 (Hsu & Chang, 2014), suggesting that multicollinearity is not a serious issue in this study.

4.2. Structural model and hypotheses testing

The proposed hypotheses were tested using the bootstrap resampling estimation of PLS, as suggested by Chin (1998). The test of the structural model consisted of path coefficients (β) and the

Table 4
Factor loadings and cross loadings for the measurement model.

Construct	HI	KC	KD	CL	OP	PS	TO
HI1	**0.77**	0.17	0.26	0.48	0.29	0.27	0.07
HI2	**0.73**	0.16	0.23	0.50	0.24	0.30	0.11
HI3	**0.80**	0.17	0.17	0.40	0.25	0.30	0.04
HI4	**0.63**	0.11	0.12	0.16	0.10	0.12	0.12
KC1	0.18	**0.89**	0.76	0.26	0.33	0.33	0.51
KC2	0.18	**0.85**	0.63	0.24	0.17	0.20	0.39
KC3	0.23	**0.89**	0.69	0.32	0.33	0.39	0.43
KC4	0.11	**0.82**	0.57	0.23	0.24	0.25	0.42
KC5	0.20	**0.74**	0.63	0.28	0.39	0.34	0.44
KD1	0.26	0.73	**0.90**	0.32	0.25	0.36	0.45
KD2	0.28	0.69	**0.92**	0.37	0.33	0.36	0.41
KD3	0.22	0.74	**0.92**	0.35	0.34	0.34	0.44
KD4	0.25	0.66	**0.91**	0.35	0.25	0.27	0.37
KD5	0.26	0.75	**0.89**	0.41	0.36	0.33	0.46
CL1	0.44	0.20	0.21	**0.67**	0.18	0.15	0.07
CL2	0.40	0.30	0.37	**0.84**	0.18	0.17	0.26
CL3	0.42	0.18	0.26	**0.68**	0.18	0.34	0.04
OP1	0.31	0.26	0.25	0.19	**0.77**	0.42	0.10
OP2	0.19	0.35	0.35	0.18	**0.82**	0.44	0.26
OP3	0.21	0.13	0.12	0.17	**0.61**	0.33	0.15
PS1	0.31	0.33	0.31	0.23	0.50	**0.85**	0.23
PS2	0.26	0.27	0.30	0.24	0.40	**0.81**	0.21
TO1	0.10	0.48	0.36	0.20	0.23	0.19	**0.88**
TO2	0.03	0.41	0.35	0.21	0.14	0.22	**0.85**
TO3	0.14	0.47	0.46	0.12	0.25	0.29	**0.83**
TO4	0.10	0.45	0.43	0.16	0.17	0.22	**0.90**

Note: Bold values indicate item loadings on the assigned constructs.

Table 5
Correlation of constructs and the square root of AVEs.

Construct	HI	KC	KD	CL	OP	PS	TO
HI	**0.73**						
KC	0.22	**0.84**					
KD	0.28	0.79	**0.91**				
CL	0.56	0.32	0.39	**0.73**			
OP	0.32	0.35	0.34	0.24	**0.73**		
PS	0.35	0.36	0.36	0.29	0.54	**0.83**	
TO	0.11	0.53	0.47	0.20	0.23	0.27	**0.87**

Note: Square root of AVEs on diagonal in boldface.

coefficients of determination (R-square value). Path coefficients demonstrated the strength of the relationships between the dependent and independent constructs. R-square values indicated that the amount of variance is explained by the independent constructs. The significance of all paths was assessed using 1000 bootstrap runs. Fig. 3 shows the results of the structural path analysis of PLS estimation. The findings support H1, H2 and H4. With H1, we examined the relationship between SPI-knowledge sharing and SPI success. The result showed that SPI-knowledge sharing has a significant impact on SPI success ($\beta = 0.38$, t-value = 2.88, $p < 0.01$), which supports H1. In H2 and H3, we focused on the perspective of organizational culture, and the findings only supported H2; that is, the positive effect of clan culture on SPI-knowledge sharing was significant ($\beta = 0.24$, t-value = 3.23, $p < 0.01$). Regarding top management support, described in H4 and H5, a positive relationship only existed between top management support and SPI-knowledge sharing ($\beta = 0.46$, t-value = 6.31, $p < 0.001$), which supports H4. In H5 top management support did not have a direct significant impact on SPI success ($\beta = 0.09$, t-value = 0.97, not significant). In addition, the R-square values of all the variables were exceeded 10%, indicating substantive explanatory power (Bock, Kankanhalli, & Sharma, 2006; Hsu & Chang, 2014). In the end, we examined predictive relevance (Stone-Geisser Q2) using the blindfolding procedure in SmartPLS with an omission distance set to 7. All of the cross-validated redundancy Q2 were larger than 0 (Tenenhaus, Vinzi, Chatelin, & Lauro, 2005), which indicates that the constructs of our model possessed predictive relevance.

Moreover, there was a statistically significant path from SPI-knowledge sharing to SPI success, and there was a statistically significant path from clan culture to SPI-knowledge sharing. In order to test the mediating effect, we adopted Sobel's test (Sobel, 1982), which indicated that SPI-knowledge sharing has a mediating effect on the relationship between clan culture and SPI success (Sobel statistics = 2.13, p = 0.03). Similarly, top management support's impact on SPI success was explained via the mediator of SPI-knowledge sharing (Sobel statistics = 2.62, p = 0.01).

5. Discussion and implications

Several studies have confirmed the relationship between organizational culture and top management in SPI implementation. This study extends this knowledge to investigate the impact of different culture types, the degree of support from top management, and the degree of knowledge sharing on SPI success. To our knowledge, this study provides the first empirical investigation of the impact of SPI knowledge sharing on SPI success. The findings clearly confirm that knowledge sharing is a critical factor during successful CMMI-based SPI implementation in specific types of organizational cultures.

As shown in Table 6, the findings support H1. From the practitioners' perspective, SPI implementation is certainly a knowledge-intensive group activity that depends heavily on the understanding and mutual support of SPI knowledge by the professionals involved. Knowledge sharing facilitates the distribution and assimilation of pivotal SPI-related experiences and skills among different employees and units in the organization so that they can perform and support continual software process improvement. Therefore, effective and extensive SPI knowledge sharing is a determining factor associated with successful SPI implementation.

Moreover, this study also examines the influence of clan and hierarchy culture types on knowledge sharing in the context of successful SPI implementation. The results revealed that only clan culture has a significant and strong positive influence on SPI knowledge sharing, which supports H2. Furthermore, it is found

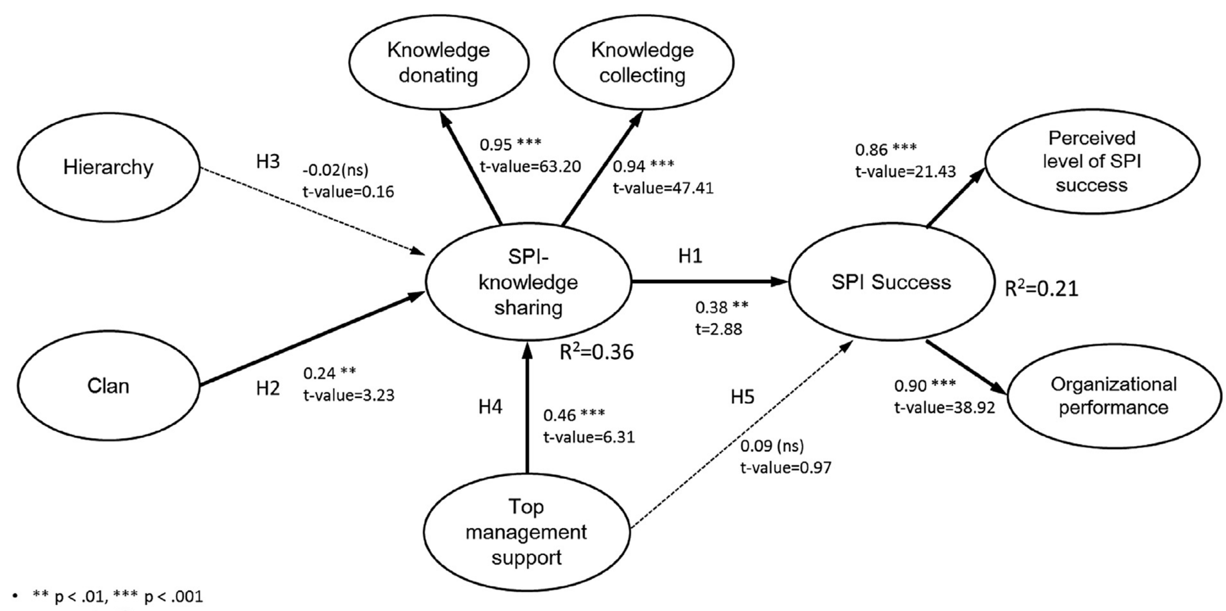

Fig. 3. PLS analysis of the proposed research model.

Table 6
Results of the tests of the proposed hypotheses.

Hypothesis	Path	Result
H1	SPI knowledge sharing has a positive influence on SPI success.	Accepted
H2	Clan culture is positively related to SPI knowledge sharing.	Accepted
H3	Hierarchy culture is negatively related to SPI knowledge sharing.	Rejected
H4	Top management support has a positive influence on SPI knowledge sharing.	Accepted
H5	Top management support has a positive influence on SPI success.	Rejected

that knowledge sharing mediates the relationship between clan culture and SPI success. For the hierarchy culture, its effect on SPI knowledge sharing is not significant, which does not support H3. This finding seems contradict some studies that found that hierarchy culture was positively related to knowledge sharing in the context of ERP success (Shao et al., 2012).

In the study of Shao et al. (2012), the positive effect of knowledge sharing was seen in the context of sharing product knowledge (i.e., the use of a new ERP system) during the assimilation stage of an IT/IS implementation. Such sharing can be reinforced in a top-down hierarchical workplace where employees at the lower levels effectively learn and accept the knowledge shared in the venues (i.e., user trainings) established by the higher-ups. In SPI, knowledge sharing involves identifying and communicating problems to stimulate improvement. Problem identification takes place during not only occasional diagnoses initiated by the higher-ups but also the software processes performed by lower-level employees. In a hierarchy, problems may not be efficiently communicated, as hierarchical levels may hinder the escalation of the problems. Therefore, in this study, the insignificant effect may reflect that the formalized and hierarchical structures act as barriers that limit some knowledge sharing activities (Chen & Huang, 2007; Kim & Lee, 2006), since they inhibit autonomy, change, communication, and dialog (Van den Hooff & De Ridder, 2004; Sanz-Valle, Naranjo-Valencia, Jiménez-Jiménez, & Perez-Caballero, 2011). Standardized procedures may govern employees' actions, resulting in minimal or no discretionary powers vested in employees (Suppiah & Sandhu, 2011) and reducing their willingness to discuss and evaluate problem-solving alternatives (Chen & Huang, 2007), when faced with difficulties during SPI implementation.

To form and enable a clan workplace, organizations may consider building domain-specific knowledge communities of practice. Considering the theory of a hierarchy of needs, we can see that sponsored knowledge groups and communities can help secure the need to belong (Chen & Chong, 2011; Hall & Nougaim, 1968; Lambe, 2014; Maslow, Frager, & Cox, 1970) across various workplaces. From the perspective of integrated process (SEI, 2010), these naturally form platforms for knowledge and skills exchange among employees from different workplaces, which consequently help stimulate the improvement of an organization's processes. The practice of knowledge groups is functionally similar to the concept of “ba” proposed by Nonaka et al. (2000) from the perspective of strategic management. Ba refers to a shared organizational environment wherein knowledge can be utilized, shared, and created. If knowledge sharing can be regarded as a process, in the context of CMMI, then the implementation of generic practices (GPs) 2.1, 2.3, and 2.5 (SEI, 2010) may be applied to cultivate such a culture in the workplace. For GP 2.1, organizational policies (e.g., providing incentives and motivation) can be offered to encourage the establishment of knowledge groups and knowledge sharing. With respect to GP 2.3, organizations should provide adequate and necessary resources (e.g., by funding and sponsoring knowledge communities and groups). The purpose of GP 2.5 is to train people, including offering mentoring and apprenticeship (Nonaka et al., 2000) for better support in clan-based work environments.

In terms of SPI knowledge sharing, we further consider two key actions: knowledge donation and collection (Van den Hooff & De Ridder, 2004; Lin, 2007b). One practical challenge in knowledge donation revolves around the willingness of skilled and experienced employees to freely donate and share their knowledge to secure and retain their competitive advantage over others. In knowledge collection and exploitation, a critical factor is the willingness of employees, especially dominant employees such as senior members, to accept new knowledge. During SPI implementation, employees should focus on setting consistent goals for SPI, even though employees on different project teams may have different goals. The implementation and maintenance of SPI success depends on organizational performance, not on individual success. In this regard, the concept of integrated teams and shared goals can be cultivated to facilitate donation and collection for effective knowledge sharing across various departments and teams (Dayan & Evans, 2006). To help achieve and sustain such an integrated improvement, guidance and support should be provided at the organizational level.

According to Janz and Prasarnphanich (2003), it is critical for top management to provide support and commitment for creating knowledge-based organizational cultures as well as for institutionalizing the aforementioned GPs. In our examination of top management support among our study participants, only the relationship stated in H4 is supported. Specifically, the findings indicate that top management support has a positively significant influence on SPI knowledge sharing but does not have a direct significant relationship (H5) with SPI success. That is, SPI knowledge sharing mediates the relationship between top management support and SPI success. These results, along with the finding of specific culture type as related to knowledge sharing, have mixed managerial implications.

In previous SPI studies, top management was typically responsible for setting the vision and was willing to allocate valuable resources to SPI implementation efforts (Dyba, 2005; Niazi, Wilson, & Zowghi, 2005, 2006; Rainer & Hall, 2002; Sulayman et al., 2012, 2014). Top management support may be a factor for SPI success; however, the empirical findings in this study show that without knowledge sharing, top management support has no direct and significant influence on SPI success. This result implies that the involvement of top management in SPI does not always guarantee motivation and dissemination of support to lower-level employees throughout the firm. The processes of improvement activities are primarily conducted by operational-level employees, and the effectiveness of employees' improvement in work determines the outcome of SPI implementation. Apart from the higher-level support of top management, emphasis on knowledge sharing by top management can be regarded as lower-level behavioral support that is closer to the daily process improvement work of employees. For front-line employees, knowledge sharing is a common and natural activity in the daily work. Employees share and mutually exchange the SPI critical knowledge to improve the existing processes, which in turn collectively determines the achievement of the overall SPI goals. This lower-level support is actually more important in effective and direct triggering of employees toward

SPI and making the improvement run smoothly, especially if there is significant resistance from the employees involved. The support of top management should appropriately emphasize knowledge sharing in order for knowledge sharing to have a larger contribution to the success of SPI.

With regard to how top management influences knowledge sharing, this study provides several suggestions. In terms of knowledge donation, top management needs to value and reward employees not only for the accomplishment of ad-hoc SPI work but also in terms of how employees donate SPI-related knowledge. Donating and sharing SPI-related knowledge are requirements for sustaining the success of SPI implementation. Management should also periodically hold award ceremonies to recognize and compensate those who enthusiastically participate in knowledge sharing (Lin, 2007a). Furthermore, management could accomplish SPI-knowledge sharing activities through educational avenues, such as conferences, seminars, and workshops. Although knowledge sharing can be promoted through education and the provision of rewards or resources, from the perspective of organizational behavior, top management should also act as role models to exemplify the desired behavior of active knowledge sharing. In terms of knowledge acceptance, it is difficult for employees to accept or collect different knowledge or suggestions; therefore, top management must lead by example to accept the new knowledge and opinions of others as well as to avoid groupthink (Gibson, 2001; Janis, 1982).

Finally, by combining aspects of knowledge management and software process management, digital tools may be developed to foster collaboration and build a knowledge-oriented environment within an organization. For example, Process Asset Library (PAL) is a knowledge repository used to store and make available all the process assets that are useful and sharable to those who define, implement, and manage processes in the organization (García, Amescua, Sánchez, & Bermón, 2011). This digitalized and weblized PAL facilitates standardization and process improvement in organizations and is a key enabler for achieving superior performance of improvements (Fogle, Loulis, & Neuendorf, 2001; SEI, 2010). PAL offers certain advantages, such as effective transfer of software process knowledge, storing software engineering best practice, reduced documentation, institutionalization of improved processes, and fostering of a knowledge-sharing culture (García et al., 2011). Top management may consider developing this tool to build a clan culture environment that enables more effective sharing of process knowledge and enhances peer interaction and teamwork.

6. Limitations and further research

In spite of the several contributions presented above, there are also a number of limitations to this study, and hence, there is room for future studies. First, since CMMI samples were collected from Taiwanese firms, the findings of this study might not be generalizable. Future studies could be done in other regions. Second, SPI models include not only CMMI but also other standard SPI programs, such as ISOs SPICE, the ISO9000 series, and QIP. Since this study only focused on the CMMI approach, further studies could replicate and enrich this empirical study by examining other SPI programs. Third, several characteristics or organizational factors were not considered in this study, such as industry types and organizational size, which may have impacted the research model. Future studies should consider demographic characteristics to further refine the research model for revealing other angles to the results. Finally, in this study, the variable of SPI knowledge sharing emphasized personal intellectual capital, and was operationalized in terms of knowledge donation and collection. Follow-up studies could measure the SPI knowledge sharing construct using the concepts of explicit and tacit knowledge sharing developed by Bock et al., (2005), as well as detect the impact of specific types of knowledge on explicit and tacit knowledge sharing in successful SPI implementation.

Appendix A. Measurement items

Note that the questions were presented in Chinese during the survey but have been translated into English here for readability.

Appendix B. Common method bias analysis

Construct	Items
SPI-knowledge sharing	
Knowledge donation (KD)	(KD1) In our organization, new working skills are often shared and are learned in the context of SPI implementation with my colleagues.
	(KD2) In our organization, colleagues often share the new working skills that they learn in the context of SPI implementation with others.
	(KD3) In our organization, we often share the new information that we acquire in the context of SPI implementation with colleagues.
	(KD4) In our organization, our colleagues often share the new information that they acquire in the context of SPI implementation.
	(KD5) In our organization, sharing knowledge with colleagues is regarded as something normal in the context of SPI implementation.
Knowledge collection (KC)	(KC1) In our organization, our colleagues often share working skills, in the context of SPI implementation, with others.
	(KC2) In our organization, we often share working skills in the context of SPI implementation with colleagues when others ask.
	(KC3) In our organization, our colleagues often share information that they know, in the context of SPI implementation.
	(KC4) In our organization, we often share information that we know in the context of SPI implementation with our colleagues.
	(KC5) Our company's staff often exchanges knowledge of working skills and information in the context of SPI implementation.
SPI success	
Perceived level of SPI success (PS)	(PS1) Our CMMI-based SPI work has substantially increased our software engineering competence.
	(PS2) Our CMMI-based SPI work has substantially improved our overall performance.
Organizational Performance (OP)	(OP1) Over the past three years, we have greatly reduced the cost of software development.
	(OP2) Over the past three years, we have greatly reduced the cycle time of software development.
	(OP3) Over the past three years, we have greatly increased our customers' satisfaction.
Organizational culture	
Clan culture (CL)	(CL1) The organization is a personal place. It is like an extended family. People share a lot of themselves with others.
	(CL2) The management style of my organization is characterized by teamwork, consensus and participation.
	(CL3) The glue the holds the organization together is loyalty and mutual trust. Commitment to the organization runs high.
Hierarchy culture (HI)	(HI1) The organization is a very controlled and structured place. Formal procedures generally govern what people do.

(*continued on next page*)

(*continued*)

Construct	Items
	(HI2) The management style of the organization is characterized by security of employment, conformity, predictability and stability in relationships.
	(HI3) The organization emphasizes permanence and stability. Efficiency, control and smooth operations are important.
	(HI4) The organization defines success on the basis of efficiency. Dependable delivery, smooth scheduling and low cost production are critical.
Top management support	
Top management support (TO)	(TO1) Top managers think that encouraging SPI-knowledge sharing with colleagues is beneficial during SPI implementation.
	(TO2) Top managers always support and encourage employees to share their SPI-related knowledge with colleagues during SPI implementation.
	(TO3) Top managers provide most of the necessary help and resources to enable employees to share SPI-knowledge during SPI implementation.
	(TO4) Top managers are keen to see that employees are happy to share their SPI-related knowledge with colleagues during SPI implementation.

Construct	Indicator	Substantive factor loading (R1)	$R1^2$	Method factor loading (R2)	$R2^2$
Knowledge donating (KD)	KD1	0.898	0.806	−0.023	0.001
	KD 2	0.927	0.864	−0.086	0.007
	KD 3	0.924	0.855	0.010	0.000
	KD 4	0.912	0.834	−0.043	0.002
	KD 5	0.888	0.816	0.010	0.000
Knowledge collecting (KC)	KC1	0.889	0.790	0.003	0.000
	KC2	0.851	0.722	−0.018	0.000
	KC3	0.890	0.791	−0.011	0.000
	KC4	0.825	0.678	−0.063	0.004
	KC5	0.728	0.549	0.099	0.010
Perceived level of SPI success (PS)	PS1	0.831	0.707	0.048	0.002
	PS2	0.832	0.681	−0.050	0.003
Organizational performance (OP)	OP1	0.752	0.590	0.050	0.003
	OP2	0.827	0.664	−0.050	0.003
	OP3	0.614	0.378	0.004	0.000
Top management support (TO)	TO1	0.884	0.800	0.038	0.001
	TO2	0.874	0.757	−0.015	0.000
	TO3	0.803	0.641	−0.010	0.000
	TO4	0.898	0.800	−0.015	0.000
Clan culture (CL)	CL1	0.711	0.520	0.040	0.002
	CL2	0.779	0.603	−0.010	0.000
	CL3	0.716	0.504	−0.029	0.001
Hierarchy culture (HI)	HI1	0.701	0.487	0.019	0.000
	HI2	0.671	0.459	0.032	0.001
	HI3	0.847	0.720	0.008	0.000
	HI4	0.731	0.529	−0.021	0.000
Average		0.82	0.720	−0.003	0.002

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