ORGANIZATIONAL CAPABILITIES BUILDING THROUGH CMMI: THE CASE OF TAIWAN SOFTWARE INDUSTRY

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ABSTRACT

This paper studies the change for capabilities/competencies of Taiwan software firms through physical systems, knowledge and skills, managerial system, and value and norm aspects before and after they introduce CMMI. By conducting qualitative-based multiple case-study approach and using semi-structural questionnaire as the tool, we identified CMMI related organization routines. Grounding on these routines, we integrate capabilities/competencies related literatures and value co-production studies to propose a co-evolution model, which suggest that capabilities/competencies of software companies come from the co-evolution between organizational standard operation procedures (SOPs) and customer projects. The co-evolution model would be useful to supplement the dynamic capabilities theory of firm from the value co-production viewpoint. Further, it is analyzed whether these capabilities can become the strategic assets of the software firms. Finally, we recommend that the introduction of CMMI is not only the behavior for Taiwan software firms to build their competitive advantage without differences, but also to build a high performance mechanism for co-producing value with their customers.

Keywords: CMMI, Taiwan, software industry, capabilities, competencies.

1. INTRODUCTION

1.1 Background

Taiwan has been recognized as a major information technology country in the world for a long time. More specifically, Taiwan has maintained the number one position producer of computer monitors, disc drives, motherboards, hubs, wireless local area network (WLAN) cards, notebooks computer, and etc. On May 16, 2005, Business Week magazine even used "Why Taiwan Matter" as the cover story, which pointed out Taiwan is the place how you reach the companies that connect the vast marketplaces and digital powerhouses of the U.S. with the enormous manufacturing centers of China. However, as the manufacturing sector gradually moving out, the GDP ratio of Taiwan service sector was up to 68.7% in 2004. So, in order to transform the economic structure of Taiwan into knowledge-based service industries, the "Guidelines and Action Plans for Service Industry Development" was issued by the Executive Yuan of Taiwan in 2004, and 12 strategic service industries including information service industry were selected as the priority for development [6].

The vision for Taiwan government on developing information service industryis "Establishing Taiwan as a major global supplier in specific areas of information service" , which includes two action programs: "BEST Project" and "CMMI Project". This paper studies and investigates the influence of the latter on the raise of organizational capabilities of Taiwan software industry.

1.2 What is CMMI?

In the mid of 1980s, in order to reduce problem, improve quality and reuse software during the development process of software used for US defence and aerospace application, and respond to the challenges from the fast progress of software factories and the Fifth-Generation Computer Project in Japan, the U.S. Department of Defense entrusted the Software Engineering Institute (SEI) of Carnegie Mellon University in 1984 to create an engineering system model for software industry, so that the individual and organization might have the basis for continuous improvement in the development process of software [8, 9]. The major purpose is to evaluate and improve software development process and software development capabilities of software firms, and help them to improve software maturity structure and quality. Furthermore, the target is to raise the

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software management capabilities of software development project and software firms, to achieve the correct function of software, shorten the development schedule, reduce the cost and assure the quality. This system is so called Capability Maturity Model (CMM), which uses 5 levels to verify the internal software engineering capabilities of software firms.

CMM has been continually developed into various modes, including Software Capability Maturity Model (SW-CMM), Systems Engineering Capability Maturity Model (SE-CMM), Integrated Product Development Capability Maturity Model (IPD-CMM), People Capability Maturity Model (P-CMM) etc. In December 2000, SEI further integrated these modes into Capability Maturity Model - Integrated (CMMI) to substitute CMM standard.

CMMI models have two representations. The first one is staged representation, which has 5 maturity levels: ML1 (Initial), ML2 (Managed), ML3 (Defined), ML4 (Quantitatively Managed), and ML5 (Optimizing). The other one is continuous representation which has 6 maturity levels: ML0 (Incomplete), ML1 (Perform), ML2 (Managed), ML3 (Defined), ML4 (Quantitatively Managed), and ML5 (Optimizing). SEI stresses both representations provide the same essential content but organized in different ways [1].

1.3 Implementation Progress for Taiwan's Software Vendors

According to the data issued by U.S. SEI in September 2005, there were only 10 countries with more than 10 organizations passed CMMI. Taiwan was eighth in the world, which was in ahead of German, Australia etc. Updated to November, 2006, there are 44 organizations (2 with ML5, 11 with ML3, 31 with ML2) in Taiwan that has passed CMMI. The goal of Taiwan government is to help seventy (70) firms pass CMMI ML3, and three (3) firms pass CMMI ML5 by 2008.

1.4 Organizational Capabilities and CMMI

For the past 20 years, the study on the relationship between organizational capabilities/ competencies and competition performances has been the key issue concerned by the scholars under the impact of resource-based view theory, evolutionary Economics, and knowledge-based view theory of firm. Especially, it is considered as an important proposition that the competitive advantage can be achieved by building firm-specific skills and capabilities through organizational learning ways [2, 10, 13, 16, 23, 29, 31, 32].

Since the purpose for the introduction of CMMI is to create organizational capabilities, but whether the firm-specific skills and capabilities can be generated when the same process improvement system is introduced into different organizations, it shall have important implications for the study of competitive strategy differentiation. So, the key study problems are,

(a) After CMMI is introduced into organization, what kind of capabitlites/competencies is created?
(b) When CMMI is introduced into organization, what is the process and path for the creation of organizational capabilities/competencies?
(c) Can these capabitlites/competencies become the strategic assets of organization?

1.5 The Structure of the Paper

In this paper, after the introduction of Section 1, Section 2 will review the literatures associated with software engineering and organizational capabitlites. Section 3 will describe reserrch methodology. Section 4 will discuss research results. The final Section will be conclusions and implication.

2. LITERATURE REVIEW

2.1 The Software Engineering Evolution

After the software appeared in the 1940s, it was debating whether it can form a new engineering discipline. It was paid more attention after the reports of NATO Software Engineering Conferences held in 1968 and 1969, then the software engineering was considered as a professional discipline formally [5, 18, 28].

The reason for why the software engineering has gradually been noticed was attributed to the advancement of electronics technology and the increasing complexity of computer hardware and application program since 1960s. Computer experts found that the addition of manpower could not save the schedule delay of software project [3], so that problems such as over cost and budget, property damage, and personnel safety were often occurred. Therefore, it was considered as a "software crisis" era from 1960s to 1980s in software engineering history, the quality of software was paid more attention instead of productivity [20]. In order to deal with the software crisis issue, many scholars, professional organizations, and software firms tried to solve it through tools, discipline, formal methods, process, and professionalism etc. But in 1987, Brooks [4] proposed "No Silver Bullet" viewpoint, arguing that no individual technology or practice would ever make a 10-fold im-

provement in productivity within 10 years. Cusumano [8, 9] reviewed 15 major software engineering problems listed in 1968 NATO Software Engineering Report by Naur and Brian [18] in 1969 , and also pointed out while the filed has made progress, the same problems that were common in the 1960s, have reappeared with disturbing regularity in the 1980s, 1990s, and 2000s.

"No Silver Bullet" viewpoint could be strictly interpreted as the failure of software engineering efforts, so not all people accepted it [7]. Actually, as SEI pointed out, the software quality was determined not only by *process*, but also by *people* and *technology*. Thus, currently in software engineering field, scholars are focusing more on talents cultivation (*people-oriented*), advancement of software reuse and component (*technology-oriented*), and CMMI Model (*process-oriented*).

Generally speaking, the efforts made by software engineering filed mainly propose varieties of solutions to solve the problems of software productivity. That is the so called "how to" thinking. However, for software companies striving to sustain their competitiveness, they consider not only technically "how to", but also strategically "why to" issues.

2.2 Capabilities/Competencies As Organizations' Strategic Assets

The two terminologies, capabilities and competencies, were overwhelmed by the academia and industry people since Prahalad & Hamel published their famous article "The Core Competence of the Corporation" in Harvard Business Review in 1990 [26]. However, its origin could be traced to Selznick [29], who discussed the organization routine and decision from the sociology aspect and proposed the concept of distinctive competence, arguing 'The distinctive competence to do a kind of thing is in question when we ask whether an agency is well adapted to carrying out an "action" program.'

When Penrose [23] developed the dynamic firm theory, she suggests that the profitability and growth of a firm should be understood in terms of its possession and development of unique and idiosyncratic resources. Though she did not use or define what are capabilities or competencies, she developed resource-based theory and proposed the resources and services viewpoints as, '..it is never resources themselves that are the "input" in the production process, but only the "services" that the resources can render.', to distinguish "factor of production" used by classical economic theory. Here the "services" concept has been evolved as "capabilities/competencies". Thereafter, Wernerfelt [32] and Barney [2] suggest that a business enterprise is best viewed as a collection of sticky and difficult-to-imitate resources and capabilities that enable it to compete against other firms. Prahalad and Hamel [26] propose core competence paradigm and suggest the real sources of competitive advantage are to be found in management's ability to consolidate corporate-wide technologies and production skills into competencies that empower individual business to adapt quickly to changing circumstances.

The evolutionary economists propose that firms have ways doing things with continuity and idiosyncrasy. The development of capabilities in a firm is very much a story of the shaping role of 'relatively constant dispositions and strategic heuristics' that provide an element of continuity that extends even over time spans long enough for radical change to accumulate in the firm's specific performance [19]. Further, their notion of organizational capabilities has been developed into the dynamic capabilities theory of firm, the essence of which is that successful firms have organizational knowledge that enables them to sustain their competitive advantage given path dependencies and market positions in a fast-changing world [31]. However, some core capabilities that served the company well in the past and may still be experienced by others as core rigidities, which are more problematic for projects that are deliberately designed to create new, non-traditional capabilities [15, 16].

Dierickx and Cool [10] suggests that competitively significant resources are gradually accumulated and shaped within the firm, and are generally non-tradable, unique, difficult-to-imitate capabilities acquired in a protracted process of organizational learning are prominent example of the sorts of resources they see as sources of competitive advantage.

Some critics argue that dynamics capabilities or core competencies can be identified only as a consequence of success. It is problematic to have a chain of causality [25]. However, Pavitt [22] argues that the identification of dynamic competencies is inevitably itself part of a learning process, and is neither an elegant theory enabling scholars to predict outcomes, nor a simple recipe enabling managers to achieve corporate success.

The recent development of knowledge-based theory of firm suggests that the firm is conceptualized as an institution for integrating knowledge, and organizational capability is the outcome of knowledge integration.[13] Therefore, Leonard-Barton [15, 16] adopts this view and define a core capability as the knowledge set that distinguishes and provides a competitive advantage. Further, she identifies four dimensions to this knowledge set: (1) employee knowledge and skills, (2) technical systems, (3) managerial systems, and (4) the values and norms.

In this paper, we do not trace the literatures relevant to industrial organization (IO) approach, which represent another mainstream of strategic management theories. We believe, for a knowl-

edge-intensive industry like software, the theoretic bases mentioned above already provide proper grounds for us to develop a specific capabilities/competencies building models for companies doing systematic improvement efforts like CMMI.

3. RESEARCH METHODOLOGY AND DATA COLLECTION

In spite of the apparent success of the dynamic capabilities and core competencies view of the firm, the notion developed by Nelson and Winter of "routines" has not been translated into operational categories [22]. Thus, instead of using quantitative paradigm, we conducted research by using the qualitative-based multiple case-study approach [11, 34].

The source of data includes secondary data and primary interview data. The secondary data includes the information of several successful CMMI demonstration cases promoted by Taiwan Government, related seminars, and government-sponsored research reports etc. The primary interview data was obtained by utilizing the semi-structural questionnaire method as the tool of interview [14, 24]. In this method, the interviewees are interviewed freely under some known outlines of a topic (see Appendix). This kind of interview is very useful for finding certain new research field. It can help us to find out what are the basic problems, how people conceptualize these problems, what terminologies are used, and what apprehension level they get [17].

In selecting our sample cases, according to CMU/SEI's 'List of Published SCAMPI Appraisal Results', in Taiwan, there are thirty-three (33) organizations which pass CMMI by the end of 2005, where seventeen (17) organizations are belonged to software firms. Because the goal of this study is to investigate the related issues such as capabilities/competencies, path, competitive capability built after the introduction of CMMI, so seven (7) software firms (founded more than 10 years) are selected as case study samples. In order to purposefully choose extremes cases, some other considerations such as business types (e.g. system integrator or software developer), size (e.g. capital and number of employee), and location (e.g. northern or southern Taiwan) are considered. The brief description of seven (7) cases is shown in Table 1.

The project leaders of CMMI projects are interviewed for all seven cases. The interview time is about 1~2 hours. Three parts of interview are used to understand the change of core business, capabilities, competencies, competitive advantages, success factors etc. before, during and after CMMI is introduced into the case companies. Because the interviewees are not familiar with capabilities/competencies concept very well, four dimensions of capabilities: (1) employee knowledge and skills, (2) technical systems, (3) managerial systems, and (4) the values and norms (defined by Leonard-Barton [16]) are explained to help them to highlight their organizational capabilities / competencies.

To analyze the data, the notes for all seven cases were organized by each protocol question. Then, we used a grounded theory approach [12] to identify the factors that appeared to present themselves across the cases. While such a methodology has only limited validity, it provides a useful means for identifying factors that previous research may have missed [34]. In this sense, then, our methodology allowed us the opportunity to conduct a truly exploratory study.

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Table 1. Brief description of seven cases

Case	Main Businesses	Focused Domain	Paid-in Capital ($NTD)	Age	Employee (CMMI/ALL)	Maturity Level	Adopted Models*
A	Integration and maintenance of financial service, e-government, defense, and healthcare systems.	Stock Trading Banking Government Defense	> 1 B Large	>30	76/576	ML3	SW
B	Integration and maintenance of e-government, defense, e-banking, IT network systems.	Government Transportation	> 1 B Large	>30	200/1100	ML3	SE/SW
C	ERP, SCM, Automation, and Related System Integration.	Manufacturing (particularly in steel industry)	< 1 B Medium	>5	60/130	ML2	SE/SW
D	ERP Software	Manufacturing Distribution	< 1 B Medium	>20	60/180	ML2	SE/SW
E	System Planning & Integration, Automation, Process Control.	Manufacturing Utilities	< 1 B Medium	~20	50/200	ML2	SE/SW
F	System Integration, Automation, and related services.	Banking	> 1 B Large	~30	200/610	ML2	SE/SW
G	Software Development & Integration, Vertical Industrial Solution Integration, IT Service, Outsourcing Service, Broadband Service	Government Banking Manufacturing Distribution Telecom	> 1 B Large	~30	60/1200	ML3	SE/SW

Note: CMMI models include software engineering (SW), systems engineering + software engineering (SE/SW), systems engineering + software engineering + integrated product and process development (SE/SW/IPPD), and systems engineering + software engineering + integrated product and process development + supplier sourcing (SE/SW/IPPD/SS)

4. RESULTS

Teece el. al [31] suggest the process, positions, and paths can determine the dynamic capabilities of a company. So the strategic capabilities of a company assessed at any time will be the function of process, positions, and paths. Therefore, there are three key points in this study. The first one is to identify the existing capabilities/competencies of company and then find out new capabilities/competencies after CMMI is introduced, that is to find out the change of position. The second one is to find out the process and path adopted by the company to create these new capabilities. The third one is to evaluate whether these capabilities can be used as the strategic assets of company to help the creation of competitive advantage.

4.1 What capabilities/competencies have built through CMMI?

In order to understand what capabilties/compet-encies are built through CMMI, it is necessary to understand what capabilities/competencies are possessed by good software firm. We use the theoretical sampling principle suggested by Glaser & Strauss [12], which means the selected seven (7) companies are considered as better software firms in Taiwan software industry. Leonard-Barton [16] indicates that capabilities can be divided into core capabilities, enabling capabilities, and supplemental capabilities based on their strategic importance. While their existence types include (i) physical systems, (ii) knowledge and skills, (iii) managerial system, and (iv) value and norms. Thus, we summary the existing and new-acquired capabilities and competencies of seven case companies in Table 2 and discuss them in the following.

Physical systems

There shall be many existing capabilities to be found on physical systems for selected software companies through deeply interview and related primary data. Firstly, we identify the accumulated domain knowledge to be considered as the most precious assets of these software companies. If domain knowledge can be commercialized, it will become the domain specific software products of the company. Two ERP (enterprise resource planning) software companies owned such capabilities [Case C, D]. Secondly, we identified some more than 30-year old companies, though their main business is system integration, which established centralized software development department or even set up software factory in the developing country on the reason to develop common-use software and explore opportunities for new businesses [Case A, F, G]. As for the existing software process, most companies use ISO-based process management mainly. It is noted because ISO quality system needs continual reappraisal, and CMMI appraisal has not built that mechanism yet, so most companies consider CMMI and ISO quality systems have mutual enhancement effect [Case A, B, D, E, F, G]. This finding is quite consistent with Yao and Lee's research conclusion that the integration of ISO 9001 and CMMI could result benefits and syner-

gies [33]. We also discovered some companies developed their own internal project management software system [Case A, E]. Even a company sold this kind of system to its customer to help customer conducting project management and coinciding as its project management interface [Case E*]. Some companies think valuable and strategic customers are very important for software industry. The valuable customer such as finance customers often provide stable income to software firms through lock-in effect [30]. While the strategic customers such as foreign customers often transfer their advanced quality control knowhow, management knowledge and displine to raise the quality level of domestic software firms [Case A, C, E, F, G]. Finally, a company indicates that it has a nation-wide instant maintenance network, which is a useful tool to acquire new business [Case E].

As for after CMMI is introduced into company, what kind of physical systems capabitlites is built? Most companies indicate it needs more time to prove it. It is obvious if the company has CMMI certificate, it will be easier to be recognized by international customers or domestic large-sized private enterprises [All cases]. However, they complain that the procurement department of Taiwan government does not provide any incentive to CMMI companies. In addition, the quality level of governmental customer has not been raised for recent years, they recommend the government shall introduce CMMI-AM (acquisition module) system aggressively. Besides, two companies report to enter CMMI consultant business through the accumulation of their CMMI experiences [Case A, C.].

Knowledge and skills

Generally speaking, two main knowledge and skills of software firms are information technology skills and domain knowledge. Because selected samples are comparatively better software companies in Taiwan, they do not have much difference on information technology skill, and the major difference is domain knowledge accumulated by them. Five of them are system integration companies, so the domain knowledge accumulated by them is system integration oriented [Case A, B, E, F, G]. Two of them are software product companies, their domain knowledge has to be transform into programming code through accumulating knowledge and technology [Case C, D]. We also found some differences are caused by locations. For example, the employees of software companies in northern Taiwan usually have more international experiences, and in southern Taiwan are more docile to accept new methods and directives of management.

As to the new-acquired capabilities in knowledge and skills, almost all companies consider CMMI enhance their knowledge and skills very well. They point out, for example, the architecture industry already has formal rules or methodologies for design drawing, construction methods, and verification ways for several decades. But the software industry does not have this. If every firm has this, it will establish an industrial environment. Further, if the industrial environment is healthy, the whole software industry in this country will have competitive advantage. Considering the information technologies owned by software companies is the first leg. The accumulated domain knowledge will be the second leg. And, the process management capabilities built through CMMI would stand as the third leg. Only these three legs are complete and robust, a stable platform can be formed for the healthy development of software firm. Generally speaking, all companies think the capabilities built by CMMI have enhanced their project management capabilities, such as cost estimation, schedule control, and rework control etc. Meanwhile, through CMMI system, internal departments and customers will speak a same language through CMMI system, so that it is more efficient for the communication, control of project, and the share of knowledge with rarely happened "Tower of Babel" phenomenon. Besides, the improvement of processes can accelerate the accumulation process of domain and IT knowledge.

Managerial system

The software firms usually face a fast changing industrial environment, so the managerial system of a good software firm has to focus on encouraging learning and training [All cases]. Because software development is not the production line work, it is necessary to have harmonious organization environment and flexible working hours [Case A, E, F]. A company indicates that in order to respect individual differences, it even hires the consultant to conduct aptitude test for the employees of whole company, so as to help the employees to understand their speciality and potential ability [Case D].

The most contribution of CMMI to the managerial system of country is clear cross-wide communications among departments so that the misunderstanding of project can be reduced [All cases]. Meanwhile, both the employees and managers have more confidence on the control of project schedule. Even without the managers' push, the employees will be more spontaneous to complete their job on schedule [All cases].

Table 2. Summary of existing and new-acquired capabilities and competencies

	Existing capabilities/ competencies	Case Identified	New acquired capabilities/ competencies	Case Identified
Physical Systems	• Domain specific software products	C, D	• Customer Recognition	ALL
	• Centralize software development unit / factory	A, F, G	• CMMI consultant business	A, C
	• ISO-based quality system (continual reappraisal)	A, B, D, E, F, G		
	• e-based internal project management system (including package software sells to customer*)	A, E*		
	• Valuable and strategic customers	A, C, E, F, G		
	• Instant maintenance network	E		
Knowledge & Skills	• Domain knowledge in specific field (system integration oriented)	A, B, E, F, G	• Enhanced project management - cost estimation - schedule control - much less rework	ALL
	• Domain knowledge in specific field (software package oriented)	C, D	• Same language for project control and knowledge sharing	ALL
	• Employee location differences	ALL	• Speedy accumulation process on domain knowledge and technology	ALL
Managerial System	• Encourage learning and training	ALL	• Clear cross-wide communications	ALL
	• Harmonious organization atmosphere	A, E, F	• More confidence on project control	ALL
	• Flexible working hours	A, E, F		
	• Respect individual differences	D		
Value & Norms	• Customer satisfaction	ALL	• Clear duty and right	ALL
	• Professional and quality	ALL	• Choose rather be chosen by project	A, B, C, G

Value and norm

Externally, the implementation of a customer project, the software firm has to communicate with customer very closely, so the customer satisfication is the most important value of good software comanies [All cases]. And Internally, because the company is composed of professional personnel, sometimes, “leading by title“ is not so effective as “leading by professional“. Thus, the respect of professional and quality is also a very important value [All cases].

As for the effect of CMMI on value and norms, every company thinks it can make duty and right clear. When the duty issue is reviewed, the manager will not attribute all faults to the employees, or the employees can clearly distinguish who should be charged [All cases]. It is also noted that many companies indicate before the introduction of CMMI, there are no criteria for them to choose good or bad projects. After the introduction of CMMI, they can choose rather than be chosen by project. Therefore, they can indirectly educate the customers to respect quality, otherwise there will be no good software firm which is willing to take their projects.

4.2 The process and path to build capabilities/competencies

In order to create the strategic advantages, not only the internal coordination and integration activities are very important, but also the importance of external activities and technological integration is increased [31]. Especially the products or services provided by software firm will become an important system for the operation activities of customers. So, it is very important to create value jointly through projects and customers. For example, Norman & Ramirez [21, 27] extended the notion of services to cover all activities in which obtaining actual utility value requires customer value creation, and termed the link between actions by supplier and customers as “offerings.” The “offerings” include four (4) elements, such as: (i) physically tangible entities, (ii) human activities (‘services’ and ‘self-service’) carried out by and shared among, at least, supplier and customer persons, (iii) risk-sharing and risk-taking formulae among interacting parties, (iv) access to, or usufruct of, systems and infrastructure. By combing these concepts with ideas from capabilities/competencies literatures, and the result of actual interview data, we propose the co-evolution model for building capabili-

ties/competencies through CMMI in Taiwan's software industry. We suggest capabilities/ competencies come from the co-evolution between organizational standard operation procedures (SOPs) and customer projects. So, it is necessary to investigate the processes and paths to build capabilities/ competencies from the routines formed from internal, external, and across boundaries (See Figure 1).

4.2.1 Internal routines

Top management

When any new system is introduced into an organization, the top management commitment is always considered as the most important key successful factor. In the studied cases, we find out the commitment is not only a declaration, but also the top management has to participate related CMMI education, training and review activities. Besides, according to the estimation, the cost of $0.3~0.5 million US dollar may be spent at the initial stage for the introduction of CMML ML2 project without significant ROI efficacy. The financial support is also very important.

CMMI team

As for piloting the CMMI introduction process team, the case companies normally select internal software development or particular professional business unit (BU) as the pioneer CMMI team based on their strategy. Some companies, in order to pass CMML ML5 (the highest maturity level) earlier, continue to introduce the successive maturity levels in the same pioneer CMMI team. Other companies diffuse the pioneer CMMI team's experiences to other BUs, then enter into next stage introduction. No matter what way is used, the role of appraisal team members (ATMs) is always the most important. Some people consider ATM as the automatic teller machine for the introduction of CMMI, and the organization members always can get "knowledge cash" from it. Even the introduction period is completed, it can not be dismissed. ATMs are loaded heavily because they not only have to draft SOPs, but also have to handle their own daily jobs. So, it is necessary to select the personnel with sufficient experience and communication capability to be team members. Besides, it is necessary to conduct continual internal experiment and integration during adjusting or creating any organizational process, so as to reach the optimal circumstance gradually. Thus it is necessary to strengthen the problem solving skills of members. In addition, the major rigidities of software firms are usually come from the behavior and culture layers, and has to be removed during the introduction process.

Related FUs and BUs

Though many processes need the cooperation of related functional units (FUs) and business units (BUs), their load is not as heavy as CMMI team. The most important thing is that the middle managers of these FUs or BUs need to support CMMI positively, so that all employees can cooperate with CMMI team members at ease. Besides, it is also very important to give complete CMMI conceptual education to the employees who do not belong to CMMI team.

4.2.2 External routines

Consultants

The consulting company plays the direct guide during the introduction of CMMI. Its function is to provide efficient methodology and tools, updated CMMI knowledge, and quantitative estimation methods to the software firm. The software firms with larger scale and foreign business, are usually located in northern Taiwan, and apt to hire foreign consulting company. In general, the internationalization degree of software firms in southern Taiwan is not as good as in northern Taiwan. Recently, a retired CMMI Leader Appraiser helps southern Taiwan software firms to introduce CMMI on a near voluntarily base. He even promotes southern Taiwan software firms to form a learning community for CMMI, and therefore raise their quality capabilities tremendously. As for dedicated CMMI tools, though there are many foreign CMMI software tools available, most companies do not use them due to high price or non-suitability in Taiwan environment. But a software firm with the CMMI experience is trying to develop the tool suitable to be used in Taiwan software industry.

Customers

During the introduction of CMMI, the software firm has to face both the improvement of process quality and the schedule of customer project in the same time. So, it is necessary to maintain good communication with customers to get their cooperation. Normally, the software firm needs to have the strategy to choose proper customers to run CMMI. For example, the customers who do not want to cooperate or customers with small projects shall be discarded. As for the recognition of CMMI, foreign customers recognize it very much, they even asks Taiwan software firms to introduce it on the whole base. For the domestic customers, most companies agree that time is needed for raising that recognition. Especially, many software firms indicate that CMMI companies still can not get the premium for better quality assurance from domestic customers.

Government

Taiwan government considers CMMI as an very important tool to raise the competitive advantage of its software industry, thus provide several supply-side assistances, such as introduce and translate the newest CMMI information from SEI, establish demo-sites, financial assistance etc. Most software firms think it is very helpful for CMMI introduction. However, they suggest the government shall pay attention to the demand-side improvement. For instance, the ignorance of demand management in some government procurement practices has been annoying CMMI companies. So, the government has to improve the procurement policy, such as introduce CMMI-AM (acquisition module) etc. As for higher education system, the software firms think the software engineering and quality is often neglected, it is necessary to enhance software quality concept in related courses or teaching programs.

4.2.3 Across boundaries routines

In our model, the momentum for the generation of capabilities/competencies is come from co-evolution between customer projects and organizational SOPs. We suggest if co-evolving mechanism is very effective and efficient, which can improve mutual knowledge integration and share problem-solving, therefore will result a strongly tight relationship to co-producing value between software companies and customers.

The co-evolving customer projects

Customer projects are not only the business source of software firm, but also the major route to accumulate domain knowledge. In order to get specific domain knowledge, certain company indicates the ideal case is to sacrifice price at the first project, balance it at the second project, and get profit at the third project. For instance, a company indicates their ERP software is quite competitive in shoe industry because their product allows customer to use 'half pair' as calculation unit, which are perfectly match the sample offering practice of shoe industry. Besides, some international software firms often subcontract their projects to Taiwan software firms due to the consideration of cost or market. We find out these customers will transfer their precious experience such as testing and quality improvement methods to domestic companies, it is also a very important external route for the company to create unique capabilities.

The co-evolving organizational SOPs

During the introduction of CMMI, the software firm often asks the consulting company to provide SOP templates, which will be used as reference for CMMI appraisal. Generally speaking, CMMI experts think this is not a suitable way. Because a good SOP represents an optimized process in an organization, but different organizations may have different optimized process. It is not advantageous for the creation of unique capabilities/competencies by depending upon the same templates. We find out most software firms know it, but the templates still have certain reference value, due to the pressure of tight introduction schedule and insufficient experience. Besides, because CMMI does not have the review mechanism like ISO system, most CMMI appraised companies still use the review mechanism of ISO to maintain the capabilities built by CMMI.

4.3 Will the built capabilities / competencies through CMMI become strategic assets?

Capabilities/competencies can provide competitive advantage and generate rents only if they are based on a collection of routines, skills, and complementary assets that are difficult to imitate [2, 10, 31]. As CMMI would result a set of organizational capabilities, we concern "When CMMI is introduced for most software companies, will CMMI companies still have unique competitive advantage?" In other words, can the built capabilities/competencies through CMMI be imitated easily?

We find out most companies think the impact for the introduction of CMMI is incremental instead of radical to the organization. As for its contribution to the software firms, except the improvement of cost, schedule, productivity, quality, customer satisfaction, return of investment (ROI) etc. emphasized by SEI, the most important thing shall be the efficient value co-production mechanism built between the company and customer, so that the software firm can accelerate the accumulation speed of strategic assets. Under this co-evolution process, the built strategic capabilities through CMMI differ due to different processes and paths of companies, meanwhile, their faster accumulation speed also make them not to be imitated easily.

Another important fact from our research reveals that, 'if Taiwan has more CMMI companies, more customers will recognize CMMI value, which will form a healthy industrial environment. Otherwise, if only a few CMMI companies in Taiwan, they will not have competitive advantage, because the software companies which use simpler method still can survive in the industry.' Apparently, it is not related to individual firm's capabilities, and probably could lead to the study of industrial capabilities/competencies building through CMMI in the future.

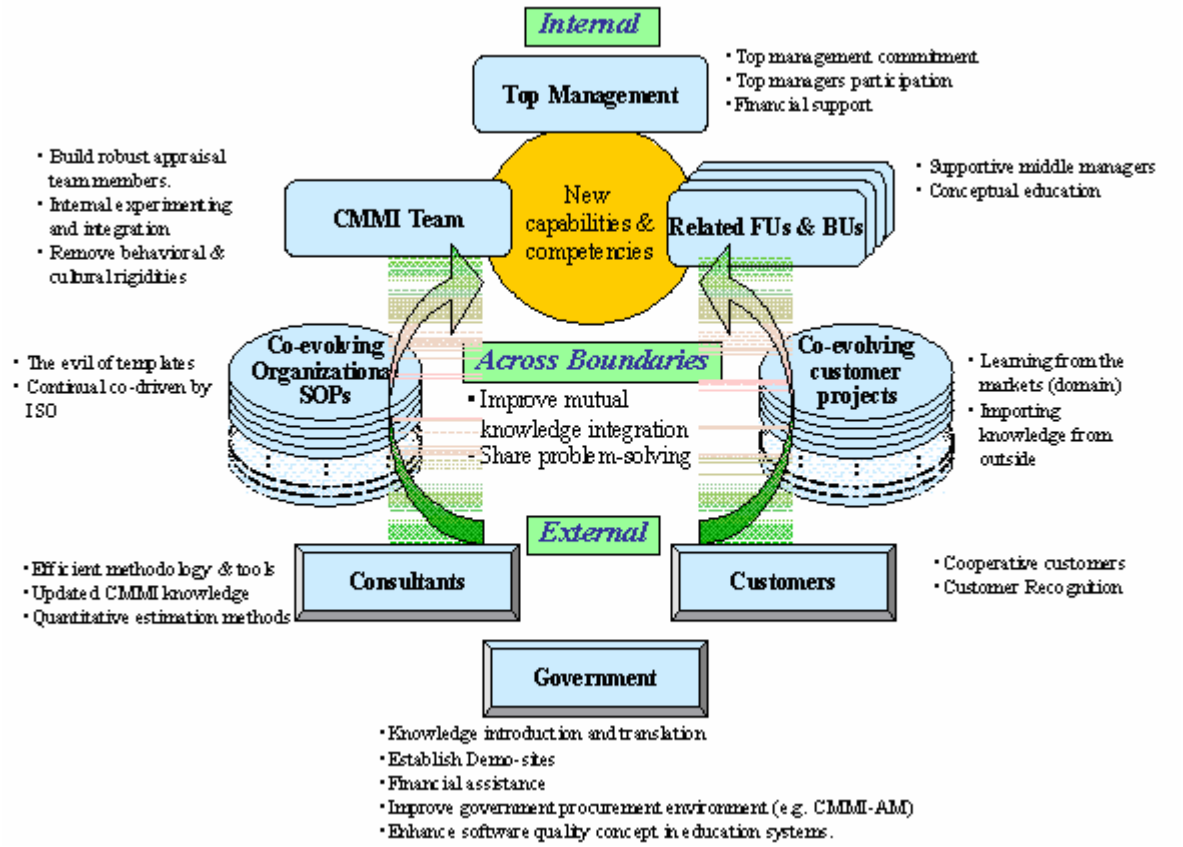

Figure 1. Co-evolving model for building capabilities/competencies

5. CONCLUSIONS AND IMPLICATION

We study how the CMMI influences the strategic assets of firms. Because the selected cases of our study are good Taiwan software firms, the contents of capabilities/competencies owned by these firms are also obtained through the aspects such as phsyical systems, knwledge and skills, managerial system, and value and norm etc. We suggest, as a strategic action, the introduction of CMMI is not only the behavior for Taiwan software firms to build their competitive advantage without differences, but also to build a high performance mechanism for co-producing value with their customers. Meanwhile, we further detailed the co-evolution mdoel for building capabiltites/competences, which might be useful to supplement the dynamic capabilities theory of firm from the value co-production viewpoint. Actually, we find, due to the co-producing value characteristics between software industry and customers, and the importance for the recognition of software quality in the market, CMMI can become a co-evolution mechanism between organizational SOPs and customer projects, which will form an important tool to accelerate the accumulation of strategic assets.

So, the implication for the software firms is, when the decison of introducing CMMI introduction is made, it is not necessary to worry about the differential strategy, the major concern should be whether the optimization between internal and external software and system development process can be continually finely tuned through CMMI. After the introduction of CMMI, it shall emphasize whether high efficient value co-production cycles can be build with customer projects.

As for the implication for the customer, because the software or system solutions provided by software firms are usually embedded into their physical systems and become one of their important business processes. The customers could learn CMMI experience and knowledge from software firms, so as to continually reinforce their own business processes and raise competitive advantages.

As for the implication for the government, in addition to set up the policy and measures to help software firms to introduce CMMI, the promotion of CMMI knowledge and skill for government buyers is also important. More specifically, for the reason to improve the planning and implementation quality of public information systems, the adjustments of government procurement policy and practices are also needed.

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APPENDIX: THE SEMISTRUCTURAL QUESTIONNAIRE

Q1. Before introducing the CMMI

1.1 Please describe the major business and market of your company.

1.2 Please describe the operation condition, the bottleneck for the existing business and new business, and the major competitor.

1.3 How about the quality standard, software engineering method or mode of your company before introducing the CMMI?

1.4 What is the core capability of your company before introducing the CMMI?

1.5 What is the motivation of your company to introduce the CMMI?

Q2. During introducing the CMMI

2.1 What are major successful factors and 3 most difficult factors during introducing the CMMI?

2.2 How to organize internal teams and utilize process improvement methods or tools?

2.3 How to organize or leverage external teams?

Q3. After introducing the CMMI?

3.1 What are the changes of business scope and the improvements of performance of your company? Are these change and improvements helpful to compete?

3.2 What are the core capabilitites built by your company after introducing the CMMI?

3.3 Do you think CMMI is an incremental or radical impact to your company?

3.4 If more domestic companies obtain CMMI appraisal, are you worry about loosing competitive advantage? How do you respond to such situation?

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透過 CMMI 建立組織能力之研究—以台灣軟體產業爲例

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摘要

本論文從實體系統、知識與技能、管理系統與價值觀等構面，研究台灣軟體公司導入「整合能力成熟度模型(CMMI)」之前中後，公司能力/能耐變化之情形。研究方法係採用質性分析爲基礎的多重個案方法，並以半結構化問卷作爲資料蒐集之工具，藉以找出與 CMMI 有關之組織常規(routines)。紮根(grounding)於這些常規之上，我們將公司能力/能耐與價值共生之理論與文獻與之進行整合後，我們提出了一個共同演化的模型，該模型指出軟體公司能力/能耐係從組織的標準作業程序(SOPs)與客戶計畫間共同演化所產生的。因此，本研究有助於從價值共生觀點對公司動態能力之理論加以補充。此外，我們也分析了是否軟體公司所建立的能力可以成爲公司的策略性資產。最後，我們建議對軟體公司而言，CMMI 導入並不至於造成競爭優勢之無差異化，而能促使與客戶間建立一個高效益的價值共生機制。

關鍵詞：整合能力成熟度模型、台灣、軟體產業、組織能力、能耐
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