Fuzzy-Monte Carlo Simulation for Cost Benefit Analysis of Knowledge Management System Investment

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1. Introduction

Nowadays, knowledge management system is not doubtful as an important tool in an enterprise business process by reason of the effective knowledge management system can give a competitive advantage. Knowledge management system (KMS) is an information technology (IT) based system, which is developed to support and enhance the processes of knowledge creation, storage or retrieval, transfer, and application (Alavi & Leidner., 2001;Tseng, 2008). There are some benefits that can be achieved by implementing KMS such as increased employee productivity, better quality of a finished product, production and labor cost saving (M.-Y. Chen et. al, 2009; Wickhorst, 2002). Many managers know these benefits, but they are still vacillating to decide for investing KMS in their structure. This vacillation comes from consideration of budget and uncertainties or risk of economic constrained. In addition, the managers do not know how to analyze cost and benefit of KMS investment correctly. Without being able to make the analysis, managers cannot determine whether investing a KMS is worthwhile or a waste for the enterprise. Therefore, the cost-benefit analysis of KMS investment is necessary in order to evaluate its attractiveness.
The traditional cost-benefit analysis that always used in KMS and other enterprise information system (EIS) investment evaluation such as net present value (NPV), internal rate of return (IRR), and payback period (PB) seek to adopt a monetary unit as a basis of analysis, in which all non-monetary parameters are given monetary values (TBC, 1998; Tang and Beynon, 2005). However, it is observed in (Phillips-Wren et al., 2004) that most benefits associated with EIS like KMS are mostly intangible, which makes the use of traditional quantitative financial models heavily biased towards tangible costs and benefits. In an attempt to bridging the intangible towards tangible in the benefits related decision-making process, some enterprises analyze based on subjective judgement. This approach constantly in linguistic term contains ambiguity data that has a number of weaknesses (Uzoka, 2009) such as: inaccurate representation of the uncertainty lack of historical data, inability to understand completely and reproduce the results, poor explanation of a decision process and associated reasoning, a possibility of missing out important problem details for the evaluation, high probability of different experts producing different results without the

ability to decide which one is correct, difficulty in exploiting past evaluations, and the risk of producing meaningless or highly faulty results.

In this paper, a fuzzy rule based system is proposed to bridging the tangibles and intangible benefits of KMS investment. The fuzzy component addresses the vagueness associated with human judgement, especially of intangible parameters. Furthermore, a Monte-Carlo simulation method is used to consider the uncertainty of economic in calculating an expected net present value (NPV). The Monte Carlo simulation is a method that appropriate for estimating the impact of KMS critical factors to the financial result by randomizing value from each of the uncertain variables and calculating the objective or target value of an investment model.

This paper starts with an introduction about problem of KMS investment decision in section 1, and then followed by discussion about cost and benefit of KMS investment, related works in cost-benefit analysis of KMS investment, and including the Fuzzy-Monte Carlo simulation as the proposed approach for this paper in section 2. Section 3 provides a framework for cost benefit analysis of KMS investment. The real life problem that the authors dealt with and intangible benefit analysis due to this problem are introduced in Sections 4 and 5, respectively. Section 6 provides a mathematical model of cost-benefit impact to KMS investment. In Section 7, the results of the Monte-Carlo simulation are analyzed and discussed. Finally, Section 8 presents the conclusions and outlines for further research.

2. Literature review

As managers became aware that the power of knowledge is the most valuable strategic resource, knowledge management (KM) became widely recognized as essential for the success or failure of enterprises. Consequently, over the past 20 years, KM has progressed from an emergent concept to an important factor in sustainable competitive advantage of business (Wagner et al., 2011). According to one estimate, 81% of the leading organizations in Europe and the U.S. are utilizing some form of KM (Grossman, 2006). Knowledge is based on data and information. Data represents the raw facts without meaning; information symbolized to what is obtained when data is organized in a meaningful context, while knowledge is characterized as the meaningfully organized accumulation of information (Zack, 1999). Nonaka (1994) points out that there are two different types of knowledge in an organization: explicit and tacit knowledge. Explicit knowledge is formal and systemic, while tacit knowledge is highly personal and difficult to formalize. These two types of knowledge are both essential to the organization and must be captured and shared for others to benefit. Thus, knowledge in the organization should be managed properly and carefully.

The KMS refers to the set of processes or practice to develop the ability of an employee in creating, acquiring, capturing, storing, maintaining and disseminating the enterprise's knowledge (Hamundu & Budiarto, 2010). Many companies are building KMS to manage their organizational learning and business "know-how". For instance, a software engineer is able to know immediately the algorithm of a security system in prior software development. Sharing this information organization widely can lead to more effective security design, and it could also lead to ideas for new or improved software. Indeed, the ability to perform all functions of KMS depends on the information technology (IT) role. Facing a tremendous amount of data on a daily basis, enterprises only use IT to integrate each division of various tools, such as intranet, data warehouse, electronic whiteboard, artificial intelligence and expert systems so that the jumbled business data is well-organized and more integrated (Khandelwal, 2003). During the development of KMS, attention should be paid to various issues and challenges related to using IT to support KM (Jungpil & Mani, 2000). This issue is considered by the managers to evaluate whether the KMS investment is feasible or not. Thus, the accurately calculating the cost and the benefit of KMS investment are necessary.

2.1 Costs

The first step of cost-benefit analysis for a KMS investment is to determine the costs. On the surface, this may seem deceptively simple, but there are costs involved in a knowledge management investment that may not be readily obvious to the manager. In fact, investment cost of EIS likes KMS is a common factor influencing the purchaser to choose the EIS (Davis & Williams, 1994). Obviously, the project will incur the cost of whatever EIS to be used. This can range from free, to nearly free, to several thousand dollars for an EIS. In addition, any technical infrastructure for the EIS that is needed will also have to be counted in the costs.

Investment costs of KMS include, but are not limited to the costs of software, hardware, incentive programs, implementing and maintaining. Technically, these costs can be grouped under two major criteria, namely, capital expenditures and operating expenditures (Ngai & Chan, 2005). Capital expenditures are the non-recurring costs involved in setting up the KMS such as product costs (the basic cost of the KM tool), license costs (the cost of the KM tools in terms of number of users) and training costs. Operating expenditures are the recurring costs involved in operating the KMS, which include maintenance costs and software subscription costs (the annual, pre-paid cost of upgrading the product to a major software release when it is launched).

2.1.1 Software

The standard software such as e-mail, web servers, corporate intranets, newsgroups, shared file systems, or centralized databases in an enterprise is commonly already existed. Hence, there is no software cost even only transfer knowledge such as the exchange of e-mail, the use of instant messaging tools, or the use of internet search engines. However, if the enterprise wishes to establish a level of knowledge integration and wishes to manage, encourage, and shepherd the transfer of knowledge, these tools are probably inadequate for the task.

In this case, the enterprise will want to invest in a commercially available product designed specifically for the tasks that the company wishes to be able to accomplish with the KMS. Costs for this may be quite high, but this KMS will be more likely to be utilized by the users, even if more user friendly than competing products.

2.1.2 Hardware

Along with the cost of software, the enterprise must also consider the costs of the infrastructure or hardware that will be needed to support the KMS. The application that is chosen may need its own application server on which to run or it may co-locate with existing applications on a server that the company already owns. If the system is placed on a server with applications already running, the company will have to consider the cost of any performance degradations that the other applications may occurrence. A server will need rack space in the server room, a universal power supply, and a network connection. Any upgrades to the enterprises network for handling an increased traffic attributable to the KMS should be considered.

Even if the company chooses to use the current systems and equipment, this equipment will be experiencing heavier loads than in the past, and this should be considered. If e-mail is chosen as a required tool, the mail server should be able to handle the increased traffic. The database server is needed to handle increased loads if it is to host a KM database. If the internet is required as part of a KMS, then the enterprise should be ensured that there is enough bandwidth available to handle all incoming and outgoing traffic and purchase more if needed.

2.1.3 Incentive programs

Another cost that should be considered, which is easily overlooked especially in the planning stages of a KMS investment, is the cost of programs that will be instituted to encourage employees to use the new system. A KMS is only useful when it is being used heavily, and the use of the system must likewise be encouraged by management. This means that the investment cost of a KMS must include the costs of awards and rewards that will be distributed to employees to encourage adoption and participation. In addition to the material costs involved, this program will also need an employee or group of employees to administer the program, determining the criteria for receiving an award, and determining the employees who are to be rewarded for their levels of participation. Managers will need to make their employees aware of the rewards program and encourage their charges to participate.

2.1.4 Implementing and maintaining cost

The implementing and maintaining cost of a KMS comes in many forms and all forms must be considered when calculating total costs. One implementing cost that should be considered is the cost for employing a member of the IT staff to install the KM hardware and software on all needed servers and client machines. In addition, the IT staff will need to configure the application to meet the needs of the business. This will require input from members of the business units that will be participating in the project, and their labor must be considered in the costs.

Once the system has been installed and is running, it will need to be maintained. A properly configured KMS will likely require little if any daily maintenance, but a member of the IT staff will need to contribute at least a few hours a month to backups, system administration, and the occasional restart. Knowledge will need to be input into the system in order for it to be useful, and in most cases this will require a substantial investment of labor capital from those possessing the knowledge to add this information to the system. The costs for the addition of knowledge will be heavy early on, but will steady out in the future, and will be based on the use of the system. In order for employees to be able to use the system, they will need to be trained on its use and the goals of the project. This training will take them away from other productive tasks and should be considered as one of the costs of the KMS investment. Once the employees have been trained, the time they spend using the system should also be considered as a labor cost attributable to the KMS investment.

2.2 Benefits

Once the costs have been calculated, the benefits of KMS investment either tangible or intangible must also be figured. One intangible benefit that will be gained after utilizing the

KMS is an increased quality of a finished product. Quality, which is delivered by KMS accounts for 20% of benefits (Anderson, 2002). An employee who uses the KMS might be able to obtain knowledge that will reduce the amount of defective finished products or will increase the effectiveness and quality or innovation of the products (Plessis, 2007). Another intangible benefit that will be recognized from the KMS is an increase in employee productivity. Productivity and speed, which is delivered by KMS account for 55% of benefits (Anderson, 2002). Employees, who use the KMS will be able to think creatively, innovatively, and also work faster, because they will find information on the KM environment that allows them to avoid repeating the work of others, such as a snippet of computer code (Chen & Huang, 2009).

The higher-quality product means potential to increase product sale or to decrease customers' dissatisfaction (Berry & Waldfogel, 2010). Consequently, it will improve the company's revenues and profit. Furthermore, an employee productivity and speed are strong related to delivery time of a finished product, while one factor that causes increase order of the finished product is an improved delivery time to customer (Ustundag et al., 2010). In addition, cost saving is also a benefit that can be realized through utilization of KMS. The practices of learning new knowledge, and sharing what is known by individuals, would enhance organizational capabilities and firm performance in terms of cost saving (Law & Ngai, 2008). Cost saving represents approximately one-quarter of benefits from KM investment (Anderson, 2002). The KMS can save in a labor costs and material costs, but the true benefit of cost saving through a KMS is realized when employees discover and share methods for reducing costs on final products.

2.3 Related works in cost-benefit analysis of KMS investment

Benefits might be difficult to measure, because many of the benefits are intangible, and cost savings delivered by KMS investment with an amount of USD*xxx* in the balance sheet will not be immediately illustrated. In addition, it is almost impossible to find metrics that will produce a one-to-one correlation between KM and financial impact (Vestal, 2002). The measurement of intangible benefits such as increased customer satisfaction and increased productivity of an employee, or cost savings is the key to evaluate the attractiveness of KMS investment. Furthermore, an evaluation of financially risk of KMS investment is needed by using objectives and parameters such as revenue, other benefits, capital and operating costs. A suitable investment model needs to be developed in order to estimate the financial outcome of the project and ascertain whether it meets any predetermined financial criteria as to what constitutes an attractive project (Ustundag et al., 2010).

Traditional cost-benefit analysis used in evaluating the value of EIS investment likes KMS relies on cash flow measures. Cost-benefit analysis include: payback period, rate of return on investment (ROI), net present value (NPV), profitability index, and internal rate of return (IRR) (TBC, 1998; Tang and Beynon, 2005). They assume that all costs and benefits are known, and it can be illustrated in a common metric–money. However, these assumptions are rarely met in the real life (K.C. Laudon and J.P. Laudon, 2005). They observed that most of the traditional cost-benefit analysis methods miss out a great deal of strategic considerations in an attempt to quantify and discount monetary units of intangibles. Therefore, this paper introduces an approach that can handle the problem that had defined earlier such as;(1) how to bridging the tangible and intangible benefits for cost-benefit analysis of KMS investment, (2) how to assess and manage the key factors as a reason the KMS success or failure, which is in uncertainty matters.

Over the years, Artificial Intelligence (AI) techniques such as Artificial Neural Network (ANN), Genetic Algorithm (GA), and Fuzzy Logic (FL) have been studied and employed in such kinds of investment decision making. Fuzzy Logic (Zadeh, 1965) has been widely used because of its obvious advantages of effectively dealing with linguistic expressions and capturing experts' knowledge on a specific problem. One of the key advantages of intelligent systems or such as fuzzy logic, is the modelling of unstructured variables and an attempt to utilize linguistic values in the evaluation process (Harmon and King, 1985). Fuzziness is inherent in many problems of knowledge representation, and the other is that high level managers or complex decision processes often deal with generalized concepts and linguistic expressions, which are generally fuzzy in nature. Modelling of imprecise and qualitative knowledge, as well as the transmission and handling of uncertainty at various stages are possible through the use of fuzzy sets. Fuzzy logic is capable of supporting to a reasonable extent, human type reasoning in a natural form. Examples of intelligent and soft computing techniques utilized in cost-benefit analysis of EIS can be found in (Uzoka, 2009). The framework of Uzoka (2009) is oriented for providing a cost-benefit analysis in EIS investment evaluation. However, cost-benefit analysis still need to provide an approach that not only includes the tangible and intangible benefits, but also provides the relationship among them and how they affect the investment output. All these benefits impact should be incorporated into an economic model with the purpose of informing the decision-maker about the amount of loss, cost saving, or revenue increase with an intention to inform the manager whether investing a KMS is worthwhile or a waste for the enterprise.

Therefore, this paper primarily concerns with providing such a framework for the cost-benefit analysis of KMS investment, which is utilized for assessment of the customer sales increase. Fuzzy rule based systems have been the most popular and easiest way to capture and represent fuzzy, vague, imprecise and uncertain domain knowledge. The fuzzy rule based systems (FRBS) uses fuzzy IF-THEN rules to determine a mapping from fuzzy sets in the input universe of discourse to fuzzy sets in the output universe of discourse based on fuzzy logic principles. In recent years, many researchers use the concept of a pure fuzzy logic system where the fuzzy rule base consists of a collection of fuzzy IF-THEN rules for many objectives such as flow time prediction in semi conductor manufacturing system (Chang et al., 2006), and Ustundag et al. (2010) who use FRBS for determining the revenue increase due to the quality of supply chain of companies after RFID implementation. Furthermore, the Monte Carlo simulation is implemented to calculate the expected net present value (NPV) for evaluating the attractiveness of KMS investment. Investment appraisal based on Monte-Carlo simulation of net present value (NPV) is a suitable methodology for KMS investment by which the uncertainty encompassing the main variables projected in a forecasting model is processed in order to estimate the impact of risk on the projected results. It is a technique in which a mathematical model is subjected to a number of simulation runs, usually with the aid of a computer. During this process, successive scenarios are built up using input values for the investment key uncertain variables which are selected at random from multi-value probability distributions. The simulation is controlled so that the random selection of values from the specified probability distributions does not violate the existence of known or suspected relationships among the investment variables.

The motivation of this paper is the lack of studies in the literature about how the expected revenue increase of KMS investment is determined by using NPV calculations. Therefore, the fuzzy rule-based system is used to calculate the expected revenue increase, and the Monte-Carlo simulation method is applied to determine the expected NPV of KMS investment at different certainty levels.

3. Cost benefit analysis of KMS investment

Referring to the limitations of existing cost-benefit analysis as discussed in Section 2, a new mechanism that can solve the problem must be established. This paper proposes framework that able to bridging intangible and tangible benefit for cost-benefit analysis as shown in Figure 1. The framework consists of four main process and one sub process namely benefit identification, knowledge acquisition, determine the probability distribution, modelling of risk impact to economic model, and performing simulation for risk analysis.

The proposed framework starts with to identify the benefit of KMS investment (See Figure 1, Benefit Identification process). Once the benefit identification has been done, the knowledge acquisition for handling the intangible benefits by using fuzzy rule-based system (FRBS) is conducted (See Figure 1, Knowledge Acquisition process). Furthermore, the output of knowledge acquisition process and tangible benefit are determined their probability distribution based on the characteristic of data (See Figure 1, Determine the Probability Distribution for Each Benefit). Once a FRBS has been set up, the probability distributions of those intangible and tangible benefits are linked to an economic model (See Figure 1, Modelling of Cost Benefit Impact to KMS Investment). Finally, perform the simulation for forecasting the certainty level of expected NPV (See Figure 1, Performing Simulation).

In order to illustrate how the proposed framework works, a cost benefit analysis of KMS investment for a software house company ABC is given in the following section.

4. A software house company ABC

An ABC company of software house has three branches in different cities, which meets the demand based on job order. The company plans to integrate KMS in their information and communication technology infrastructure. The management board of the company requests a cost-benefit analysis for the KMS investment. In the cost-benefit analysis, costs is categorized in capital expenditures and operating expenditures. On the contrary, the cost saving, increasing the quality of products, and employee productivity and speed are considered as benefits of the KMS investment. The cost savings contribute to increase the profits, while increasing orders due to the customer satisfaction is defined in expressions of productivity-speed time and quality of product impact. The benefits is identified and discussed in Section 2.2.

The revenue element of ABC Company consists of total of orders with the yearly amount before KMS adoption is 200 units with standard deviation 18% and the price per unit of USD5000. The investment costs of KMS are structured by capital expenditure (C_{Xn}) and operating expenditure (C_{Yn}) as USD200000 and USD20000 per year respectively, while the cost unit for the target of cost savings consists of average of annual direct labor cost per unit product (20 labor) of USD100, annual purchase material cost per unit product of USD800, annual method for final product per unit of USD500.

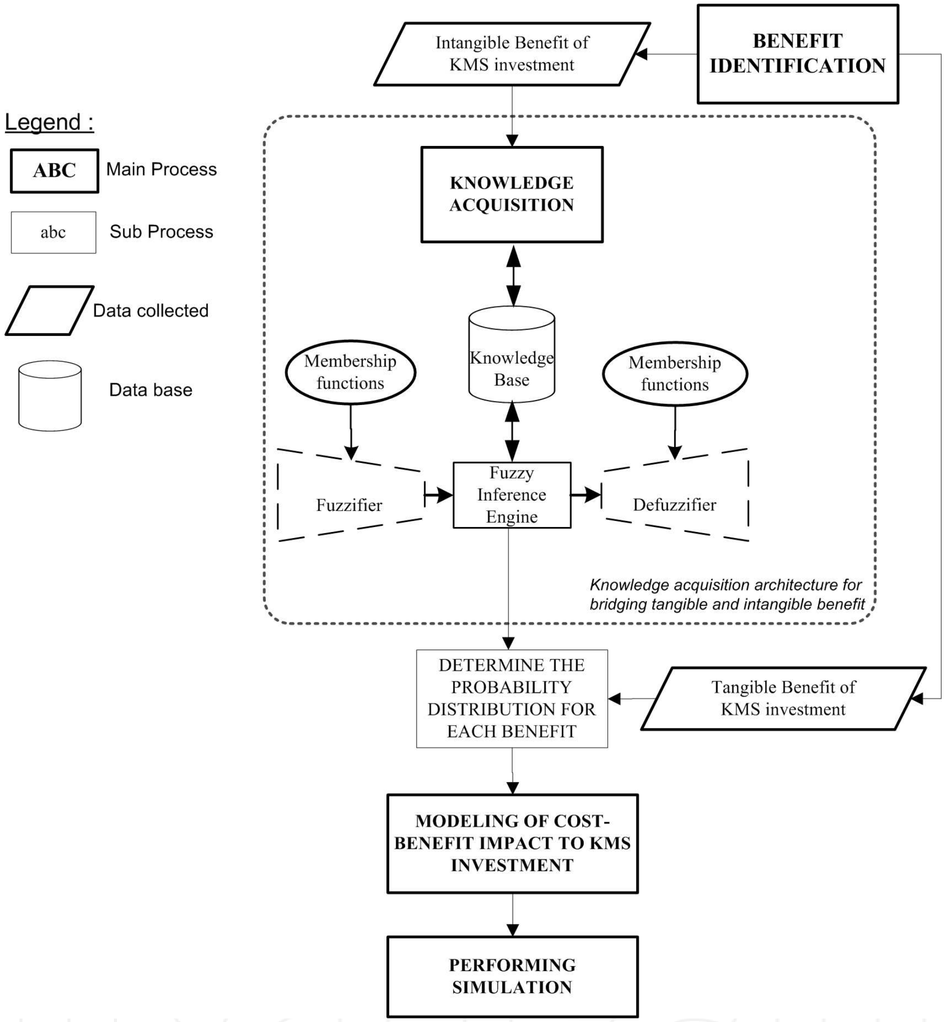

Fig. 1. Framework for Cost-Benefit Analysis of KMS Investment

Due to the fact that to illustrate the increase customer orders as an impact of intangible benefits in a balance sheet is difficult, a fuzzy rule-based system is developed. Consequently, net present value (NPV) as the feasibility indicator of the investment is computed using Monte-Carlo simulation.

5. Knowledge acquisition

Regarding the impact of intangible benefits of KMS investment to a revenue model, which is represented by increased customer orders, this paper involves expert's opinion to handle the increased by producing a fuzzy rule-based system (FRBS). This system is a systematic reasoning methodology that can capture the contextual judgment of experts by using fuzzy set theory.

This paper employs Mamdani model due to its advantages in representation of expert knowledge and in linguistic interpretation of dependencies. Hence, the increase in orders is calculated in a Mamdani-type. The composition of Mamdani-type fuzzy logic rule bases is in the following form (Tosun et al., 2010).

$$\textit{If } x_1 \textit{ is } A_1,\ x_2 \textit{ is } A_2 \ldots \textit{ And } x_n \textit{ is } A_n \textit{ then } y \textit{ is } B$$

where A and B are linguistic variables defined by fuzzy sets of the universe of discourse x and y respectively. The output of the fuzzy rule based model whose rule base is constructed using Mamdani-type fuzzy logic rules is shown in Equation (1) (Jang and Gulley, 1997).

$$Z_{MOM} = \frac{\int_{z'} z\,dz}{\int_{z'} dz} \tag{1}$$

where Z_{MOM} is the defuzzified output, z' is the maximizing z at which the membership function reaches its maximum. In this paper, both triangular and trapezoidal fuzzy numbers are used to consider the fuzziness of the decision elements. The rules established for the increase rate in orders is structured such as follows:

Rule 1: IF delivery time is Short AND quality of product is High THEN Increase Rate in Orders is High.

Rule 2: IF delivery Time is Short AND quality of product is Medium THEN Increase Rate in Orders is Medium.

Rule 3: IF delivery Time is Normal AND quality of product is High THEN Increase Rate in Orders is Medium.

Rule 4: IF delivery Time is Normal AND quality of product is Medium THEN Increase Rate in Orders is Medium.

Rule 5: IF delivery Time is Long AND quality of product is Low THEN Increase Rate in Orders is Low.

All rules defined by the experts, and then calculated in Matlab Fuzzy Toolbox. The max–min method is used for the aggregation mechanism whereas the mean of maximum method is used for the defuzzification process of fuzzy outputs. Furthermore, the membership functions of delivery time that represent of productivity and speed of employee, quality of product and increase rate in orders are defined by the experts and given in Figure 2, Figure 3, and Figure 4, respectively.

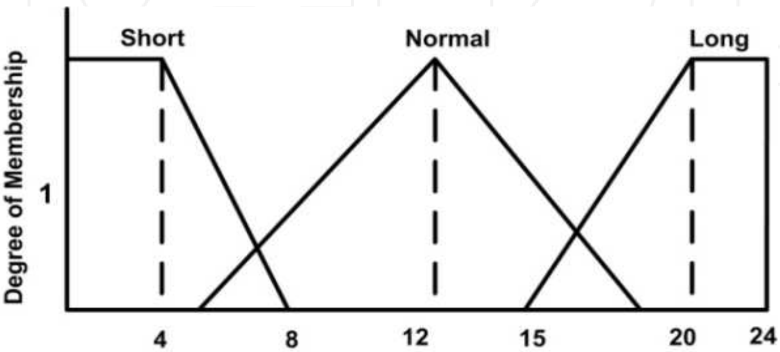

Fig. 2. The MFS of delivery time

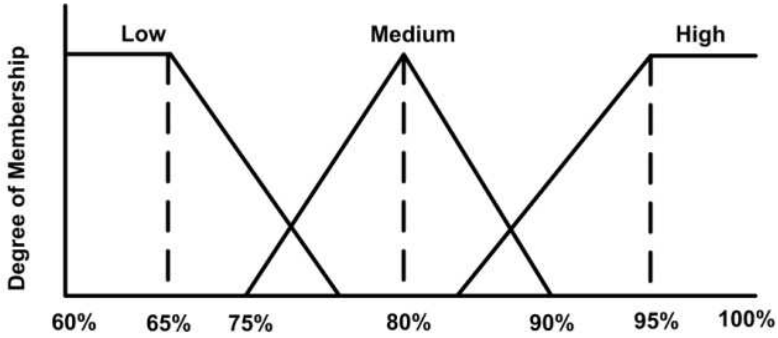

Fig. 3. The MFS of quality of product

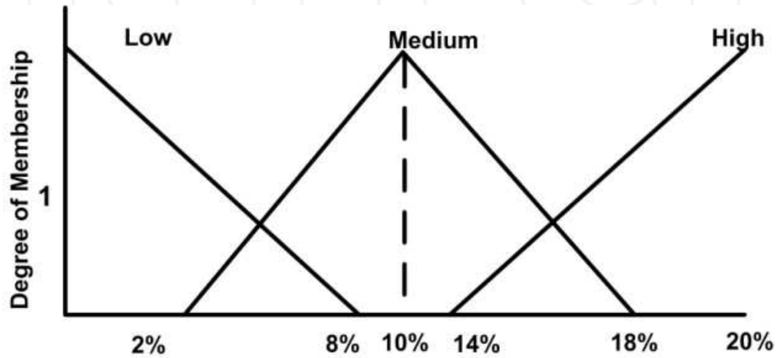

Fig. 4. The MFS of increase rate in orders

By implementing the input data into the system, the probability distribution of expected increase rate in orders is generated as shown in Table 1. In addition, the experts' also predict the expected cost savings rate (r) which is delivered by KMS investment with probabilities of 10%, 30% and 60% as shown in Table 2.

Probability (%)	Delivery Time (h)	Quality (%)	Increase Rate in Orders (%)
0	48	65	3.3
30	30	80	10
60	20	95	18.5

Table 1. The expected increase in sales

Probability (%)	Cost saving rates (%)		
	Labor Cost	Material Cost	Cost on Final Products
10	2	6	15
30	3	8	20
60	5	10	25

Table 2. The expected cost saving rates

6. Model of cost-benefit Impact to KMS investment

In the KMS cost-benefit analysis of KMS investment, the costs calculation is structured by capital expenditures (C_{Xn}) and operating expenditures (C_{Yn}). On the other hand, the benefits of KMS (B) that calculated in Eq. (2) are derived from revenue increase (RI) and costs saving such as annual purchase material cost saving (CS_m), cost saving on final product (CS_i), and labor cost saving (CS_l). Indeed, the variables of total benefit are calculated considering the increase rate in orders (s) which has been estimated by fuzzy rule based system as shown in Table 1. The increased orders (S′) is calculated by Eq. (3).

$$B = (CSm + CSi + CSl) + RI \quad (2)$$

$$S' = S(\mu,\sigma)\ x\ (1+s) \quad (3)$$

where $S(\mu,\sigma)$ is the yearly orders with a mean μ and standard deviation σ. The cost savings are computed considering the increased orders (S'), cost unit (c), cost saving rates (r) as shown in Table 2. The cost saving is calculated by Eqs. (4)-(6).

$$CS_m = S' + c_{material} + r_{material} \quad (4)$$

$$CSi = S' + c_{final\ product} + r_{final\ product} \quad (5)$$

$$CSl = S' + c_{labor} + r_{labor} \quad (6)$$

The revenue increase is calculated considering yearly total orders (S), the increase rate in orders (s) and profit for each unit (p) in Eq. (7). Finally, the NPV of the total KMS investment is determined for n years in Eq. (8) where i indexed as discount rate.

$$RI = S(\mu,\sigma)\ x\ s\ x\ p \quad (7)$$

$$NPV = -(C_{X1} + .. + C_{Xn}) + \sum_{n=1}^{t} \frac{[B - (C_{Y1} + .. + C_{Yn})]}{(1+i)^n} \quad (8)$$

In relation to investment analysis, the Monte Carlo simulation is the appropriate method for estimating the impact of KMS costs and benefits to the investment result by randomizing value from each of the uncertain variables and calculating the objective or target value of the investment model (Hacura et al., 2001). This method uses random numbers from probability distributions of increase rate in orders and cost saving rates to compute the probability distribution of NPV, which meant not only produce one value of NPV.

7. Simulation, results, and discussion

The simulation to calculate the NPV of KMS investment is carried out using software Crystal Ball Version 7.2.1. In addition, the simulations are run 500 times to minimize the possible errors arising from the random variables. A simulation generates the probability distribution for the total revenue increase, the total cost saving, and the total benefit which is the sum of total revenue increase and total cost saving as shown in Fig. 5, 6, and 7 respectively. Furthermore, the distribution of NPV in 3 years horizon is shown in Fig. 8 with the probability of a discount rate (i) of mean of 8% and standard deviation of logarithmic value of 0.22. The cost savings of material, labor and method on a final product are

computed considering the increased orders, unit costs and cost saving rates using Eqs. (3)–(6). For calculating the total revenue increase, the estimated demand increase of the company is multiplied with the profit for each unit as in Equation (7). The total yearly benefit is calculated by Eq. (1), while the NPV by Eq. (8).
According to the results of the simulation, the cost saving varies between USD35,675 and USD64,772 while the revenue increase varies between USD38,128 and USD296,894. The simulation result for total benefit varies between USD75,307 and USD360,368. The distribution of the NPV of KMS investment has the mean value of USD355,492 and the standard deviation USD254,519, which varies between USD -48,705 and USD731,091.

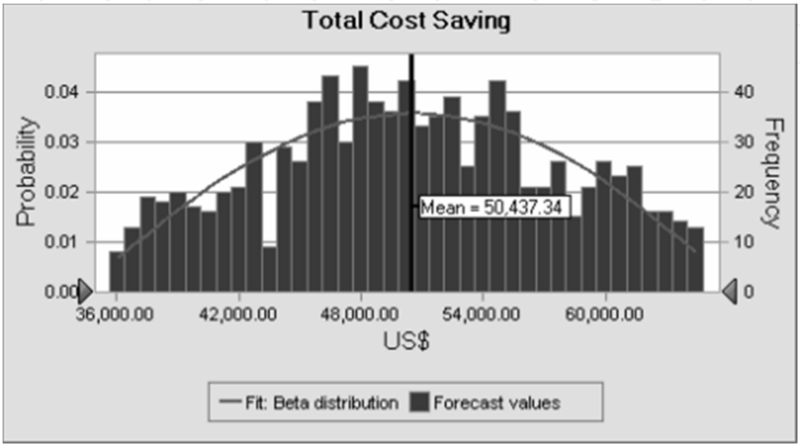

Fig. 5. The simulation results for the total cost saving

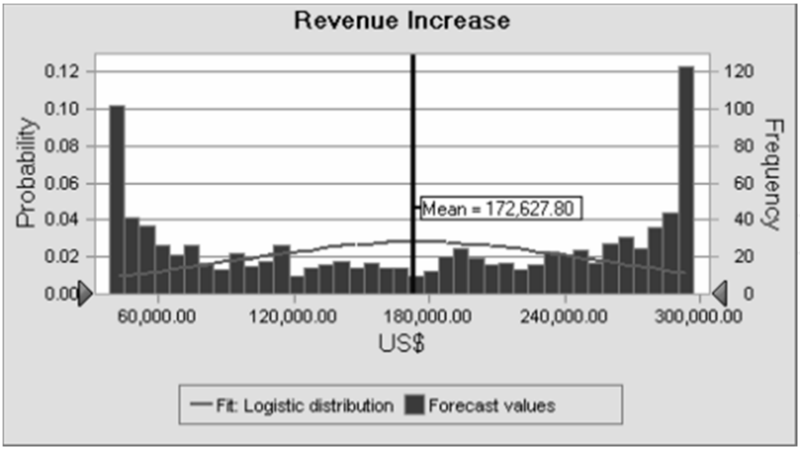

Fig. 6. The simulation results for the total revenue increase

The NPV, which is defined as the difference between a present value of cash inflow and cash outflow by considering a discount rate is important for managers to know whether the attractiveness of an investment is good or bad. If NPV is positive, then the investment decision is acceptable. Otherwise, the investment should be rejected.

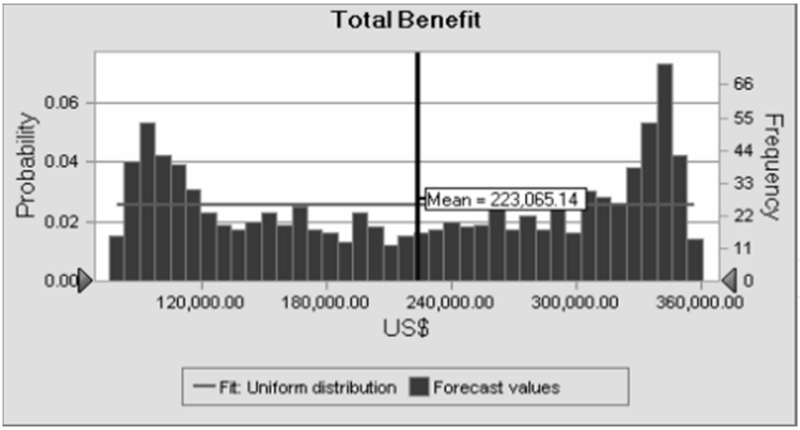

Fig. 7. The simulation results for the total benefit

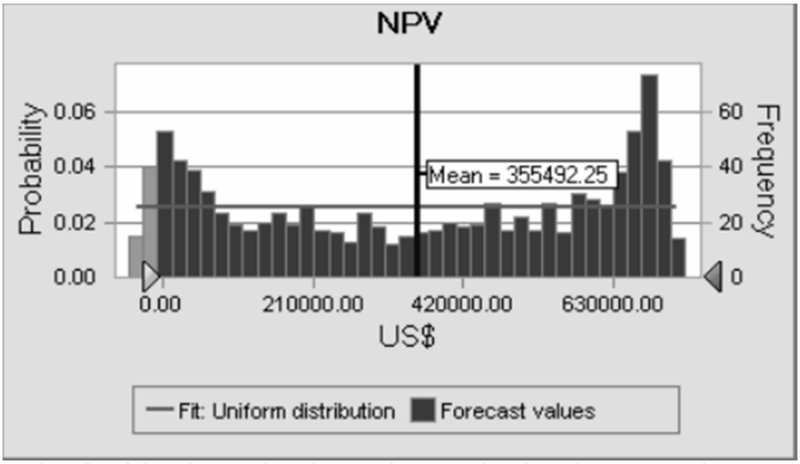

Fig. 8. The simulation results for the NPV of KMS investment

As shown in Table 3, the KMS investment for three years horizon is more than 90% certainty that the NPVs will be positive. Therefore, the managers of the software house company ABC should decide to invest in KMS. However, there is small probability (<10%) that the KMS investment will be a loss with an amount of less than –USD48,705. This may be due to the uncertainty or risk of economic constrained, which can be represented by probability distribution of the discount rate. As a summary, although the managers should invest the KMS, they should also consider the small probability of loss by ensuring the effective performance of the KMS. In order to ensure that KMS performance is effective, the managers should assure both IT infrastructure support as well as the employee participants for the KMS adoption.

Probability (%)	Net present value of KMS investment (USD)
0%	(48,705)
10%	7,401
20%	57,059
30%	151,300
40%	251,613
50%	377,746
60%	473,571
70%	573,595
80%	642,519
90%	681,202
100%	731,092

Table 3. Percentile analysis of the NPV of KMS investment

8. Conclusion

Knowledge management system (KMS) is developed to support and enhance the processes of knowledge creation, storage or retrieval, transfer, and application. There are some benefits that can be achieved by implementing KMS such as increased employee productivity, better quality of a finished product, production and labor cost saving. However, many enterprises fail in knowledge management activities, because they are unwilling to invest time and money in developing the knowledge when they do not know how to measure the benefits. For managers, it is very important to accurately measure the benefits of a KMS investment in the planning phase. Using the most proper attractiveness evaluation methods, the managers can take the accurate decisions on KMS investment.

In this study, attractiveness evaluation of a KMS investment within a company is investigated by cost-benefit analysis. The investment cost of the KMS is categorized in capital expenditures and operating expenditures. On the contrary, the cost saving, increasing the quality of products, and employee productivity and speed are considered as the benefits. The purpose of this paper is to propose an approach for bridging the tangible and intangible values of KMS investment into a model of cost-benefit analysis. Furthermore, an integrated model considering the expected revenue increase due to the KMS investment is determined. Therefore, the fuzzy rule based system is used to calculate the expected revenue increase, and the Monte-Carlo simulation method is applied to determine the expected NPV of KMS investment at different certainty levels. In the future study, the proposed model will be improved by considering risk and opportunity factors in KMS investment evaluation. In decision-making, there are criteria that are opposite in direction to other criteria, such as criteria in benefits (B) versus those in costs (C), and criteria in opportunities (O) versus those in risks (R). Thus, the BOCR should be involved into a quantitative financial model to assist the managers in KMS investment decision.

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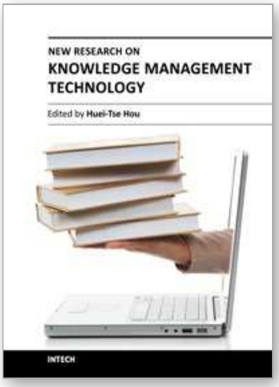

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Due to the development of mobile and Web 2.0 technology, knowledge transfer, storage and retrieval have become much more rapid. In recent years, there have been more and more new and interesting findings in the research field of knowledge management. This book aims to introduce readers to the recent research topics, it is titled "New Research on Knowledge Management Technology" and includes 13 chapters. In this book, new KM technologies and systems are proposed, the applications and potential of all KM technologies are explored and discussed. It is expected that this book provides relevant information about new research trends in comprehensive and novel knowledge management studies, and that it serves as an important resource for researchers, teachers and students, and for the development of practices in the knowledge management field.

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