Received 12 November 2012
Accepted 9 January 2013

Measuring process capital from a system model perspective

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Abstract

Purpose – The purpose of this paper is to seek effective measurement methods that reflect the real value of process capital.

Design/methodology/approach – From a system model perspective, the authors refined the existing knowledge of process measurement by distinguishing three kinds of indicator for the value of process capital: input, output, and the capability to manage process capital. The design of this study, therefore, incorporates a longitudinal analysis of the content of process capital and traces its evolution by attaching a monetary value to activities and assets.

Findings – The tested results reveal that the input measure is a less effective measure for process capital, while the output measure is a valid one for measuring operational and managerial performance of process capital. The capability to manage process capital can predict all dimensions of process capital in both the short- and long-term periods.

Practical implications – A practical view of process capital enhances the current understanding of process capital by highlighting the sustainability of process value and the validity of measuring output and management capability of the process capital. Second, the study results also explain the productivity paradox because of the complexity of the hidden cost of process input and the distinctive capability of organizations in managing technology and complementary resources. Finally, the system view of process capital, from input through process to output of the process capital, with operationalized measures, provides a useful reference for examining intellectual capital.

Originality/value – The findings offer a more robust definition of process capital as a firm's established capability to exploit the knowledge of business processes and organize resources in designing and managing business activities for sustained value.

Keywords Organizations, Business process management, Capital, Knowledge management, Process capital, Intellectual capital, System model, Process knowledge management, Process measurement

Paper type Research paper

Introduction

Process capital, in practice, embraces the practical knowledge of operations, techniques, and employee programs in the effort to extend and enhance the efficiency of manufacturing or the delivery of products and services for long-term value (Edvinsson and Malone, 1997). It is the structural part of intellectual capital (Bontis, 1996; Stewart, 1997; Sveiby, 1997), which possesses knowledge, applied experience, organizational technology, customer relationships, and professional skills that provide organizations with a competitive edge in the market (Edvinsson and Malone, 1997). Organizations invest

Business Process Management Journal
Vol. 19 No. 4, 2013
pp. 662-679

1463-7154
DOI 10.1108/BPMJ-11-2012-0117

in process capital in order to build a company's unique infrastructure for achieving operational and strategic goals (Moustaghfir, 2009).

Given the dynamics of industry and technology, the development of process capital evolves and interacts with environmental changes (Shang and Lin, 2010). Organizations have invested in information technology (IT) and organizational change programs to build process capital for achieving business excellence through customer satisfaction. The vast investments include: IT infrastructure implementation, quality-improvement projects, process-redesign projects, and various process integration projects. Although process capital plays an important role in organizing resources, processing information, interacting with stakeholders, and delivering organizational values (Kaplan and Norton, 2004; Schiuma and Lerro, 2011), few studies have discussed its specific content, and it is rare to focus attention on the level of its management. Instead, process capital has usually been hidden in the measurement of IT investment or organizational intellectual capital as an intangible element of organizational assets (Edvinsson and Malone, 1997). Failure to treat process capital as a separate and unique management issue is widespread among both businesses and researchers because most of the systems and processes within the organizations are interdependent. Therefore, a systematic approach to measuring process capital is necessary in order to manage process potential to its full extent.

The central objective of this paper is to seek effective measurement methods that reflect the real value of process capital. A system model is applied to identify three views of measuring organizational processes: the input of process capital, the output of process capital, and the process of the management of the process capital. By collecting data from the top 500 companies in Taiwan, this study compared the firms' process input, process output, and process management capability over four years of business performance. The results offer a deeper understanding of process capital by examining the different concepts of measuring process capital and testing the validity of the empirical measurements for achieving business efficiency and effectiveness in both short and long term.

Conceptual development

Process capital is essential for strategy development and implementation (Brenner and Coners, 2010; Booker *et al.*, 2008). Business processes are large with technology, location and other factors combining to generate limitless possibilities. Throughout the process of developing and appropriating technology-enabled processes, collective brainpower is formalized, captured, and leveraged to produce an asset of higher value and affect organizational performance in all aspects.

Organizational performance can include the operational, managerial, and strategic impacts of different business efforts on the management of business processes. However, because organizational performance is influenced by numerous factors (Bhasin, 2011), the benefits from process capital can be expected to take up to several years to filter through the various levels of business performance. For example, a process integration technology may take months to develop and transform into real processes and to generate increased productivity. In addition, after processes emerge into business operation, greater managerial and strategic performance may appear later. Therefore, it is important to use proper measures to reflect process value for both the short and long term.

Measuring process capital is a critical part of a firm's strategic planning and execution (Lönnqvist *et al.*, 2009; Gemmel *et al.*, 2008; Roos and Roos, 1997) because process capital consists of all work processes, information systems, techniques, and employee programs for continuous value creation (Edvinsson and Malone, 1997; Kannan and Aulbur, 2004; Taylor, 2007). Nevertheless, measuring process capital is still in its initial stage, and many indicators are still in conceptual form or exist only as qualitative measures. Companies cannot define processes as capital unless they can be converted into a value-generation asset.

In order to build a model for organizing process capital measures according to their value-generation processes system theory (Von Bertalanffy, 1968) is applied to classify measurements of process capital. The three classes of process capital measurements:

(1) the input of process capital – measuring the resources invested in process changes;

(2) the output of process capital – measuring the results of the changed processes; and

(3) the process of the management of the process capital, have different underlying principles and management assumptions, summarized in Table I.

Previously mentioned measures of process capital (Edvinsson and Malone, 1997; Van Buren, 1999; Menon and Lee, 2000; Dehning *et al.*, 2003; Lee and Kim, 2006) can be organized as the input of the process capital (investments in process capital) and the output of process capital (results of the processes). However, the "process" part of the process capital is left unspecified. Using a social perspective (Orlikowski, 2000), with the concept of techno-change management (Markus, 2004), this study constructed a process-related measurement of process capital – the capability of managing process changes.

Based on the system theory framework, we explain the three classes of process capital measurements and hypothesize the impact of process capital on business performances.

The input of process capital and business performance

Using the input of process capital or the investment of process capital in business operations, to reflect the value of changed processes makes this measure a leading

Table I.
Three classes of process capital measures contrasted

Measures of process capital	Measured	Perspective adopted	Underlying principles
Input of process capital	Current investment	Input determinism with assumption of rational behavior of actors	*Rational behavior of actors* Firms will maximize objective functions under the constraints they face
Output of process capital	Past efforts	Social constructivism with focus on organizational learning	*Path dependency* Past experience can shape future performance
Capability of managing process capital	Existing capability	Socio-techno view with focus on the capability of managing the process changes	*Techno-change management* The capability of managing process change is essential for process competence

indicator (Liyanage and Kumar, 2003). In economic terms, that is intended to predict the future value of the processes. This involves viewing the process resources, and especially the process technology, as imperatives that determine the impact of the process on organizational dimensions. Research, including field studies (Chan, 2005; Wieder *et al.*, 2006), suggests that an investment in the technology of business process can help to explain the evolutionary growth of performance from both the IT and organizational perspectives. Assuming rational behavior on the part of actors (Weill, 1990), the input of process capital has been used to predict the value of process capital in these studies. Rational behavior in an organization means that the firm maximizes a given target function, under the constraints it faces in pursuit of its self-interest. Consequently, we can derive optimal economic behavior from the investment in the capital in a normative sense.

Previous researches (Edvinsson and Malone, 1997; Lee and Kim, 2006; Mittal and Nault, 2009) have recommended using IT and operational expenses to reflect the value of process capital, which has been included in intellectual capital with the variables being the cost of administration and IT investment in the production or service (Edvinsson and Malone, 1997; Tsaih and Lin, 2006). These variables are used to explain and predict the value of the processes:

H1. The greater the input of process capital, the better the business performance.

H1a. The investment of process changes is positively related to operational performance.

H1b. The investment of process changes is positively related to managerial performance.

H1c. The investment of process changes is positively related to strategic performance.

The output of process capital and business performance

The output of process capital is considered a lagging indicator (Liyanage and Kumar, 2003) in economic terms. It is a reflection of the total sum of all efforts in managing the technology and operations for business effectiveness (Kueng, 2000). The output view of process capital assumes that the results of the past may predict future results. The process by which the input of resources, including technology and business knowledge being transformed into processes, is a firm's critical learning process. With accumulated experience in process management, the current position should follow the same path as the past and predict consistent performance in the future (Teece *et al.*, 1997). Thus, the destination of process capital may be a function of the firm's current position and the paths ahead.

Based on the assumption of the path dependency of a virtuous organizational learning (Garud and Kumaraswamy, 2005), the output of process capital – primarily the efficiency of the processes – has been used as a valid indicator of the value of process capital. Firms with accumulated experience of process value development can reduce adoption costs because they tend to have a better understanding of the true costs and thus perceive the difficulty of resource management while implementing further changes. Therefore, current outputs of the processes, such as the productivity, can predict the value of the processes:

H2. The better the output of process capital, the better the business performance.

H2a. The results of the changed processes are positively related to operational performance.

H2b. The results of the changed processes are positively related to managerial performance.

H2c. The results of the changed processes are positively related to strategic performance.

The management capability of process capital and business performance

Measuring the management capability of business process changes considers the process management capability a coincident indicator of the value of process capital. In other words, it reflects the value of the process capital at the time of the measurement. The technology's effect on business performance depends on factors such as the quality of a firm's management processes and IT strategy links, which can vary significantly across organizations (Rai *et al.*, 1997; Gemmel *et al.*, 2008; Kumar *et al.*, 2009; Iden, 2012). The value development of the processes requires knowledge and experience in designing and implementing efficient processes for business effectiveness (Markus, 1983; Mokhtar and Yusof, 2010). In addition to normative organizational learning, effective process improvement requires innovation on the human side in improving business performance with the technology-enabled processes, this is considered unique resources of the firm which is hard to be replicated in other firms (Teece *et al.*, 1997).

The capability view of process capital considers the change of processes as a socio-techno change in an organizational environment in which workers, managers, and designers interact directly with the system throughout its implementation and operational life (Markus, 1983). The successful implementation of process systems is usually accompanied by internal changes in organizational structure and culture, policies, and rules, workplace practices, and programs. It involves iterative interactions between technical and social factors so that the organization can manage relevant resources to create an objective-focused environment for the new process to continuously generate value (Markus, 1983). Accordingly, organizational process change management as a strategy-driven initiative improves and (re)designs business processes to achieve competitive advantage in performance through changes in the relationships among information, technology, people, management, and organizational structure (Kettinger and Grover, 1995).

Few studies have identified the capability of managing process resources adapted to changing environments as a key source of process value creation (Teece, 2000). Successful organizational change offers a powerful approach that will equip businesses to pursue improved performance and successfully navigate the current challenges they face while building long-term change capabilities. Due to its focus on improving the value of processes and its usefulness in examining process resources, we chose the concept of process improvement (Penfold, 1999; Cragg and Mills, 2011) as the basis for analysis of the complicated contents of process capital. The process management capability is manifested in the current and future process improvement, thus enabling the firm to translate the input of events, plans, and resources into the outputs they expected (Looy *et al.*, 2011). As a consequence, these capabilities can reflect the value of processes in responding to rapidly changing business environments:

H3. The better the management capability of process capital, the better the business performance.

H3a. The capability of managing process changes is positively related to operational performance.

H3b. The capability of managing process changes is positively related to managerial performance.

H3c. The capability to managing process changes is positively related to strategic performance.

Research methodology

The objective of this study is to investigate methods of measuring process capital and testing-related variables for measuring process capital. Organizations invest in processes in order to build unique infrastructure for achieving operational, managerial, and strategic goals (Joeris, 1997). A complete view of the achievement of these goals requires taking into consideration short- and long-term aspects. On the other hand, financial statements are the objective data that can enable firms to monitor the long- and short-term flows between process and financial capital. It should also be noted that the effects of investment of process capital may not have a precisely identifiable impact on current financial reports, and may take up to several years to develop financial performance. The design of this study, therefore, incorporates a longitudinal analysis of the content of process capital and traces its evolution by attaching a monetary value to activities and assets.

The measurement of process capital

Adapting the system view and consolidating literature and empirical research (Weill, 1990; Edvinsson and Malone, 1997), the following variables of process capital measurement are defined (Table II).

Variable used to measure the input of process capital. Edvinsson and Malone (1997) proposed measurement indicators of the process capital, which deals with the role of technology as a critical instrument supporting overall enterprise value creation. Thus, the input of process capital includes the investment in information technologies and operation, and administrative expenses in managing process changes.

Variable class	Variables	Operationalization	Indicators
Process measurement	Process inputs	Investment in process management	Investments in IT + administrative expenses
	Process outputs	Productivity	Profits/Employee
	Process management capability	Efficiency improvement	Current year productivity − prior year productivity
Business performance	Strategic	Sales growth	(Current year sales − prior year sales)/Prior year sales
	Managerial	ROAs	Earnings before interest, taxes, and depreciation/Average total assets
	Operational	Productivity	Profits/Employee

Table II. Operationalization of variables of process capital measurement

Variable used to measure the output of process capital. Edvinsson and Malone (1997) proposed that process indicators should measure the actual value contribution to firm productivity. Hence, the process output variable as defined in our study includes measures of labor productivity, such as profit/employee.

Variable used to measure the management capability of process capital. According to researchers in the capability management field (Teece *et al.*, 1997; Eisenhardt and Martin, 2000), process management capability in a rapidly changing environment is seen as the capabilities of configuring and coordinating organizational resources to integrate and renew processes to respond to changing business conditions. This study uses the percentage change in productivity as the measure of process change management capability. Data on management capability is based on the difference between current-year productivity and prior-year productivity.

Variables used to measure the value of process capital. Business excellence is about organizational performance, which means how well organizations do their jobs (Drucker, 1964). Adopted from Weill (1990) this study uses operational, managerial, and strategic performance as indicators of business value of process capital. Since processes is a potential source of sustainable completive advantage (Powell, 1995), and they may require years of implementing, improving and generating returns, process capital should focus on both short- and long-term earning capability. The measures used for each process value variable are described below:

- Strategic performance is generally measured against business goals related to competitive advantage. The sales growth of the firm is used as the strategic performance indicator in this study.
- Managerial performance is generally assessed against the business goals of improving management decision making. Based on a fit with the needs and strategy of the organization and the industry, managerial performance in this study is assessed using the financial measure return on asset (ROA).
- Operational performance is generally evaluated using reductions in the cost of doing business by substituting capital for labor. To capture this performance effect, the number of people employed as production labor was used as the measure of operational performance. It is important to note that the operational result of the current year is the same as the output of the process capital of that particular year. Therefore, the measurement of the output of the process capital will be completely correlated with short-term operational performance. However, this indicator is important for the understanding of the predictability of the output of process capital with the trend of the long-term operational performance.

Control variables. Beyond the variables outlined above, we also include two widely studied constructs as control variables in order to add breadth to our framework:

(1) *Firm size*. Firm size represents the total number of employees (Damanpour, 1991; Schoenecker and Cooper, 1998). Because economies of scale can reduce a firm's cost of acquiring financing in the capital market and disperse risk, it is possible that larger firms may enjoy lower costs and higher profits than smaller firms. Hence, firm size is an important factor affecting business performance (Raymond and Croteau, 2009).

(2) *Industry type*. Based on cross-section data analysis, Schmalensee (1985) indicated that industry effects have critical impacts on firms' financial performance. Other studies have also pointed out that industrial economic differences can determine business unit profitability (Tallman and Li, 1996; Delios and Beamish, 1999). In this study, we coded industry type into three dummy variables: manufacturing, high-tech, and service industries.

Data collection

Taiwan has the characteristics of an island economy, with a dense population but limited land and resources. It has a population of approximately 23 million people, with a per capita gross national product (GNP) of US$16,901 in 2009 (National Statistics of the Republic of China, 2012). To meet the challenges of globalization and digitization, companies in all industries have invested heavily in IT in order to improve their competitive advantages. Hence, this study selected 522 listed companies with sales growth rate above 1 percent in Taiwan as the sample. Due to the variance of data sources of studied variables, we collected data of different indicators from two reliable sources and validated the consolidated data sets by industry experts. First, data for the variable of process input between 2008 and 2010 were collected using field visits, interviews, and internet communications. A total of 522 managers (one per firm) were contacted over a period of two months to collect data on process input of the studied fiscal years. Next, we collected data on the variables process output and process capability between 2008 and 2011 from the financial database of the *Taiwan Economic Journal* (*TEJ*), a government-sponsored publication (*Taiwan Economic Journal*, 2012). TEJ was founded in 1990 in Taiwan with a professional team of researchers who conducted data collection from all publically listed companies in Taiwan. TEJ has established a full set of data-processing procedures to screen and verify data – from data input and checking, missing-value tracing, and data-logic verifying, to final relevant data deriving, in order to ensure the accuracy and integrity of the data. As long as all measured variables of a company had been collected, five industry experts, including two process-management consultants and three financial analysts from the key accounting firms in Taiwan, were contacted to review the validity of the figures of the process capital of the selected firms. After elimination of invalid data, including company financial figures showing inconsistency between process input and output, missing figures of process management, and incomplete data of process input, 167 valid samples remained, yielding an effective response rate of 31.99 percent.

Data analysis

The nature of the study is causal in that it attempts to estimate the relationship between variables. However, it is not possible to observe all of the processes that may affect the relationships between the variables. In general, correlation analysis reveals the magnitude and direction of relationships (Cooper and Schindler, 2001). Thus, this study uses Pearson's correlations to analyze separately the correlations between the measurement of variables of process capital (process input, process output, and process capability) and different performances (operational, strategic, and managerial), with details depicted in Tables III-V. Furthermore, using hierarchical multiple regression we validate three main effects of process capital measurement on the four-year business performance, with details shown in Table VI.

Input	2008	2009	2010
'08 Strategic	−0.038		
'08 Managerial	0.035		
'08 Operational	−0.033		
'09 Strategic	−0.033	−0.049	
'09 Managerial	0.046	0.071	
'09 Operational	0.021	0.029	
'10 Strategic	0.017	0.009	0.028
'10 Managerial	0.159*	0.104	0.131
'10 Operational	0.025	−0.014	−0.009
'11 Strategic	0.022	−0.030	0.115
'11 Managerial	0.175*	0.199*	−0.024
'11 Operational	0.031	0.032	0.027

Table III.
Correlations of process input and performance

Note: Significant at: $^{*}p < 0.05$ and $^{**}p < 0.01$

Output	2008	2009	2010	2011
'08 Strategic	−0.021			
'08 Managerial	0.410**			
'08 Operational	1			
'09 Strategic	−0.074	−0.032		
'09 Managerial	0.317**	0.433**		
'09 Operational	0.843**	1		
'10 Strategic	−0.048	0.097	0.316**	
'10 Managerial	0.258**	0.333**	0.227**	
'10 Operational	0.345**	0.665**	1	
'11 Strategic	−0.017	−0.077	−0.101	0.078
'11 Managerial	0.170*	0.222**	0.158*	0.396**
'11 Operational	0.181*	0.469**	0.766**	1

Table IV.
Correlations of process output and performance

Note: Significant at: $^{*}p < 0.05$ and $^{**}p < 0.01$

Management capability	2008	2009	2010	2011
'08 Strategic	0.065			
'08 Managerial	0.149			
'08 Operational	0.739**			
'09 Strategic	−0.014	0.084		
'09 Managerial	0.177*	0.129		
'09 Operational	0.675**	0.193*		
'10 Strategic	0.008	0.248**	0.365**	
'10 Managerial	0.174*	0.072	0.105	
'10 Operational	0.334**	0.463**	0.858**	
'11 Strategic	0.025	−0.098	−0.080	0.260**
'11 Managerial	0.094	0.153*	0.055	0.371**
'11 Operational	0.172*	0.440**	0.686**	0.451**

Table V.
Correlations of process management capability and performance

Note: Significant at: $^{*}p < 0.05$ and $^{**}p < 0.01$

Block	Independent variables	Model 1 β	Model 1 t-value	Model 2 β	Model 2 t-value
Control variables	Firm Size	−0.124	−1.593	0.013	0.289
	Industry Type	−0.158	−2.031*	0.005	0.111
Individual variables	Process Input			−0.084	−1.882
	Process Output			0.420	8.727***
	Process Capability			0.616	13.558***
	F	3.638*		79.237***	
	R^2	0.043		0.716	
	ΔR^2			0.673	
	F-test for ΔR^2			124.040***	

Note: Significant at: $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$

Table VI.
Hierarchical regression of independent variables on overall performance

Research results

The impact of the input of process capital on business performance

The correlations between the input of process capital and performance measures of the three years are shown in Table III. Generally speaking, prediction of performance from input is very low. First, there is no impact of the input of process capital on the operational performance in the subsequent three years. However, the correlations between the input of process capital for years 2008 and 2009 on the long-term managerial performance are significantly positive. The input of process capital for year 2008 and managerial performance from 2010 ($r = 0.159$, $p < 0.05$) to 2011 ($r = 0.175$, $p < 0.05$) are significantly positively correlated, and the process capital input of 2009 is also significantly positively correlated with 2011 ($r = 0.199$, $p < 0.05$). One possible explanation for the finding of no correlation between the input of process capital and the operational performance in the short term is that processes include a wide range of resources, such as technology, culture, structure, and capability, which must all be synchronized (Melville *et al.*, 2004). Also, because of a lag effect of IT investment on firm performance (Lee and Kim, 2006), IT investment will not necessarily translate into gains in profit measures and increases in firm value in the short term. Furthermore, during the years 2009 and 2010 industry investments in IT were mainly in CRM analytical systems such as data warehousing and data mining systems, which were to improve decision making in resource management and enhance managerial effectiveness. Thus, for strategic performance the inputs of process capital are not correlated with business growth in either the short or long terms, and *H1a* and *H1c* are not supported.

The impact of the output of process capital on business performance

The correlations between the outputs of process capital and performance measures from 2008 to 2011 are shown in Table IV. All outputs of the process capital are significantly ($p < 0.05$) and positively correlated with managerial and operational performance from 2008 to 2011. In general, there are no correlations between the outputs of process capital and strategic performance throughout the four years. Hence, *H2a* and *H2b* are supported, and *H2c* is partially supported.

The impact of the management capability of process capital on business performance
The correlations between process management capability and performance measures from 2008 to 2011 are shown in Table V. Process management capability is significantly ($p < 0.05$) and positively correlated with operational performance from 2008 to 2011, and there are partially significant correlations between process management capability and the managerial performance in both the short and long term. There are also partially significant correlations between management capability of process capital and strategic performance in the four-year period. Thus, *H3a* is supported, and *H3b* and *H3c* are partially supported.

Testing of control variables, process capital variables, and overall business performance
Using hierarchical multiple regression, we validated three main effects of the process capital variables. We used Models 1 and 2 in Table VI to show the relationships among the control variables, process capital measurement variables, and business performance. Model 1 focused on testing the relationship between the control variables (firm size and industry type) and business performance. Model 2 further added the three individual variables (input, output, and management capability of process capital) and validated the relationships between the individual variables and business performance. As shown in Model 1, firm size had no significant impact on performance, while industrial differences do influence business performance. According to Model 1, the impact of industry type on process performance was significant. However, these control variables could explain only 4.3 percent of the variation of business performance.

In Model 2, where all of the control and individual variables are considered in the equation, the results revealed that the total variance was statistically significant ($F = 79.237$, $p < 0.001$), and the percentage of explained variance (R^2) showed that the model explained 71.6 percent of the variance of performance. Adding the individual variables of input, output, and process increased the explained variation to 67.3 percent, and changes in R^2 were statistically significant ($F(\Delta R^2) = 124.04$, $p < 0.001$). The superiority of Model 2 in comparison with Model 1 appears to validate our approach, as the three measures offer a better explanation for the process value.

In sum, we further adopted Model 2 to test the control variables and the overall effects of the three process capital measures on the average performance of the firms. The results show that the control variables (firm size: $\beta = 0.013$, t-value $= 0.289$; industry type: $\beta = 0.005$, t-value $= 0.111$) and the process input variable ($\beta = -0.084$, t-value $= -1.882$) had no significant impact on business performance. The output of process capital, however, had a significantly positive impact on business performance ($\beta = 0.42$, t-value $= 8.727$), as did the management capability of process capital ($\beta = 0.616$, t-value $= 13.558$). Overall, *H1* is not supported, and *H2* and *H3* are supported.

Discussion

The central theme of this paper is seeking effective measurement that reflects the real value of process capital. Following are the implications of this study.

Input measure of process capital
Based on the study results, investment of process capital does not seem to have strong impacts on process performance. This productivity paradox is in contrast with several important studies (Brynjolfsson and Hitt, 1996; Lehr and Lichtenberg, 1998;

Mittal and Nault, 2009) regarding the positive returns from IT. This may be explained by three important characteristics of today's process management: the increasingly changing business environment, the type of technology investment, and the data collected for process investment.

First, some of the early studies that showed high positive IT returns focused on either high performance firms or monopolistic and regulated industries (Lehr and Lichtenberg, 1998; Belleflamme, 2001) in which productivity improvements were developed with relatively stable operations, whereas the firms studied here are in a highly turbulent environment. The majority of the studied firms in Taiwan are small and medium-sized (Chang *et al.*, 2003) and compete in the global market with limited resources and constantly changing customer demands. Although rational behavior theory implies that the greater the investment of resources the greater will be the resulting benefit, process management in today's increasingly dynamic business environment depends not only on sufficient quantity of technological and administrative resources but also on the quality of human resources in managing the contingency effects and resource complementarities for constructive use of the resultant business processes.

Second, in regard to the findings showing high IT productivity return (Brynjolfsson and Hitt, 1996; Lee and Bose, 2002), it is important to note that the major IT investment in these studied years account very little for the strategic use of IT (Belleflamme, 2001). IT spending in the years studied primarily went to organizational operations (Cheng, 1992). In contrast, IT spending of more than a decade later in the present study was directed more toward the strategic goals of inter- and intra-process integration, business intelligence, and the building of the agility of the infrastructure (Global Information, 2005). Many factors can mediate and moderate business performance and result in a low association between these kinds of investments in process technology and the immediate and future results.

Finally, another thing to consider is that, in addition to technology investment, business process change and management involve far more complicated efforts in different business areas (Keen, 1997) such as organizational restructuring, business rule modification, education and communication, business participation, and process oversight. This shows that an investment of process capital is complicated and it can be spread across many budgets and departments and remain undocumented. Because traditional accounting systems are not designed to capture the end-to-end costs of processes, it is unlikely that the total costs of process capital can be collected and quantified completely.

Consequently, in consideration of the competitive environment for process management, the social factors of strategic management of process technology, and the difficulty of measuring the complicated items of process investment, measuring the input of process capital is a less effective method of predicting the value of process capital.

Output measure of process capital

Based on the study results, the measure of process output appears to be a strong predictor of managerial and operational performance in both the short and long terms. The results indicate that good execution of process design can promise good operational and managerial value in the future. This appears to support the idea that the development of process capital is the process of organizational learning. Through the construction of process technologies, human agents interact with one another,

deliver business value, and accumulate knowledge collectively. Thus, measuring the results of process capital is based on the concept that the organizational experience of previous process design and management efforts leads to reduplication or better results.

However, path dependency has been used in comparative-historical analyses primarily to infer the development and maintenance of organizational operations (Mahoney, 2000). Recently, Håkansson and Waluszewski (2002) observed that this theory is often described in terms of restrictions or obstructions to the development of new innovations, products, and technology because strategic performance is a reflection of dynamic business capability not only in reaction to environmental factors but also as proactive seeking of process innovation opportunities (Teece *et al.*, 1997). The current study result has reconfirmed that path dependency has its strength in explaining organizational value in the more tactical areas such as operational and managerial performance and is less effective in reflecting the strategic value of business processes.

Capability measure of process capital

With the measure of the management capability of process capital, the study results provide evidence that process management capability can be used as a valid indicator for the current and future value of the processes in all business dimensions. This finding reinforces the importance of process management capability for transforming IT and process resources into a source of competitive advantage (Brynjolfsson, 1993).

From the study results, one would expect that a firm with similar productivity and a higher productivity improvement rate than its rivals is more likely to develop new methods of production and new products for revenue generation. Businesses today are required to pay continuous attention to process changes, including both incremental and radical process improvements and innovations. Given dynamically changing needs, organizational processes have to adapt to the flow of change to fit strategic goals, and the need for process adaptability can lead to on-the-fly modifications of the processes in operation. Firms have to decide when changes should be bred into the affected process steps. Thus, sustained business value from IT emerges particularly through process integration or reconfiguration to coordinate with business strategies and organizational structures. As a consequence, the ability to manage process changes has a greater impact on sustainable competitiveness.

Conclusion

The central theme of this paper is seeking effective measurement that reflects the real value of process capital. From a system model perspective, we refined the existing knowledge of process measurement by distinguishing three kinds of indicators for the value of process capital: input, output, and the capability to manage process capital. Each measure has its own underlying concepts and presumptions that indicate the future, past, and current potential of the organizational processes. The results demonstrate that the input measure is a less effective measure for process capital, while the output measure is a valid one for measuring operational and managerial performance of process capital. The capability to manage process capital can predict all dimensions of process capital in both the short- and long-term periods. These findings offer a robust definition of process capital as a firm's established capability to

exploit technology, process information, and organize resources in designing and managing business activities for sustained value.

In this study, we propose a practical view of process capital. First, it enhances the current understanding of process capital by highlighting the sustainability of process value and the validity of measuring output and management capability of the process capital. By clarifying the underlying concepts and presumptions of the three different kinds of process measures, the management intent can be better interpreted and implemented. The significance of the output measure of process capital highlights the importance of organizational learning and accumulated experience with process management. The significance of the management capability measures of process capital has especially revealed the importance of organizational capabilities in exploiting technology and process resources for process changes that have good strategic fit. Instead of applying a single theoretical lens to examine the value of the intangible asset, it is helpful to examine the construction of the valuable capital throughout the system model process in order to leverage what has been learned and developed in the organization.

The study results also explain the productivity paradox as the result of the input of process capital having low predictability of the value of process capital because of the complexity of the hidden cost of process input as well as the distinctive capability of organizations in managing technology and complementary resources for innovative and improved processes in today's dynamic business environment.

Finally, the system view of process capital, from input through process to output of the process capital, with operationalized measures, provides a useful reference for examining intellectual capital. Extended research is encouraged on the measurement of a variety of technological investments that involve efforts in technology as well as from human agents in constructing technology-enabled processes.

References

Belleflamme, P. (2001), "Oligopolistic competition, IT use for product differentiation and the productivity paradox", *International Journal of Industrial Organization*, Vol. 19 Nos 1/2, pp. 227-248.

Bhasin, S. (2011), "Performance of organisations treating lean as an ideology", *Business Process Management Journal*, Vol. 17 No. 6, pp. 986-1011.

Bontis, N. (1996), "There's a price on your head: managing intellectual capital strategically", *Business Quarterly*, Vol. 60 No. 4, pp. 40-46.

Booker, L., Bontis, N. and Serenko, A. (2008), "The relevance of knowledge management and intellectual capital research", *Knowledge and Process Management*, Vol. 15 No. 4, pp. 235-246.

Brenner, M. and Coners, A. (2010), "Process capital as strategic success factor: the Lufthansa example", in Vom brocke, J. and Rosemann, M. (Eds), *Handbook on Business Process Management*, Vol. 2, Springer, Berlin, pp. 57-72.

Brynjolfsson, E. (1993), "The productivity paradox of information technology", *Communications of the ACM*, Vol. 36 No. 12, pp. 66-77.

Brynjolfsson, E. and Hitt, L. (1996), "Paradox lost? Firm-level evidence on the returns to information systems spending", *Management Science*, Vol. 42 No. 4, pp. 257-276.

Chan, J. (2005), "Toward a unified view of customer relationship management", *Journal of American Academy of Business*, Vol. 6 No. 1, pp. 32-38.

Chang, S.C., Yang, C.L., Cheng, H.C. and Sheu, C. (2003), "Manufacturing flexibility and business strategy: an empirical study of small and medium sized firms", *International Journal of Production Economics*, Vol. 83 No. 1, pp. 13-26.

Cheng, J.J. (1992), "New application framework of industrial information technology", *Intelligent Times*, Vol. 141, pp. 96-103.

Cooper, D.R. and Schindler, P.S. (2001), *Business Research Methods*, 7th ed., McGraw-Hill, New York, NY.

Cragg, P. and Mills, A. (2011), "IT support for business processes in SMEs", *Business Process Management Journal*, Vol. 17 No. 5, pp. 697-710.

Damanpour, F. (1991), "Organizational innovation: a meta-analysis of effects of determinants and moderators", *Academy of Management Journal*, Vol. 34 No. 3, pp. 555-590.

Dehning, B., Richardson, V.J. and Zmud, R.W. (2003), "The value relevance of announcements of transformational information technology investments", *MIS Quarterly*, Vol. 27 No. 4, pp. 637-656.

Delios, A. and Beamish, P.W. (1999), "Geographic scope, product diversification, and the corporate performance of Japanese firms", *Strategic Management Journal*, Vol. 20 No. 8, pp. 711-727.

Drucker, P.E. (1964), *Managing for Results*, Harper & Row, New York, NY.

Edvinsson, L. and Malone, M.S. (1997), *Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower*, HarperCollins, New York, NY.

Eisenhardt, K. and Martin, J. (2000), "Dynamic capabilities: what are they", *Strategic Management Journal*, Vol. 21 Nos 10/11, pp. 1105-1121.

Garud, R. and Kumaraswamy, A. (2005), "Vicious and virtuous circles in the management of knowledge: the case of Infosys technologies", *MIS Quarterly*, Vol. 29 No. 1, pp. 9-33.

Gemmel, P., Vandaele, D. and Tambeur, W. (2008), "Hospital Process Orientation (HPO): the development of a measurement tool", *Total Quality Management and Business Excellence*, Vol. 19 No. 12, pp. 1207-1217.

Global Information Inc (2005), "Manufacturing applications model 2005", July, available at: www.giichinese.com.tw/chinese/dc31446-applications-model.html (accessed 6 May 2011).

Håkansson, H. and Waluszewski, A. (2002), "Path dependence: restricting or facilitating technical development", *Journal of Business Research*, Vol. 55 No. 7, pp. 561-570.

Iden, J. (2012), "Investigating process management in firms with quality systems: a multi-case study", *Business Process Management Journal*, Vol. 18 No. 1, pp. 104-121.

Joeris, G. (1997), "Change management needs integrated process and configuration management", *Proceedings of 6th European Software Engineering Conference, September, Zurich, Switzerland*, pp. 125-141.

Kannan, G. and Aulbur, W.G. (2004), "Intellectual capital measurement effectiveness", *Journal of Intellectual Capital*, Vol. 5 No. 3, pp. 389-413.

Kaplan, R. and Norton, D. (2004), *Strategic Maps: Converting Intangible Assets into Tangible Outcomes*, Harvard Business School Press, Boston, MA.

Keen, P.G.W. (1997), *Process Edge: Creating Value Where It Counts*, Harvard Business School Press, Watertown, MA.

Kettinger, W.J. and Grover, V. (1995), "Special section: toward a theory of business process change management", *Journal of Management Information System*, Vol. 12 No. 1, pp. 9-30.

Kueng, P. (2000), "Process performance measurement system: a tool to support process-based organizations", *Total Quality Management and Business Excellence*, Vol. 11 No. 1, pp. 67-85.

Kumar, U., Kumar, V., Grosbois, D.D. and Choisne, F. (2009), "Continuous improvement of performance measurement by TQM adopters", *Total Quality Management and Business Excellence*, Vol. 20 No. 6, pp. 603-616.

Lee, J. and Bose, U. (2002), "Operational linkage between diverse dimensions of information technology investments and multifaceted aspects of a firm's economic performance", *Journal of Information Technology*, Vol. 17 No. 3, pp. 119-131.

Lee, S. and Kim, S.H. (2006), "A lag effect of IT investment on firm performance", *Information Resources Management Journal*, Vol. 19 No. 1, pp. 43-69.

Lehr, W. and Lichtenberg, F.R. (1998), "Computer use and productivity growth in US federal government agencies", *The Journal of Industrial Economics*, Vol. 16 No. 2, pp. 257-279.

Liyanage, J.P. and Kumar, U. (2003), "Towards a value-based view on operations and maintenance performance management", *Journal Quality in Maintenance Engineering*, Vol. 9 No. 4, pp. 333-350.

Lönnqvist, A., Sillanpää, V. and Carlucci, D. (2009), "Intellectual capital management in practice: assessment of implementation and outcomes", *Knowledge Management Research and Practice*, Vol. 7 No. 4, pp. 308-316.

Looy, A.V., Backer, M.D. and Poels, G. (2011), "Defining business process maturity: a journey towards excellence", *Total Quality Management and Business Excellence*, Vol. 22 No. 11, pp. 1119-1137.

Mahoney, J. (2000), "Path dependence in historical sociology", *Theory and Society*, Vol. 29 No. 4, pp. 507-548.

Markus, M.L. (1983), "Power, politics, and MIS implementation", *Communications of the ACM*, Vol. 26 No. 6, pp. 430-444.

Markus, M.L. (2004), "Technochange management: using IT to drive organizational change", *Journal of Information Technology*, Vol. 19 No. 1, pp. 4-20.

Melville, N., Kraemer, K. and Gurbaxani, V. (2004), "Review: information technology and organizational performance: an integrative model of it business value", *MIS Quarterly*, Vol. 28 No. 2, pp. 283-322.

Menon, N.M. and Lee, B. (2000), "Cost control and production performance enhancement by IT investment and regulation changes: evidence from the healthcare industry", *Decision Support Systems*, Vol. 30 No. 3, pp. 153-169.

Mittal, N. and Nault, B.R. (2009), "Investments in information technology: indirect effects and information technology intensity", *Information Systems Research*, Vol. 20 No. 1, pp. 140-154.

Mokhtar, S.S.M. and Yusof, R.Z. (2010), "The influence of top management commitment, process quality management and quality design on new product performance: a case of Malaysian manufacturers", *Total Quality Management and Business Excellence*, Vol. 21 No. 3, pp. 291-300.

Moustaghfir, K. (2009), "How knowledge assets lead to a sustainable competitive advantage: are organizational capabilities a missing link?", *Knowledge Management Research and Practice*, Vol. 7 No. 4, pp. 339-355.

National Statistics of the Republic of China (2012), *National Statistics*, Directorate General of Budget of Accounting and Statistics of Executive Yuan (R.O.C.), April, available at: http://ebas1.ebas.gov.tw/pxweb/Dialog/statfile9L.asp (accessed 5 June 2012).

Orlikowski, W. (2000), "Using technology and constituting structures: a practice lens for studying technology in organizations", *Organisation Science*, Vol. 11 No. 4, pp. 404-428.

Penfold, S. (1999), *Change Management for Information Services*, Bowker-Saur, London.

Powell, T.C. (1995), "Total quality management as competitive advantage: a review and empirical study", *Strategic Management Journal*, Vol. 16 No. 1, pp. 15-37.

Rai, A., Patnayakuni, R. and Patnayakuni, N. (1997), "Technology investment and business performance", *Communications of the ACM*, Vol. 40 No. 7, pp. 89-97.

Raymond, L. and Croteau, A.M. (2009), "Manufacturing strategy and business strategy in medium-sized enterprises: performance effects of strategic alignment", *IEEE Transactions on Engineering Management*, Vol. 56 No. 2, pp. 192-202.

Roos, G. and Roos, J. (1997), "Measuring your company's intellectual performance", *Long Range Planning*, Vol. 30 No. 3, pp. 413-426.

Schiuma, G. and Lerro, A. (2011), "Managing knowledge assets in a complex business landscape: the relevance of emotive knowledge", *Knowledge Management Research and Practice*, Vol. 9 No. 4, pp. 279-285.

Schmalensee, T. (1985), "Do markets differ much", *American Economic Review*, Vol. 75 No. 3, pp. 341-351.

Schoenecker, T.S. and Cooper, A.C. (1998), "The role of firm resources and organizational attributes in determining entry timing: a cross-industry study", *Strategic Management Journal*, Vol. 19 No. 12, pp. 1127-1143.

Shang, S.S.C. and Lin, S.F. (2010), "A model of intellectual capital management capability in the dynamic business environment", *Knowledge Management Research and Practice*, Vol. 8 No. 1, pp. 15-23.

Stewart, T.A. (1997), *Intellectual Capital: The New Wealth of Organizations*, Bantam Doubleday Dell Publishing, New York, NY.

Sveiby, K. (1997), "The intangible asset monitor", *Journal of Human Resource Casting and Accounting*, Vol. 2 No. 1, pp. 73-97.

Taiwan Economic Journal (2012), "About TEJ", *Taiwan Economic Journal*, April, available at: www.finasia.biz/ensite/Home/tabid/90/language/zh-TW/Default.aspx (accessed 6 June 2012).

Tallman, S. and Li, J. (1996), "Effects of international diversity and product diversity on the performance of multinational firms", *Academy of Management Journal*, Vol. 39 No. 1, pp. 179-196.

Taylor, L. (2007), *Knowledge, Information and the Business Process: Revolutionary Thinking or Common Sense?*, Chandos Publishing, Oxford.

Teece, D.J. (2000), *Managing Intellectual Capital*, University Press, Oxford.

Teece, D.J., Pisano, G. and Shuen, A. (1997), "Dynamic capabilities and strategic management", *Strategic Management Journal*, Vol. 18 No. 7, pp. 509-533.

Tsaih, R. and Lin, W.Y. (2006), "The process-wide information organism approach for the business process analysis", *Industrial Management and Data Systems*, Vol. 106 No. 4, pp. 509-522.

Van Buren, M. (1999), "A yardstick for knowledge management", *Training and Development*, Vol. 53 No. 5, pp. 71-77.

Von Bertalanffy, L. (1968), *General System Theory: Foundation, Development, and Applications*, George Braziller, New York, NY.

Weill, P. (1990), *Do Computers Pay Off: A Study of Information Technology Investment and Manufacturing Performance*, International Center for Information Technologies, Washington, DC.

Wieder, B., booth, P., Matolcsy, Z.P. and Ossimitz, M.L. (2006), "The impact of ERP systems on firm and business process performance", *Journal of Enterprise Information Management*, Vol. 19 No. 1, pp. 13-29.

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