Impacts of Corporate IT Investment Strategies on Operational Performance Based on Intellectual Capital Framework

Yi-Ming Tu [a], Yi-Shun Wang [b], Yi-Wen Liao[a, *], Liang-Cheng Chang[c]

[a] *Department of Information management, National Sun Yat-Sen University, 70 Lien-Hai Road, Kaohsiung 80424, Taiwan*

[b]*Department of Information Management, College of Management, National Changhua University of Education, Changhua 500, Taiwan*

[c]*Department of Information Management, Chin Chien University, 200, University Rd, Neimen Township, Kaohsiung 834, Taiwan*

Abstract

In recent years, due to fast development of information technology and fierce competition, information technology investment strategies are significant factors to sustain business operation. Furthermore, rival investment strategies and allocation of complementary assets should be taken into account so as to achieve maximum efficacy of the strategies. This study adopts the intellectual capital structure and complementary asset theory, and investigates Taiwan's information-intensive services. A research model is presented to discuss the impacts of information technology investment strategies on organizational performance based on intellectual capital framework. This study introduces a system dynamics method to analyze a case of two rival companies, and interprets the effects of different IT investment strategies on operation performance through simulation and scenario analysis. The simulation results can help companies making information technology strategies and evaluating their overall performance. The results indicate that different information technology investment strategies and matching degree of complementary resources have different impacts on the organizational performance. Moreover, this can help companies to make IT investment strategies. The studied results can provide important theory and practice implications for organizational IT management.

Keywords: Intellectual Capital, System dynamics, IT Investment, Organizational performance, Information-intensive services

1. Introduction

Modern companies have entered into a new economy era. To accommodate themselves to the fast and complex business pattern, they need to have high integration, flexibility, and diversification to cope with market changes. In the dynamic and competitive global market environment, companies require a set of perfect operating strategies for competition. In the past two decades, IT has become a pivotal drive of the economic reform and organizational reconstruction. Regarding whether IT investment can promote industrial growth and organizational performance, many researches have attempted to demonstrate efficiency generated from IT; however, there are many conflicting and different results. Some proved that IT makes contribution to industrial production, but some presented the contrary views, such as "Productivity Paradox of Information Technology". Due to different inter-industry characteristics, the input of IT investment is different, and information technology has different impacts on efficiency generated from organizational capacity. Past researches (Brynjolfsson, 1993; Devaraj & Kohli, 2003) found IT investment has impacts on organizational performance and has time lag. In addition, the impact factors are mutually affected, showing nonlinear relationship and feedback. This is a dynamic complex problem. Lastly, IT investment strategies require a set of effective performance assessment instruments which can guide the organizations to develop towards their goals. At present, there are many performance evaluation methods, and most studies use the financial and operation situations as the major measures. If companies only consider finance indicators, the overall view cannot be seen. The future focus should shift from short-run product strategies to long-run strategies of labor power, organization and customers. The relationships between the intellectual capital factors are discussed conceptually in many studies. Few studies discuss the relationship between information technology investment and other factors, and lack of actual data for evidence.

Since information technology investment has dynamic, stagnation and feedback characteristics, this is a dynamic complex problem. We should see the correlation behind the problem to know the causal relation from the systems thinking point of view. Therefore, this study aims to discuss long-run dynamic impacts of corporate IT investment strategies on the organizational performance, and impacts of different IT investment strategies and allocation of complementary resources on the organizational performance by the system dynamics method. The "establishment of information technology investment strategies" involves types of information technology investment (including know-how and customer relationship management systems), time and investment volume, allocation of other resources, and consideration of rival investment strategies. This paper firstly discusses the literature

related to the impacts of organization IT investment strategies on organizational performance, which serve as the basis for building simulation model. It then selects the intellectual capital structure of the organizational performance evaluation method, and establishes the research model in combination with system dynamics. This study suggests that during preparation of investment strategies, company factors and development of current information technology need to be considered. Proper investment strategies should be implemented as competitive market environment changes, and proper performance evaluation should be carried out for information technology investment.

Based on literature review, the information technology investment has impacts on the organizational performance, which is affected by many factors, such as internal process coordination, and information technology talents. Thus, this study suggests that information technology investment requires allocation of other complementary resource to achieve maximum investment performance. It is assumed that the information technology investment strategy is decided by the organization. Besides IT investment, other important factors, such as company cultural difference, financial resources and investment cost difference, employee training and know-how share, will affect the difference of the organizational performance after implementation of the information technology investment strategies. For relationship between IT investment time and organizational performance, most past researches focus on improving short-run organizational performance and profitability based on the linear or unidirectional backward causal relation, so the dynamic nature of some is a variable, causal feedback and non-linear relation between variables, or sectional research cannot be reflected. The investment strategies which can ensure long-run profitability and competitive advantage cannot be found for the organizations. Moreover, the relationship between information technology investment and organizational performance is important, and this is a dynamic complex problem. Thus, the long-run trend of the impacts of the investment strategies on the company operation performance needs to be taken into account when proposing the investment strategies. In order to correctly measure organizational performance, this study utilizes intellectual capital structure to measure organizational performance, and establishes a causal feedback diagram, a system flow chart, and a quantitative simulation model for organizational IT investment strategies through system dynamics method. Lastly, this study discusses long-run and dynamic impacts of companies' different IT investment strategies on organizational performance and conducts different scenario analysis. The findings can serve as reference for companies to develop effective IT investment strategies and provide important theory implications for IT investment strategies research.

2. Literature Review

1. Literature on information technology investment and organizational performance

In global and information era, IT investment plays a key role in improving organizational performance, creating value and maintaining organization competitive power. In past studies on the relationship between IT investment and organizational performance, total IT investment is often used but not differentiated according to different investment patterns. However, different IT investment patterns may have different impacts on organizational performance. It is necessary to test performance of different IT investment patterns. Many current studies have discussed the correlation between IT investment and organizational performance, and proved that both have positive relationship. In addition, internal skills and resources will be allocated according to company and rival situations to achieve maximum organizational performance. Besides IT investment, many studies have proposed allocation of other complementary assets, such as employee competence, employee training, knowledge share and customer demands. As a result, IT investment should combine with allocation of other complementary assets to achieve maximum efficacy.

2. Time lag of information technology investment and industrial characteristics difference

Although, many studies support positive relation between IT investment and cooperate operation performance, some studies have different conclusions, among them, priority is given to the studies related to information productivity paradox. Brynjolfsson (1993) suggested that there is no definite significant relationship between IT and corporate operation performance because of time lag effect between them. Mahmood et al. (1998), Anderson et al. (2004), and Devaraj & Kohli (2003) found that IT expense has deferral effect on earnings and operation performance in the later years. Brynjolfsson (1993), Brynjolfsson & Hitt (1996b) further indicated that the time of IT investment efficacy becoming visible is slower than the investment time when correctly and properly investing information technology, and sometimes the investment efficacy would become visible after 2~3 years. Another reason for the inconsistency with past empirical results may be the research methods, such as particular samples, incorrect measures, and failure to the control the industries affecting corporate operation performance and some special factors (Brynjolfsson & Hitt, 1996a; 1996b; Bharadwaj et al., 1999). This study selects a specific industry (information-intensive services) for investigation to avoid result distortion due to different industrial characteristics, and uses findings to make up the research gap.

3. Impacts of information technology investment and complementary assets on corporate and relevant theory

Carr (2003) suggested that "IT Doesn`t Matter" in Harvard Business Review, and this has led to a debate. Until now, there is no final conclusion. Carr (2003) emphasized the importance of complementary trait. The "complementary asset" theory stresses that information technology is the important component of the corporate competitive advantages, but the corporate competitive advantages cannot only rely on information technology. If only depending on information technology, as Carr suggested, competitive advantages cannot remain for long time. The corporate information technology must combine with other assets to form a competitive weapon which is difficult to copy. These complementary assets mainly include accumulated financial asset, brand asset, channel asset, partner relationship, large number of customers, and specialized knowledge. The complementary assets in this study refer to intellectual capital. IT investment needs human capital, organizational capital, process capital, innovation capital, customer capital and financial capital to achieve and maintain competitive advantages, and to improve organizational performance. Intellectual capital has direct impact on organization business performance, but relying on intellectual capital is not enough to bring better business performance. Similar resources have increased effect, and different resources are complementary. Furthermore, some factors need other factors for improvement or accumulation. Interaction between the factors can create value by means of support and combination of the factors (Edvinsson and Malone, 1997; Mouritsen et al., 2001; Van der Meer-Kooistra & Zijlstra, 2001; Hussi & Ahonen, 2002; Bukh, 2003). Edvinsson & Malone (1997) emphasized the importance of interaction between intellectual capital factors, and indicated that the interaction between the factors can create value. Youndt et al. (2004) proposed a similar view, and indicated that the larger picture is neglected if intellectual capital is considered as independent dimension, and the impacts of the intellectual capital dimension on the organization cannot be known completely. To thoroughly understand how intellectual capital drive organizational performance, the focus should be placed on intellectual capital rather than its individual dimensions. Likewise, only putting emphasis on information technology is not enough when considering IT impact on organizational performance. Other factors related to IT should be taken into account so as to understand actual impacts of information technology on organizations.

Based on the above, if properly eliminating some errors (IT type and industrial characteristics) and unnoticed factors (support of other complementary assets of information technology investment), IT investment should have positive impacts on

the organizational performance, and may have deferral effect on further operation performance. From the viewpoint of intellectual capital, the results obtained through creation and accumulation of intellectual capital would reflect the organizational performance, so information technology as a component of intellectual capital has positive impacts on organizational performance. According to the viewpoint of value chain, IT which belongs to organizational infrastructure is only a link of the value chain, and thus it can inferred that it could help increasing organizational value and operation performance.

4. Measurement approaches of organizational performance

Intellectual capital is one of the measurements of organizational performance. The concept of intellectual capital was first proposed by John Kenneth Galbraith (1969), and many theories on intellectual capital have been proposed afterwards. However, due to the wide scope of intellectual capital, different scholars have different definitions, and no agreement has been reached. To effectively reflect corporate value, measurement of intellectual capital is important but is difficult. The following section will describe the most typical measure of the intellectual capital. Skandia Navigator includes Skandia Navigator architecture, intellectual capital model, and market value framework. The Navigator is consisted of five components: financial, customer, process, human and renewal, and development focus. Roos et al. (1998) developed intellectual capital model using Skandia market value framework and described establishment of intellectual capital measure. Based on corporate operation concepts and strategies, key success factors should be found, and analysis of summary measures is conducted to find the specific measures for expression of intellectual capital. Edvinsson & Malone (1997) suggested the Skandia market value framework and guidelines, and divided the intellectual capital into human capital, innovation capital, process capital, and customer capital.

5. Impacts of information technology investment on corporate operation performance by intellectual capital framework

The measurements of corporate performance include productivity, profitability, and market share. In addition, there are some intangible asset measures, such as corporate value, and competitive advantage. The PIMS project published by Strategic Planning Institute (1970) suggested that market share is positively correlated with profitability (Buzzell, 2004). Buzzell (2004) agreed with the findings. Rodríguez-Pinto et al. (2008) suggested that market share is a widely used measure of

competitive position, and has positive impacts on corporate profitability. Based on the above, this study refers to customer-oriented view, and use market share and profitability are the measures of the corporate operation performance. Information technology value for corporations is the important studied problem in MIS researches, which have suggested that information technology investment is important for corporate operation performance measurement. Therefore, this study uses market share and profitability as the measures of the corporate operation performance.

Intellectual capital is often described as the gap between corporate market and book value. Intellectual capital is the key asset of knowledge-based corporations, and it is not disclosed and used in annual report and general analysis model. Intellectual capital must be converted into knowledge resources for presentation. The knowledge resources are often classified into technologies, process, important related parties and employees, and these factors are interacted. Therefore, corporate operation performance in this study is measured by Skandia intellectual capital architecture (Roos et al., 1998), consisting of five components: financial, customer, process, human and renewal and development focus. The relationship between corporate IT and complementary assets investment strategies and value creation is discussed by using intellectual capital architecture.

Based on the above, corporate IT investment does not always have one-way and linear relationship with corporate performance, complicated dynamic relationship also exists. With reference to IT investment-related literature and five components (i.e., financial, customer, process, human and renewal and development focus) of intellectual capital architecture, this study applies simulation model based on system dynamics to analyze dynamic impacts of corporate different IT strategies on corporate performance. Through the simulation model, corporations can find out which IT investment strategies can effectively improve corporate operation performance, while considering their rival strategies to maintain long-run competitive advantages.

3. Research Method

System dynamics is an approach to understand and solve complex problems, suitable for research of dynamic complex problem. Its purpose is to create simulation model to analyze behavior of dynamic complex system, and identify problem in the system. In building system dynamics model, system thinking is used to analyze causal feedback relationship of the system to depict dynamic complex system, define system process, information transmission and system boundary, and establish system dynamic model. Furthermore, dynamic complex problem is discussed by computer simulation method. System dynamics model can adjust different variables and scenarios to observe and analyze long-run dynamic effect of corporate strategies. IT

investment shows long-run and dynamic corporate performance, system dynamics is very suitable for analysis. Thus, this study utilizes system dynamics to observe non-linear and casual dynamic feedback relationship between variables.

4. System Dynamics Model

IT plays an important role in information-intensive services, and has significant impacts on corporate performance in the service industry. This study investigates information-intensive services (e.g., financial and insurance industries and real estate intermediary services). For the purpose of model simplification and clear observation of system dynamics, this study assumes that there are only two rivals companies with same size in the market. Before building a computerized system dynamics model, the causal feedback relationship between IT investment strategies and corporate performance in duopoly market is illustrated (see Figure 1). With reference to the five components of the intellectual capital, the human capital (i.e., employee productivity, work load), innovation capital (i.e. activity of employee training investment and knowledge share, share degree, innovative products/services), process capital (i.e., service level, IT investment activity and IT productivity), customer capital (i.e. customer satisfaction, number of customers, reputation and market share), and financial component (including cost, sales revenue, profitability and market value) are incorporated into the model. The "establishment of information technology investment strategies" involves type of information technology investment (including knowledge and customer relationship management systems), time and investment, allocation of other resources, and consideration of rival investment strategies. Besides IT investment strategies, the study model also takes other resource into account, including complementary assets of employee training and knowledge share. The dynamic causal relationship between IT investment strategies of two corporations and their performance is observed. The causal feedback loops are presented in Figure 1 below.

(1) Negative Feedback 1

Negative feedback 1 refers to: service level-> customer satisfaction (Anderson et al., 1997; Boulding et al., 1993; Mithas et al., 2005)->reputation (Oliver, 1997; Ha, 2004)-> number of customers (Naumann & Hoisington, 2001)-> service level. Higher corporate service level leads to higher customer satisfaction and higher reputation, thus more customers. However, more customers lead to lower service level.

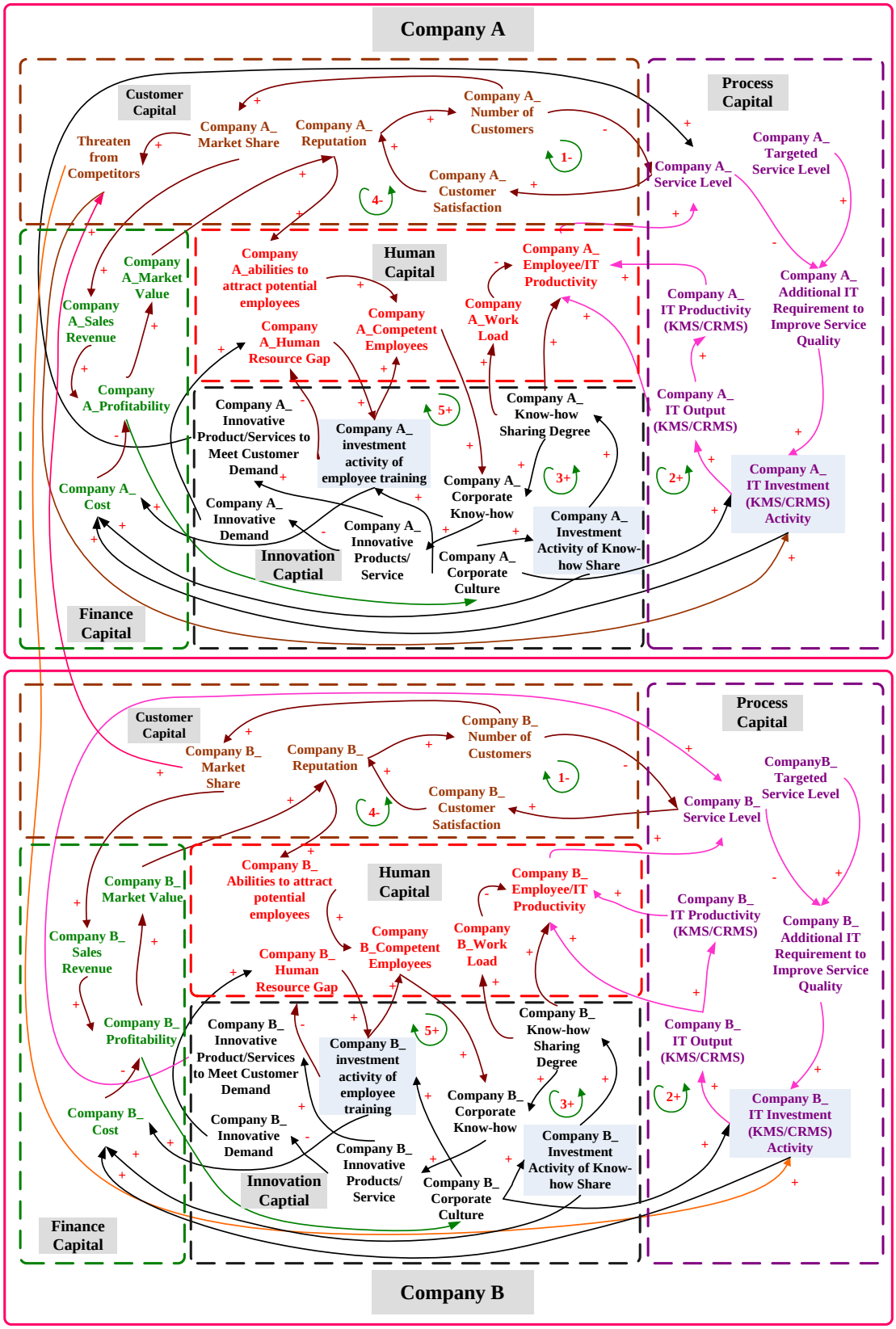

Figure 1: Causal feedback diagram for corporate IT investment dynamics

(2) Positive Feedback 2

Positive feedback 2 refers to: corporate culture-> IT investment activity (Hu & Plant, 2001; Hu & Quan, 2005; Shin, 2001)->IT output -> IT productivity (Bergendah, 2005)->employee/IT productivity (Karimi et al., 2001; Chopra & Meindl, 2003)-> service level (Karimi et al., 2001; Saeidaa et al., 2007)->customer satisfaction (Anderson et al., 1997 ; Boulding et al., 1993; Mithas et al., 2005)->reputation (Oliver, 1997; Ha, 2004)-> number of customers (Naumann & Hoisington, 2001)->market share->sales revenue (Aaker & Jacobson, 1994; Nelson, 1995; Naumann & Hoisington, 2001)->profitability->corporate culture

As the corporate culture is more innovative, the IT investment strategies are more active; as IT output and productivity is higher, service level is higher, and customer satisfaction is higher; when reputation is higher, there are more customers; higher market share leads to higher sales revenues and higher profitability, thus, corporate culture tends to be more innovative.

(3) Positive feedback 3

Positive feedback 3 refers to: Corporate culture->investment activity of know-how share (Hu and Plant, 2001; Shin, 2001; Hu and Quan, 2005; Vorakulpipat & Rezgui, 2006; Vorakulpipat & Rezgui, 2007; 2008) -> know-how sharing degree (Rivera-Vazquez et al., 2009)->employee/IT productivity(Karimi et al., 2001; Saeidaa et al., 2007)-> customer satisfaction (Anderson et al., 1997 ; Boulding et al., 1993; Mithas et al., 2005)-> reputation (Oliver, 1997; Ha, 2004)->number of customers (Naumann & Hoisington, 2001)->market share->sales revenues (Aaker & Jacobson, 1994; Nelson, 1995; Naumann & Hoisington, 2001)->profitability->corporate culture. As corporate culture is more innovative, know-how sharing and degree is higher; when IT productivity is higher, service level is higher, and customer satisfaction is higher; when corporate reputation is higher, there are more customers; higher market share leads to higher sales revenues, and profitability is higher, thus corporate culture tends to be more innovative.

(4) Negative feedback 4

Negative feedback 4 means: Corporate culture->investment activity of know-how share (Hu & Plant, 2001; Shin, 2001; Hu & Quan, 2005; Vorakulpipat & Rezgui, 2006; Vorakulpipat & Rezgui, 2007; 2008)->know-how sharing degree (Rivera-Vazquez et al., 2009)->work load (Saeidaa et al., 2007)-> employee/IT productivity->service level (Saeidaa et al., 2007)-> customer satisfaction (Anderson et

al., 1997; Boulding et al., 1993; Mithas et al., 2005)-> reputation (Oliver, 1997; Ha, 2004)-> number of customers (Naumann & Hoisington, 2001)-> market share->sales revenue (Aaker & Jacobson, 1994; Nelson, 1995; Naumann & Hoisington, 2001)->profitability->corporate culture. As corporate culture is more innovative, investment activity and degree of know-how sharing is higher; when the work load is higher, IT productivity and lower service level is lower; when customer satisfaction is lower, corporate reputation is lower; when there are less customers, market share is lower, and sales revenues are lower; lower profitability leads to less innovation corporate culture.

(5) Positive feedback 5

Positive feedback 5 refers to: Corporate culture-> investment activity of employee training (Hu and Plant, 2001; Shin, 2001; Hu and Quan, 2005; Batt and Moynihan, 2006)->competent employees (Romijn & Albaladejo, 2002; Souitaris, 2002; Shipton et al., 2005; Vorakulpipat & Rezgui, 2008)->corporate know-how(Lin, 2007)-> innovative products/service (Saeidaa et al., 2007; Lin, 2007)->innovative product/services to meet customer demand (Ehigie & McAndrew, 2005; Saeidaa et al., 2007)->service level (Chopra & Meindl, 2003)->customer satisfaction (Anderson et al., 1997; Boulding et al., 1993; Mithas et al., 2005)->reputation (Oliver, 1997; Ha, 2004)->number of customers (Naumann & Hoisington, 2001)-> market share ->sales revenue (Aaker & Jacobson, 1994; Nelson, 1995; Naumann & Hoisington, 2001)-> profitability -> corporate culture. As corporate culture is more innovative, investment activity of employee training is higher, and employees are more competent; when there are more innovative products and services that can better meet customers' demands; as service level is higher, customer satisfaction is higher, and corporate reputation is higher; when there are more customers, market share is higher, and sales revenues are higher; higher profitability leads to more innovation corporate culture.

5. Fundamental analysis, validation and scenario analysis

(1) Fundamental analysis and validation

The fundamental analysis assumes two rival companies with the similar size in oligopolistic markets, and both adopt the same information technology strategies, including initial IT investment (including know-how and customer relationship management), IT investment of additional know-how and customer relationship management, IT investment time, IT investment cost (both are 1, thus, the same investment proportion is 1:1). Furthermore, the two companies adopt the same

offensive IT investment strategies for competition in the market. The matching degree of other corporate complementary assets is the same; investment proportion of know-how share and employee training is 0.5; know-how share investment is the same with employee training investment. The simulation period is assumed to be 5 years (i.e.60 months). The analysis results are shown in Figures 2 and 3.

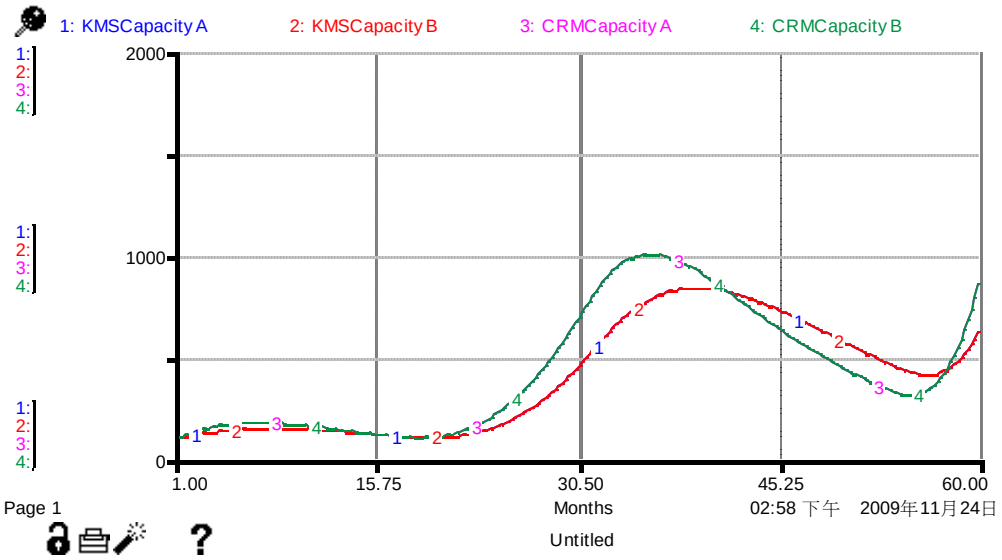

Figure 2: Results of fundamental analysis

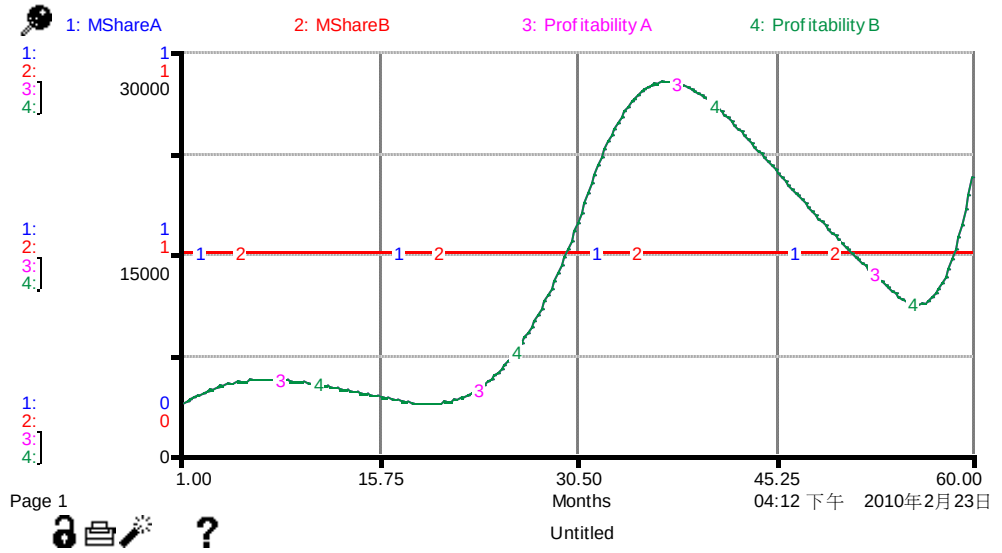

Figure 3: Results of fundamental analysis (continued)

The simulation results show that the two companies have the same operational performance using the same investment strategies. This means that the research model effectively controls other factors affecting market performance, and increases validity of the results. The variables of the figures are as follows: KMSCapacityA and

KMSCapacityB denote know-how management capacity of companies A and B respectively; CRMCapacityA and CRMCapacityB denote customer relationship management of companies A and B respectively; MShareA and MSahreB denote market share of companies A and B respectively; ProfitabilityA and ProfitabilityB denote profitability of companies A and B respectively.

The validation in this study includes steady-state method of test, time extreme value test, initial minimum value test and transitional policy test. Steady-state test assumes that strategy goal policy has not been implemented, i.e. initial IT investment and additional investment are 0; time extreme value test increases the simulation period to 8 years; initial minimum value assumes IT investment strategies are to increase investment to 1 in the sixth month, IT investment ratio is 0.1 and complementary asset investment ratio is 0.1; transitional policy test assumes IT investment strategies are to increase investment to 50 in the sixth month; IT investment ratio and complementary asset investment ratio is not changed (0.5). The tested results are consistent with the general system behavior, and simulation results are discussed and interpreted in the reasonable range.

This study further builds a system dynamics-based computerized simulation model according to Figure 1 casual feedback diagram. For the purpose of model simplification, the study focuses on information-intensive services, and assumes that there are only two rivals companies with same size in the market, and the simulation period is 60 months (5 years). After establishing the system dynamics-based model, it is utilized for scenario analysis. There are three different market scenarios for analysis of impacts of two companies' IT investment strategies on organizational market performance through computerized simulation model. The simulation results of the different scenarios are presented as follows.

(2) Scenario Analysis I: IT Investment Difference

With the same IT investment, investment time, cost and complementary asset investment strategies are different.

The scenario assumes A and B have the same size and compete with each other in the market. Company A's IT investment is larger than company B, but two companies have the same IT investment time and cost, as well as the complementary asset investment strategies. The simulation results are shown in Figures 4 and 5.

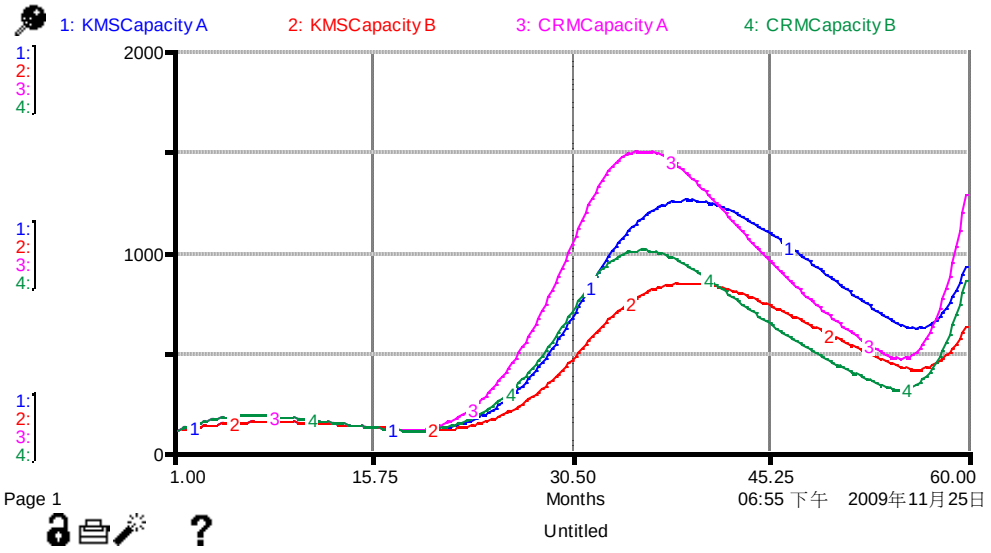

Figure 4: Results of Scenario Analysis I

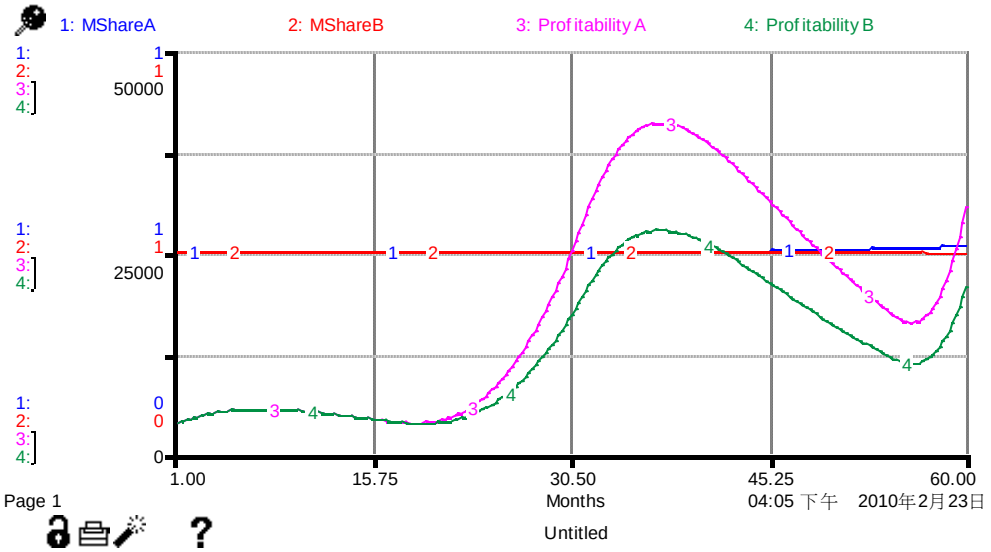

Figure 5: Results of Scenario Analysis I (continued)

The simulation results indicate that two companies have the same **customer satisfaction, knowledge accumulation, innovation level, reputation and service level**. For other measures, company A has more IT investment than company B and thus it has better performance for human capital (i.e. employee/IT productivity), process capital (i.e. KMS capacity and CRMs capacity and service level), customer capital (number of customers and market share), and financial capital (profitability and market value). Based on the analyzed results, in the information-intensive services, a company and its rival make IT investment at the same time. If the company can input more resources in IT, it can increase corporate IT productivity, employee-used IT productivity, market share, profitability and market share.

(3) Analysis of scenario II: IT investment time point and investment cost difference

In the scenario, it is assumes that A and B of the same size compete with each other in market, and company A carries out IT investment strategies 18 months earlier than B. In addition, past study indicated that earlier investor (A) spends more investment costs than the later investor (B). It is assumed that company A's investment cost is 1.5 times higher than that of company B, with the same complementary asset investment strategies. The simulation results are shown in Figures 6 and 7.

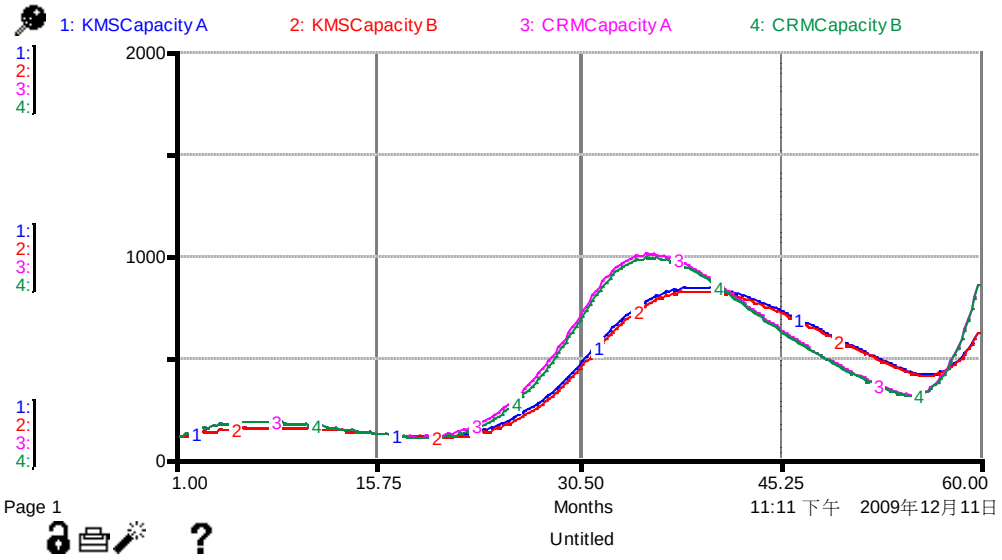

Figure 6: Results of Scenario Analysis II

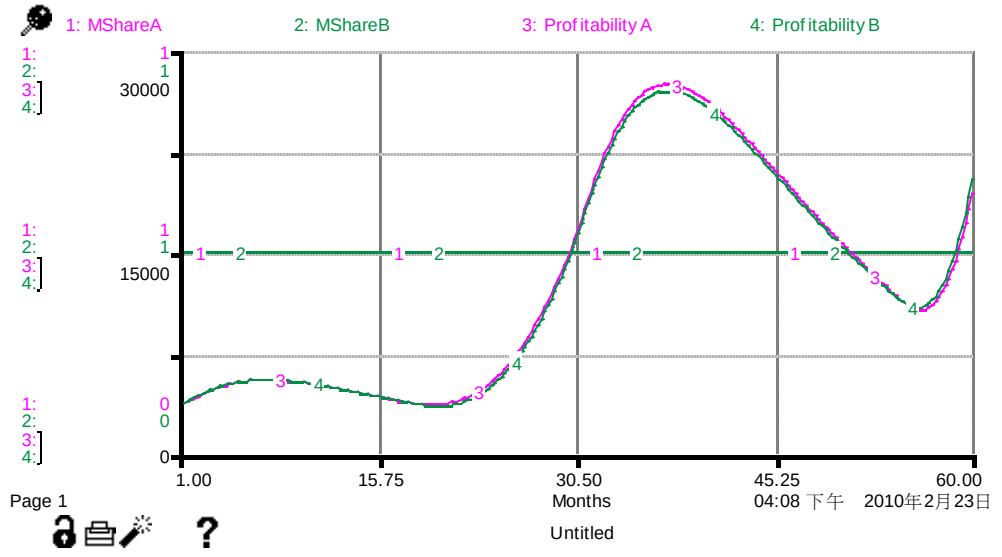

Figure 7: Results of Scenario Analysis II (continued)

The simulation results indicate that two companies have better customer satisfaction, knowledge accumulation, innovation level, reputation and service level. For other measures, company A's IT investment time is earlier than that of company B's and thus it has better performance for human capital (i.e. employee/IT productivity), innovative capital (i.e. innovative products/services), process capital (i.e. KMS capacity and CRMs capacity and service level), customer capital (number of customers and market share), and financial capital (profitability and market value), but the difference is small. Due to company A's earlier investment time, its investment cost is higher. Thus, company B seems to catch up with A in the following simulation period. Based on the analyzed results, in the information-intensive services, the earlier investor can obtain higher profitability and market value as compared to the later investor, but the gap is quite small. The earlier investor spends higher investment cost, and the later investor will catch up with the earlier investor in later period. The possible reason is that earlier investor makes IT investment, without complementary resources, and the advantage gap will be closed by the later investor.

(4) Analysis of scenario III Difference of IT investment time and cost, investment proportion of IT system types and complementary resources

This scenario assumes that companies A and B of the same size compete with each other in market, and both have the same IT investment. However, investment time and cost, KMS and CRMS investment proportion and complementary resource investment strategies are different. It is assumed that company A's investment time is the sixth month, and company B's investment time is the 18^{th} month. The investment cost of earlier investor, company A, is 1.5 times higher than that of the later investor, B. In addition, company B is more active in KMS and know-how share and employee training investment strategies (company A's investment proportion of KMS and two complementary resources is 0.5; however company B's investment proportion is 0.7). The simulation results are shown in Figures 8 and 9.

The simulation results show that company B's performance is lower at the beginning but will catch up with company A in the middle and later period after KMS and complementary asset investment is enhanced. Based on the above results, in the information-intensive services, the earlier investor can obtain better corporate operation performance and competitive advantages in the short period. However, if KMS and complementary asset investment is not enhanced, the later investor will catch up with the earlier investor. The later investor's investment time is slower, but its performance will gradually excel the earlier investor after its KMS and

complementary asset investment is enhanced, and it may obtain the long-run competitive advantage.

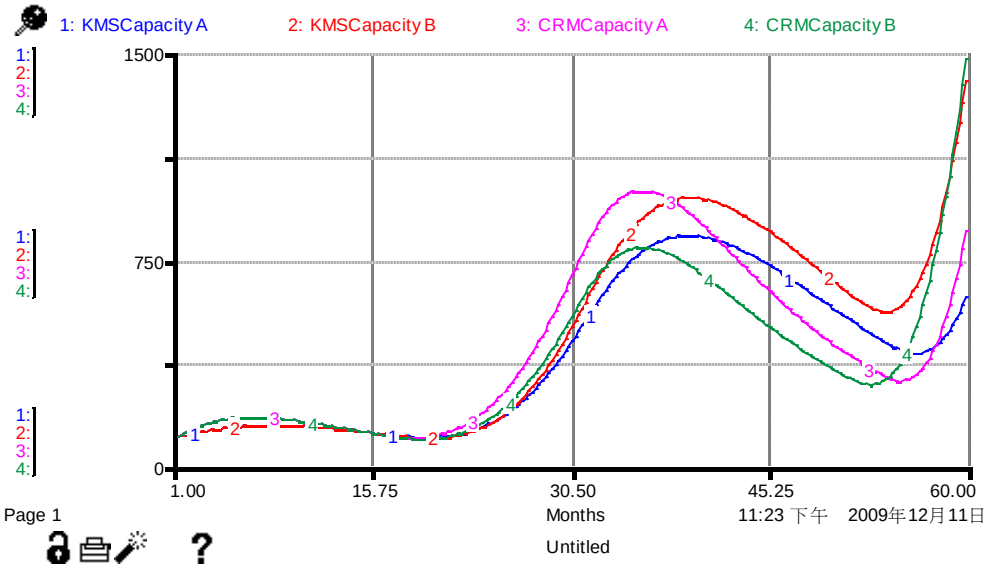

Figure 8: Results of Scenario Analysis III

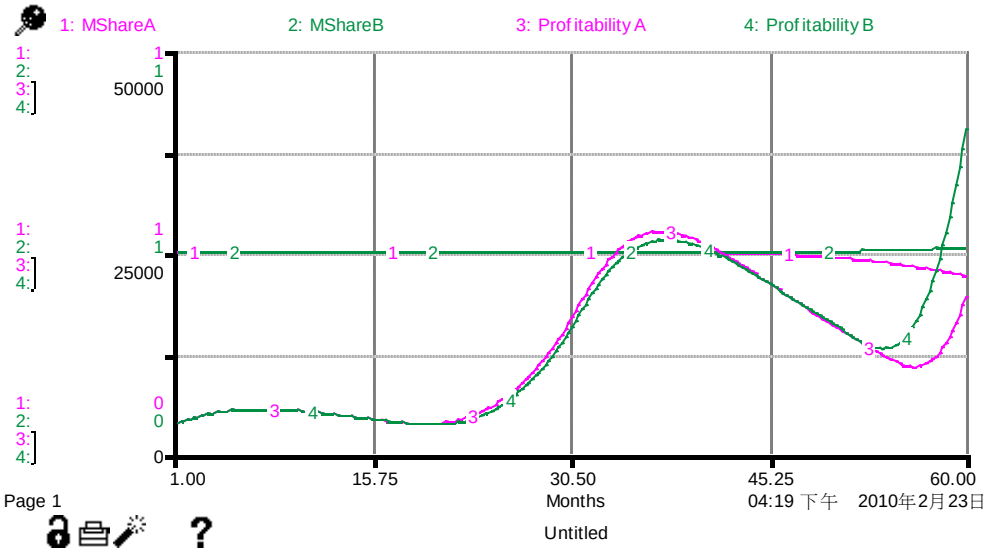

Figure 9: Results of Scenario Analysis III (continued)

(5) Discussion of scenario analysis results

Based on the above simulation results, [Scenario I] if only considering IT investment strategies, namely IT investment and IT investment time, the simulation results indicate that the company with more IT investment volume and earlier IT investment time has better performance in IT productivity, number of customers, profitability and corporate market value when compared to the company with less IT

investment and later IT investment time. [Scenario II] if the two companies have different IT investment time, it is assumed that earlier investor spends higher investment cost than the later investor (this study defines the earlier investor's investment cost is 1.5 times higher than that of the later investor). The two companies show no significant difference in knowledge accumulation and innovation degree, and the earlier investor has better performance in IT productivity, number of customers, profitability and corporate market value. In terms of earlier investor's higher investment cost, the later investor will excel the earlier investor in the later period. [Scenario III] if two companies have the same IT investment, the investment time and cost, KMS and CRMS investment proportion and complementary resource investment strategies are different. It is assumed that A makes earlier IT investment, with higher investment cost; company B makes IT investment later, and spends more complementary resources. Simulation results show that company A has better performance in IT productivity, profitability, and corporate market value because it makes earlier investment during initial simulation period. Company B also makes IT investment and enhances complementary resource investment. Its performance in IT productivity, profitability and corporate market value will excel A, and the gap will be widened gradually.

Based on the simulation results from the three investment strategies, the company with better IT investment strategies and more investment show better performance in all aspects. Investment of different IT systems may reflect different performance in productivity, profitability and market value. The corporate performance after CRS investment is shorter than that after KMS investment. In long term, the higher investment proportion of KMS can obtain better overall performance. In addition, if a company makes IT investment later and the complementary asset strategy (employee training and knowledge share) have higher coordination degree, that is resources are input to improve human resources and help corporate performance. Therefore, IT investment cannot bring long-run advantage, and require complementary assets to maintain long-run competitive advantages.

In the current environment of fierce competition, how to determine IT investment strategy and investment time, and how to maintain organizational performance is important. This study simulates different scenarios of actual situations, and the difference from the past studies is to consider the rival IT investment strategies, investment of different IT types, and coordination of complementary resources in addition to company 's IT investment strategies so as to analyze long-run dynamic results after interaction of two companies' strategies. A company often considers investment volume and time (early investment or late investment) when

making IT investment strategies. In fierce competition, the management shall choose suitable investment strategies, such as investment volume, early investment or late investment strategies. However, the findings indicate that earlier investor and later investor cannot always maintain their advantages. If only considering IT investment volume and time, the later investor cannot excel the earlier investor, but if investment cost and complementary assets are taken into account, the later investor will excel the earlier investor in market share, profitability and corporate market value. The later investor will show excellent performance in the market share. Although investment time is later, after the middle period the later investor will excel the earlier investor in market share, and the gap will become greater. Thus, the impact of IT investment strategies on the corporate operation performance is dynamic complex problem. The decision-maker of IT investment strategies should consider many factors, and system dynamics can make corporate management simulate corporate IT investment dynamics and help the decision-maker make IT investment strategies.

6. Conclusions and Research Limitations

Due to fast development of information technology and fierce competition, how to utilize information technology investment strategies for improving corporate operation performance and obtain competition advantages has become an important issue for companies and researchers. Apart from pursuing profits, the ultimate goal of companies is sustaining operation. However, the business environment is rapidly and complicatedly changing and global economy is in recession. Maintaining continuing operation is a challenge for operators. Business operators must make definite operation strategies and input the limited resources in the core business to maintain continuing operation and competitive advantages. In the difficult environment, meticulous strategy planning, control and management are the key factors to maintain competitive power and continuing operation, especially information-intensive services. Information technology investment strategies can determine whether companies can surpass their rivals and obtain leading advantages. Besides IT investment, allocation of complementary assets is the key to helping companies achieve higher operation performance and obtain competitive advantages. Better operation performance evaluation model can assist companies to conduct well performance management, understand driving factors of operation, precisely measure operation performance and guide companies to develop and gain profits. Past studies on IT investment and market performance are mostly based on linear model or unidirectional causal relationship, and nonlinear and causal long-run dynamic relationship between variables cannot be discussed. This study utilizes system dynamics to simulate and analyze dynamic relationship between IT investment strategies and market

performance of two companies in information-intensive services. Based on literature review, this study conducts analysis of feedback relationship between variables with reference to intellectual capital architecture, and builds a system dynamics-based computerized simulation model, in order to analyze the non-linear and casual dynamic relationship. Lastly, this study utilizes system dynamics model to analyze IT investment strategy scenarios. The results of scenario analysis provide important theory and practice implication.

This study has some limitations to be improved by future research despite simulation model built for scenario analysis. To simplify models for easily analysis, the model assumes that there are only two companies of the same size competing with each other in market, and the data are not from the actual companies. The limitations are not serious because the system dynamics stresses that system structure will affect system behavior. The results from simulation analysis reflect the long-run dynamic relationship between IT investment strategies, as well as growth and decline of competitive advantages of information-intensive services, and act as important reference for theory and practice. Future studies can develop system dynamics-based model close to actual data on the basis of the model in this study.

References

1. Aaker, D. A., and Jacobson, R. (1994). "The financial information content of perceived quality," *Journal of Marketing Research*, 31(2). pp 191-201.
2. Anderson, E. W., Fornell, C., and Mazvancheryl, S. K. (2004). "Customer Satisfaction and Shareholder Value," *Journal of Marketing*, 68, pp 172-185.
3. Anderson, E. W., Fornell, C., and Rust, R. T. (1997). "Customer satisfaction, productivity, and profitability: Differences between goods and services," *Marketing Science*, 16(2), pp 129-145.
4. Batt, R., and Moynihan, L. M. (2006). Human resource management, service quality, and economic performance in call centers. Available at: http://works.bepress.com/rosemary_batt/31.
5. Bergendahl, G. (2005). "Models for investment in electronic commerce—financial perspectives with empirical evidence," Omega, 33(4), pp. 363-376.
6. Boulding, W., Kalra, R. S. and Zeithaml, V. A. (1993). "A dynamic process model of service quality：from expectations to behavioral intentions," *Journal of Marketing Research*, 30, pp 7-27.
7. Brynjolfsson, E. (1993). "The Productivity Paradox of Information Technology,"

Communications of the ACM, 36(12), pp.67-77.

8. Bharadwaj, A., Bharadwaj, S. and Konsynski, B. R., (1999). "Information Technology Effects on Firm Performance as Measured by Torbin's q," *Management Science*, 45(6), pp.1008-1024.
9. Boulding, W., and Christen, M. (2003). "Sustainable pioneering advantage? Profit implications of the market entry order," *Marketing Science*, 22(3), pp 371-392.
10. Brynjolfsson, E., and Hitt, L. (1996a). "Is infonnation systems spending productive? new evidence and new results," *Proceedings of the Fourteenth Intemational Conference on Information Systems*, pp 47-64.
11. Brynjolfsson, E., and Hitt, L. (1996b). "Paradox Lost? Firm-level Evidence on the Returns to Information Systems Spending," *Management Science*, 42(4), pp. 541-558.
12. Boulding, W., Kalra, R. S. and Zeithaml, V. A. (1993). "A dynamic process model of service quality：from expectations to behavioral intentions," *Journal of Marketing Research*, 30, pp 7-27.
13. Bukh, P. N. (2003). "Commentary The relevance of intellectual capital disclosure: A paradox? Accounting," *Auditing & Accountability Journal*, 16, pp. 49-56.
14. Buzzell, R. D. (2004). "The PIMS program of strategy research. A retrospective appraisal," *Journal of Business Research*, 54, pp 478−483.
15. Carr, N. (2003). "IT Doesn't Matter," *Harvard Business Review*.
16. Chopra, S., and Meindl, P. (2003). "What will drive the enterprise software shakeout?" *Supply Chain Management Review*, 7(1), pp 50-56.
17. Devaraj, S., Kohli, R. (2003). "Performance Impacts of Information Technology: Is Actual Usage the Missing Link?" *Management Science*, 49(3), pp. 273-289.
18. Edvinsson, L., and Malone, M. S. (1997). *Intellectual Capital – Realizing Your Company's True Value by Finding its Hidden Roots*. New York：Harper Business.
19. Ehigie, B. O. and McAndrew, E. B. (2005). "Innovation, diffusion and adoption of total quality management (TQM)," *Management Decision*, 43 (6), pp. 925-940.
20. Ha, H.Y. (2004). "Factors influencing consumer perceptions of brand trust online," *Journal of Product & Brand Management*, 13(5), pp. 329-342
21. Hu, Q., and Plant, R.T. (2001) "An Empirical Study of the Causal Relationship between IT Investment and Firm Performance," *Information Resource Management Journal*, 14(3), pp 15-26.
22. Hu, Q. and Quan, J. (2005). "Evaluating the Impact of IT Investments on Productivity: A Causal Analysis at Industry Level," *International Journal of Information Management*, 25(1), pp. 39-53

23. Hussi, T. and Ahonen, G. (2002), "Managing intangible assets—a question of integration and delicate balance," *Journal of Intellectual Capital*, 3(3), pp. 277-86.
24. Karimi, J., Somers, T. M., and Gupta, Y. P. (2001). "Impact of Information Technology Management Practices on Customer Service," *Journal of Management Information Systems*, 17(4), pp 125-158.
25. Lin, H. F. (2007). "Knowledge sharing and firm innovation capability: an empirical study," *Internal Journal of Manpower*, 28(3/4), pp. 315-332.
26. Mahmood, A., Crawford, J. P., Michaud, R., and Jezek, K. C. (1998). "Mapping the World with Remote Sensing," *EOS Transactions, American Geophysical Union*, 79, pp. 17-23.
27. Mithas, S., Krishnan, M. S., and Fornell, C. (2005). "Effect of Information Technology Investments on Customer Satisfaction：Theory and Evidence," Ross School of Business Working Paper, pp. 971.
28. Mouritsen, J. H. T., Larsen, Bukh, P. N., and Johansen, M. R. (2001). "Reading an intellectual capital statement: Describing and prescribing knowledge management strategies," *Journal of Intellectual Capital*, 2(4), pp. 359-383.
29. Naumann, E., and Hoisington, S.H. (2001). *Customer Centered Six Sigma：Linking Customers, Process Improvement, and Financial Results*, ASQ Quality Press, Milwaukee, Wisconsin.
30. Nelson, R.R. (1995). *Evolutionary theorizing about economic change, in：Handbook of Economic Sociology,* N.J. Smelser and R. Swedberg (eds.), Princeton University Press, Princeton, pp. 108-136.
31. Oliver, R. L. (1997) "Satisfaction：A Behavioral Perspective on the Consumer," Richard D. Irwin/McGraw-Hill, Boston, MA.
32. Rivera-Vazquez, J., Ortiz-Fournier, L. V., Flores, F.R. (2009). "Overcoming cultural barriers for innovation and knowledge sharing," *Journal of Knowledge Management*, 13(5), pp. 257-270.
33. Romijn, H., and Albaladejo, M. (2002). "Determinants of innovation capability in small electronics and software firms in southeast England," *Research Policy,* 31(7), pp 1053-1067.
34. Roos, J., G. Roos, L. Edvinsson, and N. C. Dragonetti. (1998). *Intellectual Capital：Navigating in the New Business Landscape.* New York：New York University Press.
35. Saeidaa, S., Nejatib, M., and Nejatic, M. (2007). "Measuring Knowledge Management Processes," *Proceedings of the 13th Asia Pacific Management Conference*, Melbourne, Australia, pp. 551-555
36. Shin, N. (2001). The impact of information technology on financial performance:

the importance of strategic choice. *European Journal of Information Systems*, 10(4), pp. 227-236.

37. Shipton, H., Fay, D., West, M., Patterson, M., and Birdi, K. (2005). "Managing People to Promote Innovation," *Creativity & Innovation Management,* 14(2), pp 118-128.
38. Souitaris, V. (2002). "Firm-specific competencies determining technological innovation：A survey in Greece," *R & D Management,* 32(1), pp 61-77.
39. Van der Meer-Kooistra, J., and Zijlstra, S. M. (2001). "Reporting on intellectual capital. Accounting," *Auditing & Accountability Journal*, 14(4), pp. 456-476.
40. Vorakulpipat, C. and Rezgui, Y. (2006), "From knowledge sharing to value creation: three generations of knowledge management," *Proceedings of the 2006 IEEE International Engineering Management Conference*, Salvador.
41. Vorakulpipat, C. and Rezgui, Y. (2007), "Value creation: the next generation of knowledge management," *Proceedings of the 2007 Information Resources Management Association International Conference*, Vancouver.
42. Vorakulpipat, C., and Rezgui, Y., (2008). "An evolutionary and interpretive perspective to knowledge management," *Journal of Knowledge Management*, 12(3), pp. 17-34.
43. Youndt, M. A., M. Subramanian, Z. (2004). "Intelllectual capital profiles: an examination of investments and returns," *Journal of Management Studies*, 41(2), pp. 335-361.