Hybrid Qualitative Reasoning Approach to Predicting the Expected Performance of the Intellectual Property Rights Management System- KIPONet Case

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Abstract

In the previous e-government studies, there was no study in which the ambitious problem of assessing the expected performance of an e-government software when it is adopted in other country. This study was motivated to propose a new method to resolve this research question. With using the KIPONet (Korean Intellectual Property Office Net) as a target e-government software, which has been successfully implemented and operated by the Republic of Korea government since Jan 1999 for the purpose of managing the intellectual property rights (IPRs), we propose a Hybrid Qualitative Reasoning (HQR) approach to predicting the expected performance of the KIPONet. The main recipes of the HQR are that the HQR considers causal relationships existing among both qualitative and quantitative variables of the KIPONet, and that uncertainties embedded in some variables are handled by using Monte Carlo mechanism. The application of the proposed HQR to predicting the expected performance of the KIPONet results in statistically significant outcomes with 95% confidence level.

Keywords: E-government system; Intellectual property rights (IPRs); KIPONet (Korean Intellectual Property Office Net); Qualitative reasoning; Uncertainties; Monte Carlo simulation

Introduction

As the advent of the web technology, e-government systems are being developed in an eye-dazzling pace across the globe. Especially, the e-government system dedicated to administering the intellectual property rights (IPRs) becomes essential in sustaining a nation's competitive position in the world market.

IPRs differ in significant ways from those in physical property. In other words, IPRs are hard to define and hard to enforce. Let us first think about why IPRs are hard to define. Basically, IPRs protect the principle that underpins a novel idea. It requires the citation of prior art and journal publications in order to clearly delineate the property rights or claims of the patent (Lanjouw and Schankerman 1997). Copyright, by contrast, protects the concrete form or expression rather than the abstract principle of an idea. In both cases, the process is more effective in the case of simple rather than complex ideas since the former are easier to describe unambiguously. But then, for the same reason, simple ideas are easier to 'invent around' than complex ones (Mansfield 1985).

Meanwhile, IPRs are much more difficult—and hence costly—to enforce than physical ones (Liebeskind 1996; Cheung 1982; Besen and Raskind 1991; Friedman et al. 1991). Even well delineated IPRs give rise to ambiguous interpretations and, partly for that reason, the violation of property rights can remain undetected for a long time.

The US Constitution imposes on Congress an explicit obligation 'to promote the progress of science and useful arts, by securing for limited times to authors and inventors, the exclusive right to their respective writings and discoveries' (Shapiro and Varian 1999). Where such rights cannot be secured, innovation may not take place. Countries that offer little protection for intellectual property see less innovation and more diversification across industries than those that do offer protection. In the former case, intellectual property is kept inside the firm as a 'secret' rather than externally traded (Khanna and Palepu 1997). Unfortunately, IPRs lack the intuitive appeal of property rights in tangible goods. They often challenge our notions of fairness and, as the music industry has discovered to its cost, do not always mobilize much popular support in their defense.

Aware of the two features of IPRs like this, this study starts with a motivation that adoption of an effective IPRs management system will determine national competitiveness. Therefore, when a country is going to adopt a specific IPRs management system, checking its performance before adoption is crucial. In this sense, we propose a research question that remains unproven in the current e-government literature- how to predict the performance of the IPRs management system when it is adopted in other countries. This research question becomes important much more as the advent of the need to adopt e-government systems across the globe. Besides, both the quality and the number of registered IPRs are well known to define competitive position of a specific country in a global market. Therefore, this paper is aimed at resolving this research question by using the hybrid qualitative reasoning (HQR) approach in which a number of factors relevant to the target IPRs management system are interlinked with direction, and some of them are embedded with uncertainties.

Republic of Korea is famous in its innovative and bold stride in developing cutting-edge e-government systems. The IPRs management system named KIPOnet (Korean Intellectual Property Office Net) was also developed under Korean Government's ambitious initiatives. KIPOnet is the first computerized system to automate administrative procedures for IPRs such as filing and receiving of applications, examinations, registrations, and the publication of official gazettes. It is a unified portal providing a work-at home system, nonstop public services 24 hours a day 365 days a year, and options such as push mail and short message service (SMS). At the end of 2006, the online filing ratio for IPRs applications reached a 92.2% of all applications, and an impressive 97.2% of all patent applications.

With the KIPOnet as a target IPRs management system, the proposed research question can be rephrased as follows- how can we predict the performance of KIPOnet when it is adopted in other country ? KIPOnet is famous in its highly acclaimed economic benefits when adopted. First of all, the lowest-hanging benefits expected from using the KIPOnet is an enhanced efficiency in the IPRs management due to on-line filing, real time accessibility to examination results, high quality patent information and the nonstop public affairs service. In addition, both efficiency and transparency of the IPRs management are improved with computerized searches, and renovated business processes. According to the Korean Government reports, economic benefit from using the KIPOnet marked a total of US$2,897 million between 1999 and 2005. After the rollout of the KIPOnet system in January 1999, the economic benefits rose rapidly, almost doubling each year. As well as direct economic benefits, additional benefits to the industries are projected at 26.18 percent reduction in R&D time and an 27.59 percent reduction in R&D cost. The saved costs for government-funded R&D projects reached 1.5 billion US dollars in 2004 alone. Summary of economic benefit analysis is shown in Table 1.

*** Insert Table 1 ***

To resolve the research question, the hybrid qualitative reasoning (HQR) approach is proposed where Monte Carlo simulation technique is applied to handle the uncertainties embedded in some variables.

The structure of this study is composed of four sections. Section 2 addresses theoretical backgrounds of the IPRs studies. Section 3 describes methodology adopted in this study, and the simulation results and its implications. Concluding remarks are summarized in section 4.

2. Theoretical Backgrounds

2.1 E-Government

The Internet has provided a new medium of communication. The impact of this medium on the government is tremendous. From serving as a static website to providing direct citizen services, the transformation of the government has demanded a change of focus from the administration to the serving of the citizenry. The rapid technological changes that have transformed the economy and society are now reaching and transforming the government as well. This governmental transformation is being adopted across the globe.

Electronic government is an important area of ICT applications in the last few years. There is also a growing body of research in this area. As of beginning of May 2007 the Web of Science brings 537 articles with the search word "e-government." Although almost all of these articles investigate e-government systems in individual countries, a few of them are country-independent and aim to develop theory. For example, Layne and Lee (2001) propose a four-stage model for e-government maturity. Although the model is based on the e-government experiences in the US context, the authors assert that it is applicable to other countries' "stages of growth".

An overwhelming majority of e-government articles are based on, or use an e-government application as a case study within an individual country. As can be expected, the USA hosts the majority of e-government articles in this group. For example, Moon (2002) Ho (2002), and Kaylor et al. (2001) investigate e-government efforts of the local authorities; and Thomas & Streib (2003) examine the intensity and quality of government-citizen interaction through the e-government systems. Several other articles are based on e-government applications in other industrialized or developing countries. For example, Akman et al. (2005) investigate the impact of gender and education amongst the e-government users in Turkey. Lee and Gong (2004) report about a system that has been developed by South Korean government to give citizens a place in cyberspace to express their concerns. Moulsley (2005) discusses the implementation of a number of e-government initiatives aimed at modernizing the operations and services of local authorities in the UK.

Perhaps due to the nature of e-government applications that dictates the boundary within an individual country, most of e-government studies are confined to analyzing a specific country's case in a broad and generic sense. Therefore, to our best knowledge the present article is the first attempt to analyze the performance of KIPONet in a number of situations and help other countries predict its expected performance after its adoption.

2.2 Qualitative Reasoning

Qualitative reasoning (QR) is necessary in the fields where both qualitative and quantitative data needs to be handled to solve the problems, and especially some underlying measures require qualitative information. Such problems like Balanced Score Cards, Strategic Management, and Software Assessment need the QR. The QR can be realized in the form of qualitative simulation (Forbus 1984; Kuipers 1986) which is a new way to deal with complex decision-making problems by integrating the simulation method with artificial intelligence technologies. In this study, the simulation method adopted is Monte Carlo simulation technique, and the artificial intelligence technology adopted is causal mapping, all of which will be addressed later.

QR aims to carry out designs, diagnosis, analysis and simulation with incomplete information (Lunze, 1998). It tries to incorporate the common sense or the intuition, and gives qualitative explanations based on qualitative descriptions of the possible state of the real world. Now, there are many theories of QR, in which the naïve physics school is the most well developed method. Three main lines of research in qualitative modeling contribute to the development of naïve physics method. The first is the Theory of Confluence brought up by de Kleer and Brown (1983), who developed the first qualitative system ENVISION. The second is Qualitative Process Theory (QPT) brought up by Forbus (1984). The third is the Kuipers' QSIM (Qualitative Simulation), which makes QR more practical (Kuipers 1994, Raghunathan 1997).

QR is useful when numerical information about the system is unavailable, or when a precise answer is not required (Bandelj et al 2002). It is widely used in industry control, fault diagnosis, artificial intelligence, ecology, sociology, economics and so on (Chenxi 2004). However, it is not widely accepted in the management field (Berends and Romme 1999). Especially, QR was never attempted to simulate the performance of a specific e-government system like KIPONet. E-government system performance is subject to a wide variety of factors, qualitative or quantitative, ranging from culture, IT infrastructure & policy to users' personal attitude, etc. Therefore, decision makers want to assess the e-government system based on both qualitative and quantitative factors. In this sense, it seems very timely and appropriate for the QR to be used to investigate the performance of KIPONet under an assumption that it is adopted in other country, and there exist other competitors' systems.

2.3 Monte Carlo Simulation

The Monte Carlo simulation provides approximate solutions to a variety of mathematical problems by performing statistical sampling experiments on a computer. Especially, the Monte Carlo simulation is effective when target problem involves uncertainty, but there is no empirical data enough to be handled by already-known statistical methods. This case occurs very often when we face uncertain or variable market demand, fluctuating costs, variation in a manufacturing process, or effects of weather on operations. The target problem of this study can be a typical problem to which the Monte Carlo simulation can be applied. The KIPONet has never been used in a certain country, but decision makers want to know how effective the system would be in terms of cost-benefit ratio, increase in per capita productivity, and user satisfaction, etc when it is adopted as one of the e-government systems for managing IPRs. The problem here is that there is no empirical data to be used for rigorous statistical analyses. In this sense, the basic philosophy of the Monte Carlo simulation is affordable to our target problem.

It is well known that the Monte Carlo method was invented by scientists working on the atomic bomb in the 1940s, who named it for the city in Monaco famed for its casinos and games of chance. Its core idea is to use random samples of parameters or inputs to explore the behavior of a complex system or process to be solved. The scientists faced physics problems, such as models of neutron diffusion, that were too complex for an analytical solution -- so they had to be evaluated numerically. They had access to one of the earliest computers -- MANIAC -- but their models involved so many dimensions that exhaustive numerical evaluation was prohibitively slow. Monte Carlo simulation proved to be surprisingly effective at finding solutions to these problems. Since that time, Monte Carlo methods have been applied to an incredibly diverse range of problems in science, engineering, and finance -- and business applications in virtually every industry.

For the Monte Carlo simulation to be applied more effectively to the target problem, there should exist a set of logical structure which is available to be used as basic equations. The proposed HQR provides a set of qualitative structure in which causal relationships of the variables or nodes relevant to predicting the expected performance of the KIPONet are explicitly figured out. Then, the Monte Carlo simulation is applied to the qualitative structure with generating random samples for those variables that are uncertain and subject to heavy variations when situations change. We will generate the random samples using the three typical probability distributions like uniform, beta, and normal distribution.

3. Methodology

3.1 Hybrid Qualitative Reasoning

This study proposes a new simulation approach named HQR (Hybrid Qualitative Reasoning) to predicting the expected performance of e-government system like KIPONet when it is adopted in other country. The proposed HQR consists of two phases. First phase is concerned with defining the qualitative structure hidden in the target problem. In this study, since the KIPONet is a target system, the first phase of the HQR is devoted to defining the qualitative structure of the KIPONet in a form of causal relationships. Second phase of the HQR is to incorporate the Monte Carlo simulation to deal with the uncertainties of highly volatile variables.

The proposed HQR starts with statistical assumption that 95% confidence level is maintained. Basically, with the confidence level 95%, 5,000 runs of random number generation were performed to secure the statistical validity of the QR simulation results. All the factors considered in this simulation are assumed to have 5-point Likert scale according to each condition, where 1 denotes Very Bad, 2 Bad, 3 Neutral, 4 Good, 5 Very Good. To ensure systematic and consistent calculation of the simulation results, each Likert scale is transformed into a specific value between interval [-1, +1]. In this QR simulation case, 5-scale Likert value is transformed as follows: 1 into -0.5, 2 into -0.2, 3 into 0.2, 4 into 0.6, and 5 into 1.0. This scale transformation depends on the decision maker's judgment. However, due to the law of large number, interpretation of the QR simulation results remains consistent irrespective of the transformation rule. On the basis of the transformation rule like this, output value over 0.6 indicates that the output is at least "Good" according to the 5-point Likert scale.

3.2 Nodes and Qualitative Structure

First, the HQR simulation mechanism requires definition of the nodes representing the components or factors that consist of the target problem. In our case, the target problem is to predict the expected performance of KIPONet when it is adopted in other country. Factors of the target problem were determined through five rounds of indepth interview with four experts and three professors working in the IPR fields in Republic of Korea. Those nodes that were selected for the HQR simulation are summarized in Table 2.

*** Insert Table 2 ***

C29, C30, C31 mean the output nodes, and C3, C4, C6, C8, C16, C26, C27, C28 denote the characteristics of the KIPONet that a customer country wants to know in comparison with the competitor's software. Therefore, the eight nodes should be dealt with in the way that they could vary sharply according to customer country's judgment and assessment about the KIPONet. Henceforth, the HQR simulation process should represent the high volatility of the nodes by using the Monte Carlo simulation mechanism. We consider three kinds of probability distribution functions to represent the uncertainties embedded in the eight nodes C3, C4, C6, C8, C16, C26, C27, C28. They are uniform distribution, beta distribution, and normal distribution. Details will be explained in 3.3

The qualitative structure consists of the constraints that the proposed HQR adheres to in the process of the simulation. Basically, the qualitative structure is denoted as the construction using influences among the nodes which are monotonically either positive or negative. The qualitative structure was also determined through three rounds of interview with two experts and one professor working in the IPR fields in the Republic of Korea. Table 3 depicts the qualitative structure used in the HQR simulation, where cause variables influence effect variables with direction. Using the qualitative structure as well as the Monte Carlo simulation, the HQR simulates the expected performance of the KIPONet. Experiments were performed as described in 3.3

*** Insert Table 3 ***

3.3 Results

As described in 3.2, the eight nodes like C3, C4, C6, C8, C16, C26, C27, C28 should be relatively dealt with considering the competitor's software. How customer country will evaluate the eight nodes is very uncertain, because the country has its own peculiar culture, policy, IT infrastructure, and user characteristics, etc. Some nodes are quantitative, and others are qualitative. Therefore, the proposed HQR is an appropriate simulation mechanism for the situation like

this. Then each of the eight nodes should be represented by a specific probability distribution depending on the situation that the customer country faces.

Let us suppose that a customer country is considering the KIPONet as one of the e-government system candidates for the IPRs management. Therefore the customer will surely want to evaluate the expected performance of KIPONet by leaving those eight nodes above to high volatility. If the HQR simulation results represented by the values of the three output nodes C29, C30, C31 seem good despite the high volatility of some nodes, then the customer country can safely conclude that the KIPONet will work as expected when it is adopted in that country.

In this sense, let us assume probability distributions for the eight uncertain nodes. If we want some nodes to remain highly volatile or uncertain, then uniform distribution with minimum -0.5 and maximum 1 is applied. If we have already supplementary evidences about the nodes, then normal distribution with mean 0.2 and standard deviation 0.2 is used. Therefore, we found that there exist evidential data about the three nodes like C4, C6, C8. Therefore, the normal distribution was applied. Meanwhile, the uniform distribution is applied to the rest of the nodes such as C3, C16, C26, C27, C28.

Then after 5,000 trials, the proposed HQR simulation yields the results about the three output nodes C29, C30, C31 as shown in Table 4. The results show that C29 (Benefit for cost) is 1.78 at the minimum, and its mean value is 3.72 which is very large meaning "Very Good" in terms of 5-point Likert scale. For C30 (Increase in per capita productivity), the HQR simulation result is that its minimum is 2.12, and mean value is 2.80, which is also "Very Good" in terms of 5-point Likert scale. For C31 (User satisfaction), the HQR simulation result tells us that minimum value is 4.10, and mean value is 4.85, indicating that the User Satisfaction would be "Very Good" when a customer country adopts the KIPONet.

*** Insert Table 4 ***

Similarly, we have changed probability distributions for the eight nodes to know whether the three output values would change significantly. Scenario 2 is such that beta distribution is used for C3, C16, C26, C27, C28, and that normal distribution is applied to C4, C6, C8. For Scenario 3, only uniform distribution is used for all the eight nodes. For Scenario 4, uniform distribution is applied to C4, C6, C8, and beta distribution is used for the rest of the eight nodes. Table 5 summarizes the HQR simulation results for the four scenarios. All the mean values for the three output nodes are stable statistically under 95% confidence level. In average term, benefit for cost (C29) of the KIPONet is expected to range from 3.72 to 4.05. The increase in per capita productivity (C30) is believed to lie between 2.80 and 2.85, while user satisfaction (C31) falls within 4.85 and 4.99. Therefore, when the customer country adopts KIPONet to administer its IRPs registration, the country can expect that all the mean values for the three output nodes will be "Very Good" in terms of the 5-point Likert scale because all of their average values are greater than 1.0.

*** Insert Table 5 ***

4. Concluding Remarks

This study proposes a new method with which the target problem of assessing the expected performance of the e-government software when it is adopted in a country. This problem has remained unsolved due to the fact that it requires a lot of field knowledge and ample information about the country, and there exist a number of uncertainties and volatility in the relevant variables to be considered in the process of decision analysis. The target problem is to predict the expected performance of the KIPONet, the IPRs management software which has been successfully implemented and operated by the Korean Government since Jan 1999.

To pursue solving the target problem, we developed a new simulation approach called Hybrid Qualitative Reasoning (HQR) in which the conventional QR is modified to incorporate the causal relationships among the qualitative and quantitative variables, and solution mechanism is integrated with the Monte Carlo simulation. For this purpose, we addressed main thrusts of the HQR, applying it to the target problem. Experimental results showed that the proposed HQR could yield statistically significant and valid estimation results for the expected performance of the KIPONet when it is adopted in other country. Especially, main advantages of the proposed HQR are as follows.

First, the customer country can simulate the performance of the KIPONet by using the proposed HQR without spending a huge amount of money and time to collect questionnaire data before adoption of the KIPONet.

Second, the proposed HQR can help save decision makers a lot of time and cost in analyzing the economical efficiency of a specific e-government software even under very uncertain circumstances. Third, the HQR can be easily applied to tasks of analyzing the cost-benefit ratio of other e-government software.

We hope that this study would trigger more serious studies in the field of assessing the performance of the e-government systems.

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Table 1. Summary of Economic Benefit Analysis of KIPOnet

(Unit: US$ 1000)

Section		1999	2000	2001	2002	2003	2004	2005	Saving
Internal Business Process Opportunity Cost Savings	Administration	21,160	18,631	24,521	25,381	26,770	30,854	39,264	186,581
	Examination	11,495	10,656	9,728	13,947	16,942	19,294	21,387	103,449
	Total	32,655	29,287	34,249	39,328	43,712	50,148	60,651	290,030
Customer	E-filing	1,809	2,424	2,866	4,182	4,635	5,364	6,099	27,379
	Search	60,399	165,127	330,092	401,748	464,988	536,113	621,412	2,579,879
	Total	62,208	167,551	332,958	405,930	469,623	541,477	627,511	2,607,258
Grand Total		94,863	196,838	367,207	445,258	513,335	591,625	688,162	2,897,288

Promotion technology development	Shortening R&D period	26.18%
	Reduction of R&D cost	27.59%
Elevation of national status	Leading role in international cooperation in IT	
	Elevation of national brand image	

Table 2. Nodes of the Target Problem

Node #	Description
C1	Firm size
C2	Firm's overseas business experience
C3	Firm's overseas technical support capability
C4	Technological capability level compared to competitor's
C5	Data interoperability
C6	Software quality compared to competitor's
C7	Cooperation between interested government agencies
C8	Price competitiveness compared to competitor's
C9	Application of international standard for business process
C10	Application of international standard for informatization
C11	Integration of language and user interface
C12	Cooperation experience for international informatization
C13	Security
C14	Ease of use
C15	Software interoperability
C16	Level of technological originality
C17	Automatic administration capability
C18	Packaging/Modularization
C19	Government support for software export
C20	Government support for marketing
C21	Implementability in a short period
C22	Government support for software development
C23	Strengthened notification service for customers
C24	Full-scale online processing for international patents
C25	Cost savings in patent registration
C26	S/W operation records
C27	S/W operation performance
C28	S/W operation stability
C29	Benefit per cost
C30	Increase in per capita productivity
C31	User satisfaction

Table 3. Description of the Qualitative Structure

Cause	Effect	Direction
C1	C2	Increase
C2	C3	Increase
C3	C31	Increase
C4	C5	Increase
C5	C28	Increase
C6	C28	Increase
C6	C30	Increase
C7	C31	Increase
C8	C29	Increase
C9	C30	Increase
C9	C25	Increase
C10	C29	Increase
C11	C10	Increase
C12	C29	Increase
C13	C31	Increase
C14	C31	Increase
C15	C10	Increase
C15	C14	Increase
C16	C29	Increase
C17	C13	Increase

C17	C14	Increase
C18	C11	Increase
C18	C15	Increase
C19	C31	Increase
C20	C31	Increase
C21	C29	Increase
C22	C31	Increase
C23	C14	Increase
C24	C31	Increase
C24	C29	Increase
C25	C27	Positive
C26	C28	Positive
C26	C27	Positive
C27	C29	Positive
C28	C31	Positive
C29	C30	Positive
C31	C30	Positive

Table 4. HQR Simulation Results for Scenario 1

Benefit for cost (C29)		Increase in per capita productivity (C30)		User satisfaction (C31)	
Statistics	Forecast values	Statistics	Forecast values	Statistics	Forecast values
Trials	5,000	Trials	5,000	Trials	5,000
Mean	3.72	Mean	2.80	Mean	4.85
Median	3.73	Median	2.80	Median	4.85
Mode	—	Mode	—	Mode	—
Standard Deviation	0.64	Standard Deviation	0.20	Standard Deviation	0.44
Variance	0.42	Variance	0.04	Variance	0.19
Skewness	-0.0519	Skewness	-0.0105	Skewness	-0.0040
Kurtosis	2.96	Kurtosis	2.96	Kurtosis	1.78
Coeff. of Variability	0.1733	Coeff. of Variability	0.0720	Coeff. of Variability	0.0905
Minimum	1.78	Minimum	2.12	Minimum	4.10
Maximum	5.50	Maximum	3.54	Maximum	5.60
Range Width	3.71	Range Width	1.42	Range Width	1.50
Mean Std. Error	0.01	Mean Std. Error	0.00	Mean Std. Error	0.01

Table 5. Summary Statistics of Four Scenarios

Scenario	Statistics	Benefit for cost (C29)	Increase in per capita productivity (C30)	User satisfaction (C31)
Scenario 1	Min, Max	1.78, 5.50	2.12, 3.54	4.10, 5.60
	Mean	3.72	2.80	4.85
Scenario 2	Min, Max	2.37, 5.37	2.19, 3.56	4.15, 5.59
	Mean	4.00	2.80	5.00
Scenario 3	Min, Max	1.66, 5.84	2.10, 3.60	4.10, 5.60
	Mean	3.76	2.85	4.85
Scenario 4	Min, Max	2.05, 5.71	2.10, 3.60	4.13, 5.58
	Mean	4.05	2.85	4.99

Using the Monte Carlo-Assisted Causal Mapping Simulation to Predict the Expected Performance of Korea e-Procurement System

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Abstract

Among the e-Government systems, the Korea e-Procurement system (KEPS) has unique position in that it requires a wide spectrum of jobs to be done automatically across the whole procurement process, from exchanging documents, opening bids and contracting, shopping electronically, paying electronically, to sharing information on goods & services as well as participants. In addition, the KEPS is known widely that it is a rare successful e-procurement system, helping saving huge amount of cost and time needed in the G2B (Government-to-Business) procurement process. In this respect, the Korea e-Procurement system (KEPS) administered by Republic of Korea, is worth of being investigated as a successful e-procurement system case. However, most of e-procurement system studies are just centered on analyzing case studies rhetorically without showing rigorous method and results, which are not suitable to convince customer countries considering whether to adopt it or not. To fill the research void like this, this study proposes a generalized approach to estimating the expected performance of e-procurement system by integrating Monte Carlo simulation and causal mapping technique, named MOCA-CAMS (Monte Carlo-Assisted Causal Mapping Simulation). Simulation experiments with the proposed MOCA-CAMS applying to KEPS show that the KEPS would show very promising performance under uncertain situations even when adopted by customer countries. We hope that this study would provide a foundation for further discussions on this increasingly important area of research and practice.

Keywords: e-Government; e-Procurement systems; Korea e-Procurement system (KEPS); Monte Carlo simulation; Causal Mapping

1. Introduction

The nature of government functioning has been undergoing a rapid transformation in the latter part of the 1990s. This is due to the impact of the technological changes that enabled delivery of services over the Internet. The private sector has taken great strides in utilizing these technologies to the development of their functioning. New service industries, better delivery of services and faster, cheaper communication are some of the by-products of the technological revolution.

These transformations have created an expectation among citizens for a better delivery of services from government. However, most governments have been very slow or even unprepared for these transformations. Despite the increasing efforts of adopting web technology in recent years, most government efforts have concentrated on putting up a web page (Seavey, 1996). However, this administrative-focus has gradually changed to become a customer-focus serving citizens and trading partners directly by providing services, information and transactions on-line via the Internet. This has been termed as "electronic government (e-government)", or "electronic commerce" within the context of government services (Stratford and Stratford, 2000). Implementing such changes, however, is not a simple task. Several governments lack the fundamental infrastructure, organizational culture, understanding and resources for the transformation of the magnitude that e-governments require. To many governments, this transformation is the start to establishing the basic infrastructure to build a comprehensive e-government. To some, this is also the opportunity to deliver services innovatively, showing the way for other governments.

Republic of Korea (abbreviated as "Korea" hereafter) is one such government, with a commitment to adopting new technologies and re-engineering processes for the benefit of an efficient functioning of the government. The national IT policies in Korea have created a suitable environment for the utilization of ITs to deliver a wide spectrum of e-government services. Especially, concentrating on e-procurement system in which Government to Business (G2B) e-commerce activities are supported, this study aims to measure the performance of the Korean e-procurement system. Considering the limitations that most of previous e-government studies are centered too much on simply introducing and analyzing cases showing superficial features of the target systems and broad market survey results without attempts to perform rigorous simulation approaches, this study initiates a pioneering approach to measuring the expected performance of the Korean e-procurement system (KEPS) when it is applied in other countries.

Measuring the performance of the KEPS requires consideration of several factors relevant to the system and parties involved in the G2B transaction process. Emphasis of particular aspects of the e-procurement system might probably lead to biased results. Therefore, we need holistic mechanism in which all the features of the KEPS are considered simultaneously to measure the precise performance of the KEPS in various situations. In this sense, a causal mapping method (Lee & Kwon, 2006) is adopted to systematically incorporate all the factors relevant to the KEPS.

Our approach named MOCA-CAMS (Monte Carlo-Assisted Causal Mapping Simulation) is that when all the factors that are deemed relevant to the KEPS are explicitly sorted out, and a set of possible causal relationships and causal coefficients (causalities) between the factors are induced, uncertainties about KEPS are dealt with Monte Carlo simulation (Salling et al., 2007; Parssian, 2006) to hypothetically generate a wide spectrum of application situations compared to competitor's systems, and derive statistically significant results about predicting the performance of KEPS in various uncertain situations.

The structure of this study is organized to provide an understanding of the current literature on e-government, followed by a description of the methodology and then the

presentation of the case itself. Accordingly, Section 2 describes the literature that is emerging in this new area of research interest, and reviews some of the e-government, e-procurement systems, causal mapping, and Monte Carlo simulation. Section 3 describes the proposed MOCA-CAMS methodology applied to the KEPS, and its experimental results. Section 4 is dedicated to explaining the concluding remarks.

2. Literature review

2.1 e-Procurement and KEPS

E-procurement systems work for exchanging documents, opening bids and contracting, shopping electronically, paying electronically, and sharing information on goods & services as well as participants. Whereas business-to-business e-commerce has prospered, e-procurement by government or government-to-business (G2B) has not progressed as much. Advantage System (e-procurement systems) of United States General Service Administration has been assessed as "limited success" and has been recommended to develop a "comprehensive business strategy" by General Accounting Office (GAO, 2003). Integrated Acquisition Environment of the U.S. – the federal government's procurement e-procurement initiative anticipates creating a single web-based portal site (Drabkin and Thai, 2003). A number of states in the U.S. are reported as successful cases of e-procurement. Commonwealth of Virginia's *eVA* has been identified as a good e-procurement system.[1] Yet, it is very hard to find good models of e-procurement at the national or federal level. A report on Chilean e-procurement systems, ChileCompra, shows the disappointing results of systems development and agencies' usage in recent years (ChileCompra, 2002).

However, the e-procurement systems in Korea have been acknowledged as successful. Public Procurement Service of Korea (PPS, http://www.pps.go.kr) launched the Government electronic Procurement Systems (KEPS, http://www.g2b.go.kr) on September 30, 2002. KEPS is e-procurement systems "aiming to establish a nationwide web-based procurement system, dealing with the whole procurement process, including acquisition of all information on the national procurement projects, procurement requests, bids, contracting, and payment for 27,000 public organizations and 90,000 private firms" (PPS, 2002; p. 2). Most public organizations in Korea, from central and local government agencies to public enterprises, can purchase and contract through KEPS. They just need a personal computer connected through the Internet. Since PPS began to develop its e-procurement systems, it has received attention by many organizations, international and non-government. The United Nations (UN) Division for Public Economics and Public Administration announced that PPS is a winner of the United Nations Public Service Awards 2002. According to the UN, PPS has reorganized procurement service by converting to e-commerce and is expected to save $ 2.8 billion every year. Other international organizations including the World Bank show their interest in KEPS because the system is expected to save costs and to increase transparency of government purchasing and contract processing. PPS' effort of reforming and of developing the e-procurement systems has received awards from other Korean government agencies.2 The most recent report of Organization for Economic Co-operation and Development (OECD, 2004) evaluated that KEPS has a "strong pull-through effect on information and communications technology use in the private sector" and "no further action required".

2.2 Monte Carlo Simulation

Monte Carlo simulation turned out to be very effective when there is no empirical data enough about the target problem, and a certain level of uncertainty exists for some decision variables. By generating random number for the uncertain variables in line with the appropriate probability distribution, the Monte Carlo simulation provides approximate solutions to a variety of mathematical problems on a computer.

When KEPS is going to be adopted in some countries, the customers would be concerned how effectively the KEPS might be working as expected. They might be worried about the KEPS quality and its user-friendliness in comparison with competitor's system. Moreover, the customer countries have peculiar culture and ethnic groups, all of which are quite different from Republic of Korea. In this sense, the customers need to be ensured about the KEPS before they decide to adopt the KEPS as their main e-procurement system. Therefore, Monte Carlo simulation should be applied to all the uncertainties embedded in the decision-making process about adopting the KEPS.

It is well known that the Monte Carlo method was invented by scientists working on the atomic bomb in the 1940s, who named it for the city in Monaco famed for its casinos and games of chance. Its core idea is to use random samples of parameters or inputs to explore the behavior of a complex system or process to be solved. The scientists faced physics problems, such as models of neutron diffusion, that were too complex for an analytical solution -- so they had to be evaluated numerically. They had access to one of the earliest computers -- MANIAC -- but their models involved so many dimensions that exhaustive numerical evaluation was prohibitively slow. Monte Carlo simulation proved to be surprisingly effective at finding solutions to these problems. Since that time, Monte Carlo methods have been applied to an incredibly diverse range of problems in science, engineering, and finance -- and business applications in virtually every industry.

For the Monte Carlo simulation to be applied more effectively to predicting the expected performance of KEPS, uncertainties should be clarified in a way that at which variables describing the KEPS there exist a certain level of uncertainties. The proposed MOCA-CAMS provides a series of simulation results based on (1) causal relationships among the variables regarding KEPS, (2) uncertainties about some variables, and (3) probability distribution functions like uniform, beta, and normal distribution.

3. Methodology

3.1 MOCA-CAMS

This study proposes a new simulation approach named MOCA-CAMS (Monte Carlo-Assisted Causal Map Simulation) to predicting the expected performance of e-government system like KEPS when it is adopted in other country. The proposed MOCA-CAMS consists of two phases. First phase is concerned with defining the causal relationships hidden in the target problem. In this study, since the KEPS is a target system, the first phase of the MOCA-CAMS is devoted to defining the causal relationships of the KEPS in a form of causal relationships. Second phase of the MOCA-CAMS is to incorporate the Monte Carlo simulation to deal with the uncertainties of some highly volatile variables regarding the KEPS.

The proposed MOCA-CAMS starts with statistical assumption that 95% confidence level is maintained. Basically, with the confidence level 95%, 5,000 runs of random number generation were performed to secure the statistical validity of the MOCA-CAMS simulation results. All the factors considered in this simulation are assumed to have 5-point Likert scale according to each condition, where 1 denotes Very Bad, 2 Bad, 3 Neutral, 4 Good, 5 Very Good. To ensure systematic and consistent calculation of the

simulation results, each Likert scale is transformed into a specific value between interval [-1, +1]. In this MOCA-CAMS simulation case, 5-scale Likert value is transformed as follows: 1 into -0.5, 2 into -0.2, 3 into 0.2, 4 into 0.6, and 5 into 1.0. This scale transformation depends on the decision maker's judgment. However, due to the law of large number, interpretation of the simulation results remains consistent irrespective of the transformation rule. On the basis of the transformation rule like this, output values over 0.6 and 1.0 indicates that the output is "Good" and "Very Good" respectively, according to the 5-point Likert scale.

3.2 Derivation of Causal Map

First, the MOCA-CAMS simulation mechanism requires definition of the nodes representing the components or factors that consist of the target problem. In our case, the target problem is to predict the expected performance of KEPS when it is adopted in other country. Factors of the target problem were determined through three rounds of interview with two procurement experts and two professors working in the e-procurement fields in Korea. Those nodes that were selected for the MOCA-CAMS simulation are summarized in Table 1.

*** Insert Table 1 ***

The three nodes C26, C27, C28 mean the output variables, and the five nodes C3, C4, C6, C8, C24 denote the characteristics of the KEPS that a customer country wants to know in comparison with the competitor's software. Therefore, the five nodes should be dealt with in the way that they could vary sharply according to the customer country's judgment and assessment about the KEPS. Henceforth, the MOCA-CAMS simulation process should represent the high volatility of the five nodes by using the Monte Carlo simulation mechanism. We consider three kinds of probability distribution functions to represent the uncertainties embedded in the five nodes C3, C4, C6, C8, C24. They are uniform distribution, beta distribution, and normal distribution.

Methods of determining causal relationships among variables consisting of the target problem or KEPS, and their corresponding causality coefficients, include using the statements of decision makers (Axelrod, 1976; Eden et al., 1979), questionnaires prepared specifically for this purpose (Montazemi & Conrath, 1986), and neural network-based learning (Caudill, 1990). The first and second approaches are based on the assumption that experts in the domain can accurately provide the causality coefficients in causal relationships. In contrast, this study used structured interview with experts to determine causal relationships between the relevant KEPS factors extracted from literature and then calculate causality coefficients among them, in a bid to construct an appropriate CM and simulate the expected performance of KEPS that would most improve the three output variables C26, C27, C28.
The causal relationships among the variables describing KEPS consists of the constraints that the proposed MOCA-CAMS adheres to in the process of the simulation. These causal relationships were also determined through two rounds of interview with three e-procurement experts working in the procurement firms. Then the next step is to determine the causal coefficients. In our study, however, all the causal coefficients are limited to +1 or -1 for the sake of simplicity. To induce more objective and unbiased causality coefficients, a questionnaire survey can be conducted according to the approach by Montazemi and Conrath (1986), in which CM was used for information requirements analysis. Figure 1 depicts the causal relationships of the variables about KEPS.

*** Insert Figure 1 ***

3.3 Experiment Results

Let us suppose that the five nodes C3, C4, C6, C8, C24 should be relatively dealt with considering the competitor's software. How customer country will evaluate the five nodes is very uncertain, because the country has its own peculiar culture, policy, IT infrastructure, and user characteristics, etc. Some nodes are quantitative, and others are qualitative. However, those five nodes have uncertainty in common. Then in the framework of the proposed MOCA-CAMS, the Monte Carlo simulation should be applied to the five nodes in the process of simulation. Whether the MOCA-CAMS simulation process ends or not depends on the results by using the 1/2 threshold as described in 2.3.

For the sake of clear understanding about the MOCA-CAMS process, let us suppose that a customer country is considering the KEPS as one of the e-government system candidates for the procurement process management. Therefore the customer will surely want to evaluate the expected performance of KEPS by leaving those five nodes above to high volatility. If the MOCA-CAMS simulation results represented by the values of the three output nodes C26, C27, C28 seem good despite the high volatility of some nodes, then the customer country can safely conclude that the KEPS will work as expected when it is adopted in that country.

As addressed in 2.2, we calculated the adjacency matrix **E** as shown in Figure 2.

*** Insert Figure 2 ***

Using the adjacency matrix E in Figure 2, and 1/2 threshold, MOCA-CAMS performed simulation process. Meanwhile, let us assume probability distributions for the five uncertain nodes. If we want some nodes to remain highly volatile or uncertain, then uniform distribution with minimum -0.5 and maximum 1 is applied. If we have already supplementary evidences about the nodes, then normal distribution with mean 0.2 and standard deviation 0.2 is used. For example, we found that there exist evidential data about the three nodes like C4, C6, C8. Therefore, the normal distribution was applied. Meanwhile, the uniform distribution is applied to the rest of the nodes such as C3, C24.

Then after 5,000 trials of random number generation, the proposed MOCA-CAMS simulation yields the results about the three output nodes C26, C27, C28 as shown in Table 3. The results show that C26 (Benefit for cost) is 1.80 at the minimum, and its mean value is 3.0 which is very large meaning "Very Good" in terms of 5-point Likert scale. For C27 (Increase in per capita productivity), the MOCA-CAMS simulation result is that its minimum is 0.7, and mean value is 1.4, which is also "Very Good" in terms of 5-point Likert scale. For C28 (User satisfaction), the MOCA-CAMS simulation result tells us that minimum value is 4.9, and mean value is 5.7, indicating that the User Satisfaction would be "Very Good" when a customer country adopts the KEPS. Scenario 1 results are summarized in Table 2. Meanwhile, Figure 3 depicts the three output values of scenario 1.

*** Insert Table 2 ***
*** Insert Figure 3 ***

Similarly, we have changed probability distributions for the five nodes C3, C4, C6, C8, C24 to know whether the three output values would change significantly. Scenario 2 is such that beta distribution is used for C3, C24, and that normal distribution is applied to C4, C6, C8. For Scenario 3, only

uniform distribution is used for all the five nodes. For Scenario 4, uniform distribution is applied to C4, C6, C8, and beta distribution is used for C3 and C24. Table 3 summarizes the MOCA-CAMS simulation results for the four scenarios. All the mean values for the three output nodes are statistically stable under 95% confidence level. In average term, benefit for cost (C26) of the KEPS is expected to range from 3.0 to 3.2. The increase in per capita productivity (C27) is believed to fluctuate between 1.4 and 1.5, indicating that mean value is very stable, and the likelihood that the adoption of KEPS causes significant increase in per capita productivity is "Very Good" in terms of the 5-point Likert scale. Meanwhile, the mean value for user satisfaction (C28) falls within 5.6 and 5.8, which is also very stable from the statistical perspective with 95% confidence level. Therefore, when the customer country adopts KEPS to manage the G2B procurement process, the country can expect that all the mean values for the three output nodes (benefit for cost, increase in per capita productivity, user satisfaction) will be "Very Good" in terms of the 5-point Likert scale because all of their average values are greater than 1.0.

*** Insert Table 3 ***

4. Concluding Remarks

This study proposes a new method with which the target problem of assessing the expected performance of the e-government software when it is adopted in a country. This problem has remained unsolved due to the fact that it requires a lot of field knowledge and ample information about the country, and there exist a number of uncertainties and volatility in the relevant variables to be considered in the process of decision analysis. The target problem of this study is to predict the expected performance of the KEPS, the e-procurement system for G2B transactions which has been successfully implemented and operated by the Korean Public Procurement Service.

To pursue solving the target problem, we developed a new simulation approach called MOCA-CAMS in which the conventional CM is modified to incorporate the Monte Carlo simulation mechanism. Experimental results showed that the proposed MOCA-CAMS could yield statistically significant and valid estimation results for predicting the expected performance of the KEPS when it is adopted in other country. Especially, main advantages of the proposed MOCA-CAMS are as follows. Primary advantage of the MOCA-CAMS is that it enables predicting the expected performance of the KEPS after its adoption without spending a huge amount of money and time. Another advantage is that the MOCA-CAMS can be easily generalized and revised to incorporate additional variables, update the causal relationships depending on the characteristics of the KEPS adoption situations. Most brilliant thing that was made clear in the application process of MOCA-CAMS is that MOCA-CAMS can be applied to predicting the expected performance of other kinds of e-government systems. We hope that this study would trigger more serious studies in the field of assessing the performance of the e-government systems in the future.

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Figure 1. Causal Map for the KEPS

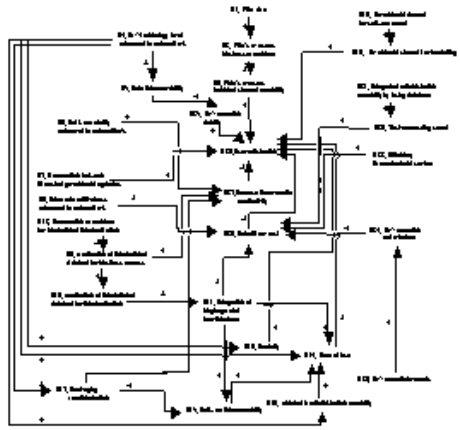


Figure 2. Adjacency Matrix for KEPS

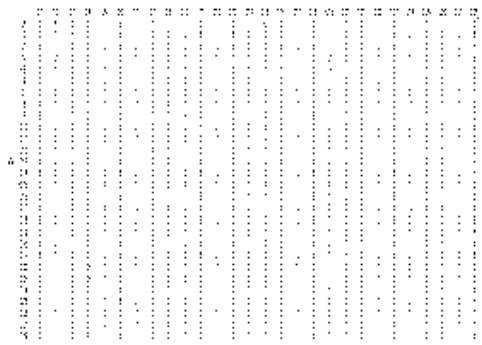
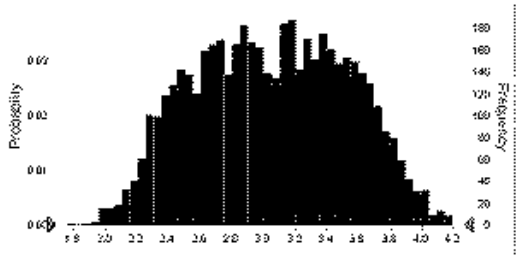
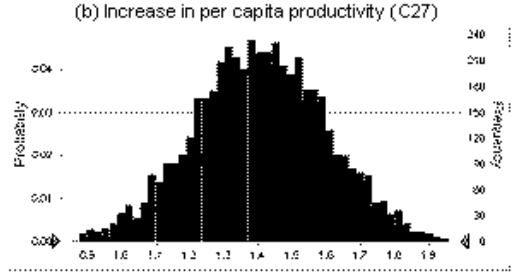


Figure 3. Graphical Display of Output Variables

(a) Benefit per cost (C26)



(b) Increase in per capita productivity (C27)



(c) User satisfaction (C28)

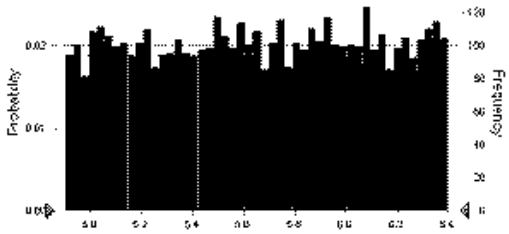


Table 1. Node Description

Node #	Description
C1	Firm size
C2	Firm's overseas business experience
C3	Firm's overseas technical support capability
C4	S/W technology level compared to competitor's
C5	Data interoperability
C6	Software quality compared to competitor's
C7	Cooperation between interested government agencies
C8	Price competitiveness compared to competitor's
C9	Application of international standard for business process
C10	Application of international standard for informatization
C11	Integration of language and user interface
C12	Cooperation experience for international informatization
C13	Security
C14	Ease of use
C15	Software interoperability
C16	Automatic administration capability
C17	Packaging/Modularization
C18	Government support for software export
C19	Government support for marketing
C20	Task processing speed
C21	Integrated administration capability by using database
C22	Efficiency in procurement service
C23	S/W operation records
C24	S/W operation performance
C25	S/W operation stability
C26	Benefit per cost
C27	Per capita productivity
C28	User satisfaction

Table 2. MOCA-CAMS Simulation Results for Scenario 1

Benefit for cost (C26)		Increase in per capita productivity (C27)		User's satisfaction (C28)	
Statistics	Forecast values	Statistics	Forecast values	Statistics	Forecast values
Trials	5,000	Trials	5,000	Trials	5,000
Mean	3.0	Mean	1.4	Mean	5.7
Median	3.1	Median	1.4	Median	5.7
Mode	—	Mode	—	Mode	—
Standard Deviation	0.5	Standard Deviation	0.2	Standard Deviation	0.4
Variance	0.2	Variance	0.0	Variance	0.2
Skewness	-0.0064	Skewness	-0.0437	Skewness	-0.0180
Kurtosis	2.14	Kurtosis	3.03	Kurtosis	1.81
Coeff. of Variability	0.1579	Coeff. of Variability	0.1409	Coeff. of Variability	0.0765
Minimum	1.8	Minimum	0.7	Minimum	4.9
Maximum	4.2	Maximum	2.1	Maximum	6.4
Range Width	2.4	Range Width	1.4	Range Width	1.5
Mean Std. Error	0.0	Mean Std. Error	0.0	Mean Std. Error	0.0

Table 3. Summary Statistics of Four Scenarios

Scenario	Statistics	Benefit for cost (C26)	Increase in per capita productivity (C27)	User satisfaction (C28)
Scenario 1	Min, Max	1.80, 4.2	0.7, 2.1	4.9, 6.4
	Mean	3.0	1.4	5.7
Scenario 2	Min, Max	2.0, 4.2	0.7, 2.1	5.0, 6.4
	Mean	3.2	1.4	5.8
Scenario 3	Min, Max	1.6, 4.6	0.7, 2.2	4.9, 6.4
	Mean	3.1	1.5	5.6
Scenario 4	Min, Max	1.7, 4.5	0.7, 2.2	5.0, 6.4
	Mean	3.2	1.4	5.8