확률적 변수에 기초한 연속적 시뮬레이션 모델을 이용한 시스템 성과측정 방법에 관한 연구

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Measuring The System Performance Based on a Continuous Simulation Model with Random Interactions of Organizational Behaviors

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Abstract

This paper focuses on the measurement of increased work efficiency expected from the information system through random interactions of the organizational behavioral factors whose attributes can be changed with the implementation of the information systems. Specifically the work reported here is concerned with modeling and analyzing the random interrelationships among the organizational behavioral factors which an information system will have impact on throughout the time horizon of its implementation in terms of office productivity. In addition, it is also concerned with developing a multi-factor analysis model based on random interactions to be used to assess the impact of information systems.

1. INTRODUCTION

To take a full advantage of an information system, it must be implemented to the right level and right scale. Before making a decision about size, type, and level of the information system, the managers should consider factors critical to its successful implementation such as management situations their organizations are faced with and characteristics their operations currently have. Implementing the information system with the lack of understanding the width and depth of the operations merely causes the organization to increase cost and reduce benefit.

To solve this problem, methods to assess the impacts of the information system on the performance factors in the organization, such as work efficiency, productivity, and customer satisfaction need to be developed so that they may be grasped and monitored by the organization. This paper presents a method to assess the impacts of the information system based on a mathematical model. The mathematical model consists of dozens of causal relationships among the organizational behavioral factors whose level could be increased or decreased by the implementation of the information system. The causal relationships is expressed in the form of linear

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equations whose coefficients are stochastic values rather than deterministic values so that the impacts of the information system could be measured through random feed-forward and feed-backward relationships among organizational behavioral factors. The mathematical model is developed into a schema of continuous simulation model for the analysis purpose and analyzed with a commercial simulation package. In the remainder of this paper the descriptive model formulated to capture the inter-factor relationships among organizational behavioral factors is explained and the application of this methodology based on the parameters obtained through a survey into Korean IT industry is presented.

2. LITERATURE REVIEW

Since the computer technology was introduced into organizations, lots of researches capturing the impact of the information system on the organizations have been performed. They are mainly focused on the change of organizational environments created by the information system and the impact on the working life in organizations.[1][4][6] With the advent of management information system, efforts to minimize organizational shocks were made in most organizations. As a result, researches concerning the ways of implementing the information system in harmony with the existing organizational cultures were conducted[2][7] and empirical studies was performed to identify any contributions that the information system could bring about[5]. Also the impact of information technology on the market value of the firm was studied[3].

Most of the researches on assessing the impact of information system have been directed more theoretically, but less empirically. The literature survey discloses the impact of the information system has rarely been analyzed with a mathematical model. The literature review arrives at a conclusion that no researches on assessing the impact of the information system through random feed-forward and feed-backward relationships among organizational behavioral factors have been performed.

3. THE MODEL

To measure the impact of the information system on the performance factors, behavioral factors in organizations whose level can be increased or decreased with the implementation of the information system are identified. The size of the contribution each of the organizational behavioral factors could bring into the performance factors in one organization is quite different from that of another. The relationships among behavioral factors in an organization normally vary with the characteristics of the business it operates, and the types of industry it belongs to. Therefore the very important factors in one organization are not so much important in other organizations, and vice versa. With the fact in consideration, 30 organizational behavioral factors cited most commonly in the literature were extracted and shown in Table 1.

Some of the factors displayed in Table 1 have positive impacts on the performance factors, while others have negative impacts. For example, factors such as data keeping system, the quality of data, and work method have positive impacts on the performance factors, but the factors such as privacy problem, computer crime, and occupational disease have negative impacts. The high value of positive factors means better performance, but the high value of negative factors means worse performance. The performance is measured with the changes made in the level of these positive and negative factors.

Once the factors are identified, their causal relationships are set up as a form of linear equations to define the degree of the impact which one factor has on the other factors. Inside the causal relationships, coefficients of the linear equations represent the degree of the impact. These causal relationships basically construct a mathematical model to capture how the change in one organizational behavioral factor influences other organizational behavioral factors, and ultimately bottom-line performance in terms of work efficiency and productivity.

Most of the coefficients of the linear equations in the mathematical model are defined as stochastic values, not deterministic values to take random interactions among the factors into account. It was assumed that the degree of the impact of one factor on the other factors is not constant but changeable throughout the time horizon of the implementation of information system.

The impacts of the information system are assessed based upon the stochastic causal relationships among the factors. An example of the causal relationship is as followings:

First the implementation of the information system makes the work method improved. And then the work-volume per worker is increased by the improvement of the work method. The increase in the work-volume per worker brings about the displacement of some workers and reduces the number of workers, consequently contributes to an increase in labor productivity. This stands for the positive impact of the information system. But, on the negative side, the displacement can demoralize workers more or less and make work efficiency changed downward. This causal relationship is depicted in Figure 1.

The causal relationships among the factors in Table 1 are displayed in Figure 2. Each of the arrows in Figure 2 defines a relationship between two factors. The factor indicated by the beginning point of the arrow is the independent factor while the factor indicated by the ending point of the arrow becomes a dependent factor. If a factor has multiple ending points, its causal relationship becomes multiple, and its level is affected by the multiple independent factors.

The impact each of the factors has on other factors could be time-dependent. Some of them have an immediate impact on other factors but others may need several months for the expected changes to be realized. Therefore the different time-lag in each of the causal relationships has been taken care of in the analysis model.

4. SURVEY

To find out parameter of the causal relationships displayed in Figure 2, a survey was conducted for the industry-wide in Korea. The questions in the survey ask how the changes in one independent factor affect the dependent factor when the level of the independent factor is improved by 10% from the current level. For example, to discover the parameter of the causal relationship between the *information system* and the *quality of data*, the survey asks how the level of quality of data will be changed when the current level of information system has been improved by 10%. Likewise, all the causal relationship in Figure 2 are identified through the survey results.

The questionnaire for the survey consists of three sections. The first section has questions asking general information on the company and the industry it belongs to. The second section of the questionnaire, which is the key part of the survey, functions to grasp inter-relationships among the factors. Its questions ask EDP managers how much change was (or will be) made for the dependent factors when the level of independent factors was (or will be) increased or decreased by 10% in their companies. In the last section base line values for quantitative factors, such as the number of workers, average scrap & rework rate, and data gathering cost are questioned.

The questionnaire was mailed to over 200 companies and 51 responses were collected. Then, based on the survey results, parameters of the causal relationships was defined with randomness obtained from the survey. Therefore, the level of impact of one factor upon the other factors will be determined by the experimental probability obtained from the survey.

Based on the survey results, each of the causal relationships displayed in Figure 2 is defined as a linear equation with random coefficients. Here is an example of the random coefficients of the causal relationships between the *information system* and the *quality of data*:

quality of data = ED * *information system*

ED: 0.025(coefficient) ==> 0.12 (probability)
0.075(coefficient) ==> 0.28 (probability)
0.125(coefficient) ==> 0.32 (probability)
0.175(coefficient) ==> 0.22 (probability)
0.225(coefficient) ==> 0.04 (probability)

In total, 29 linear equations such as the one shown above have been set up to make a mathematical model.

The mathematical model could not be free from some assumptions and subjectivity. It is because the cost or the expense incurred with the implementation of an information system is quantitative, but most of its effects come out as qualitative values. So the qualitative values get changed into quantitative values with assumptions to compare the cost of the implementation with its benefit. On the other side, the impacts of the information system on organizational behavioral factors are totally estimated from the survey results, which stand for the EDP experts' subjective views included in the survey.

The multi-factor interrelationship analysis is performed based on a continuous simulation model using SIMAN package.[8] The linear equations which stand for the interrelationship among the factors are provided to SIMAN model and the randomness defined from the survey are applied to the model using Monte

Carlo sampling techniques as a form of Fortran codes. Then the FORTRAN codes are compiled and linked to the SIMAN body to analyze the impact of the information system on the work efficiency.

5. APPLICATION / DEMONSTRATION

The empirical study is launched with the assumption of 10% improvement in the level of the information system. After that, the impacts on the factors displayed in Table 1 are traced month by month for one year with time-lag in consideration. The result of the empirical study is shown in Table 3 as a form of SIMAN Summary Report. It displays the values of each factors observed for one year after the impetus of the 10% improvement in the level of the information system by average, standard deviation, minimum value, and maximum value. Table 3 shows that the 10% improvement in the level of information system increases the quality of information by 9.1%, the quality of working life by 6.6%, the work-volume per worker by 12.89%, the worker's morale by 3.85%. But it also increases the displacement by 3.55% and the general overhead by 5.1%. Finally, the 10% improvement of information system brings about 5.15% increase in work efficiency and 13.43% in overall productivity.

6. CONCLUSIONS

A continuous simulation model has been described so far to estimate the impact of the computer system. First, organizational behavioral factors whose attributes can be changed favorably or unfavorably with the implementation of computer systems are identified and their causal relationships are defined based on the survey results. Then the continuous model is developed and validated with the assumption of 10% increase in the level of the information system.

The mathematical model makes it possible for an organization to carry out a feasibility study for the information system before its implementation. It can also help for an organization to find out an appropriate way of implementing the information system. For this research to be applied to a real problem, however, the parameters of the mathematical model should be changed to the right values reflecting its own organizational characteristics. On the assumption that the work efficiency can be converted into monetary value, initial investment made on the information system can be compared with its effects to make a decision to go or not to go for the proposed information systems In conclusion, an organization can implement information systems efficiently to compare its effect with its expense based on the suggested simulation model before the money is invested.

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