

MEASURING THE TANGIBLES AND INTANGIBLES VALUE OF AN ERP INVESTMENT

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ABSTRACT. Enterprise Resource Planning (ERP) recent is widely implemented in various fields of industry. However, there are companies which still vacillate to decide for investing the ERP systems. This vacillation comes from consideration that ERP system is the high investment cost and also there is an apprehensive of inadequate technical capability. Therefore, taking into account the ERP contribution or impact both of tangible and intangible value including cost and benefit to the evaluation is essential for the success of this project. This paper will reveal how the factor of cost and benefit in an economic analysis can be applied to ERP investment plan. The expected increase of market share due to the customer satisfaction is determined in expressions of information cycle time and quality between customers and suppliers by using fuzzy rule based system. Furthermore, the expected Net Present Value (NPV) is calculated by employing the Monte Carlo simulation method.

Keywords: ERP, cost-benefit analysis, economic analysis, Fuzzy rule based system, Monte Carlo simulation

INTRODUCTION

Enterprise Resource Planning (ERP) is an information system designated for manufacturing and service industries, which is able to integrate and automate business processes related to aspects of the operation, production and distribution in the industry concerned. There are two values added that have been delivered by ERP implementation and not occur in non-integrated departmental systems (Umble, 2003). Firstly, encompasses all functions and departments within the firm, while secondly is enhancing the interdepartmental cooperation and coordination because of the firm database in which all business transactions are entered, recorded, processed, monitored, and reported.

The ERP history started from 1960 where signed by the system designed to assist the manufacturing process. The first software that was developed in this process happens to be MRP (Material Requirement Planning) in the year 1975. This was followed by another advanced version namely MRP II (Manufacturing Resource Planning), and ERP itself evolved from MRP II (Robert Jacobs and Ted' Weston, 2007). This development of ERP in several times to create a more optimal system that can leverage the potential cost savings and productivity becomes a reason the companies from various industries for adopting this system. Due to these successful, the ERP system market is one of the fastest growing markets in the software industry (Willis T.H. and Willis-Brown, 2002). Since the early to mid-1990s, the ERP software market has been and continues to be one of the fastest growing segments of the IT industry with growth rates averaging from US\$25.4 billion in 2005 to US\$28.8 billion by 2006 and the number was projected to grow at a compound annual growth rate of 11% until 2011 (S. Jacobson, 2007). However, a recent Standish Group report on ERP implementation projects reveals that these projects were on average of 178% over budget,

took 2.5 times as long as intended and delivered only 30% of promised benefit (Zhang et al., 2005). One explanation for the high failure rate is that managers do not take prudent measures to assess and manage the key factors either tangible or intangible that caused these projects failure or success (Wright, 2001). Thus, this paper proposes a fuzzy rule-based system to measure both of intangible and tangible value of an ERP system. In addition, the Monte-Carlo simulation method is used to calculate the expected net present value (NPV) in order to evaluate the feasibility.

LITERATURE REVIEW

There are number of methods have been conducted for measuring the impact of ERP systems in the business process of an industry. It was taken by researchers since the growing up of interest to the ERP. Definitely, management of companies considers the importance of ERP implementation due to the intention to meet customer's need and to maximize their profit for facing a more complex and competitive environment than ever before. Business success is no longer a matter of analyzing only the individual firm, but rather the chain of delivering and supplying organizations. Consequently, to pursue successful and to be competitive for improving firm and business unit performance, the managers must use information and communication technology such as ERP system (Xiaohong and Gang, 2009). In reality, several companies have satisfied with the outcome generated after ERP implementation. Davenport and Brooks (2004) proposed that implementing ERP systems brings many benefits to the organization that concern to customer satisfaction, including reduction of cycle time, improvement in information flow, rapid generation of financial information, promotion of e-commerce, and assistance in development of new organizational strategies. Some managers reported reduced costs due to the lower error rate experienced in purchasing, production and sales while the positive changes in Return on Assets during the implementation period are statistically significant at the 5% level (Hendricks, Singhal and Stratman, 2007).

From all those methods used above, cost benefit analysis (CBA) is a methodology that is often used in calculating the impact either ERP system or other enterprise information. Furthermore, these findings of ERP adoption are advanced observed by involving the intangible values in order to find the more significance benefit or examine the multi-criteria as the critical factors that impact to business performance. Murphy and Simon (2001) incorporated the intangible values in the cost benefit analysis or ERP evaluation and found that the customer satisfaction improved by 5%. Wier et al. (2007) investigated empirically whether the joint adoption of an ERP system and the inclusion of non-financial performance indicators (NFPI) in executive compensation contracts significantly enhances customer satisfaction and business performance measured by the return on assets (ROA) and the return on stocks (ROS) as compared to either of them alone. These methods are focused for providing the involvement both of tangible and intangible value into cost-benefit analysis. However, it still needs to provide an approach that not only includes the multiple criteria, but also provides the effectiveness standard of the framework to assess and manage the key factors as a reason the ERP success or failure. In addition, the uncertainty factors should be incorporated by reason of no absolute matter in every subject (Zhao, Tong and Sun, 2009). Therefore, we introduce an approach that can handle the problem defined earlier such as: (1) how to combine both of tangible and intangible values into cost and benefit analysis, (2) how to assess and manage the key factors as a reason the ERP success or failure, which is in uncertainty matters.

COMBINING TANGIBLES AND INTANGIBLES VALUE OF ERP ADOPTION INTO ECONOMIC ANALYSIS

This paper proposes an approach a feasibility analysis for evaluating the ERP attractiveness. To conduct this analysis, the main cost items of the investment are examined.

In another side, the targets to be realized after ERP adoption is to reduce the annual purchase material cost, annual inventory cost, and annual direct labor cost (Barjis et al., 2010). Furthermore, increasing sales due to the customer satisfaction is determined in expressions of information cycle time and quality that support activities of customers, employees and suppliers (Xiaohong and Gang, 2009). The cost reduction contributes to increasing profits and increased customer satisfaction contributes to increasing sales and market share (Law and Ngai, 2007).

The solution design of the problem in this paper will be conducted by the following two phases. First is the technique to handle the intangible value by using fuzzy rule-based system (FRBS) before assigned its output to appropriate probabilistic distribution. In addition, the probability distribution of cost saving items is assigned. Once a FRBS has been set up, the probability distributions of those intangible and tangible factors are linked to an economic model in order to define the relationship between each value and cost saving in terms of total benefit calculation before forecasting the certainty level of expected NPV.

Intangible Value Analysis

With regard to the impact of intangible value toward the revenue model which is represented by increasing sales, we involve expert's opinion to handle the increasing by producing a FRBS. A fuzzy rule-based system (FRBS) is a systematic reasoning methodology that can capture the contextual judgment of experts by using fuzzy set theory (Zadeh, 1965). Currently, quite a few of researchers have proposed fuzzy set theory especially the FRBS for various purposes such as Fuzzy evaluation approach is applied to quantify intangible benefits of ERP (Wu et al., 2006). Ustundag et.al (2010) utilize the FRBS for determining the revenue increase due to the quality of supply chain of companies after RFID implementation. We use Mamdani model due to its advantages in representation of expert knowledge and in linguistic interpretation of dependencies. Hence, the increase in sales is attempted to be calculated in a Mamdani-type. The composition of Mamdani-type fuzzy logic rule bases is in the following form;

If x_1 is A_1 , x_2 is A_2 And x_n is A_n then y 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 membership functions of information cycle time, information quality and increase rate for sales are defined by the experts and given in Fig. 1, Fig. 2, and Fig. 3, respectively.

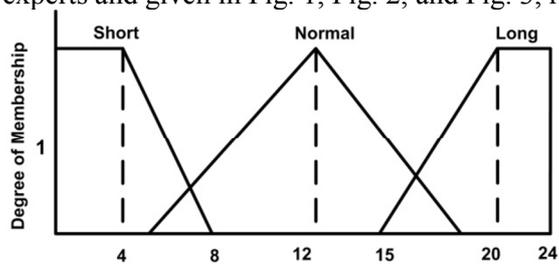


Fig. 1 The MFS of information cycle time

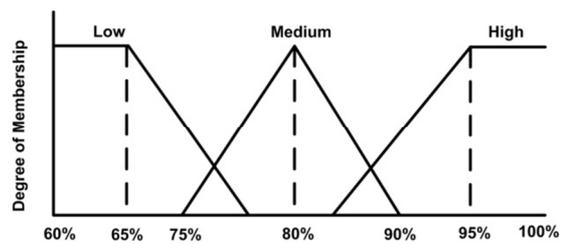


Fig.2 The MFS of information quality

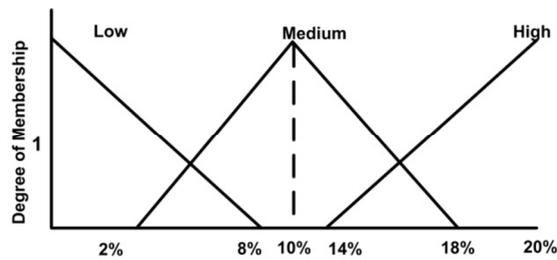


Fig.3 The MFS of increase rate in sales

The rules established for the increase rate in sales is structured such as; Rule 1: IF Information Cycle Time is Short AND Information Quality is High THEN Increase Rate in Sales is High. Rule 2: IF Information Cycle Time is Short AND Information Quality is Medium THEN Increase Rate in Sales is Medium. Rule 3: IF Information Cycle Time is Normal AND Information Quality is High THEN Decrease Rate for Traffic Volume is Medium. Rule 4: IF Information Cycle Time is Normal AND Information Quality is Medium THEN Increase Rate in Sales is Medium. Rule 5: IF Information Cycle Time is Long AND Information Quality is Low THEN Increase Rate in Sales is Low.

All rules defined by the experts, which is implemented 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. By implementing the input data into model, the probability distribution of expected increase rate in sales is generated as shown in Table 1. In addition, the experts’ estimation as well as the expected cost saving rates (*r*) by ERP adoption with probabilities of 10%, 30% and 60% are shown in Table 2.

Table 1 The expected increase in sales

Probability (%)	Cycle Time (h)	Quality (%)	Increase Rate in Sales (%)
10	15	65	3.3
30	10	80	10
60	6	95	18.5

Table 2 The expected cost saving rates

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

Model of Cost-Benefit Analysis

In the ERP cost-benefit analysis, the implementation costs of ERP are structured by onetime costs (C_{Xn}) and ongoing costs (C_{Yn}). These costs consist of (a) installation costs include hardware, software and customizing; (b) Data control costs include inventory records, bills of material (BOM), and routings; (c) Education costs include external, internal, direct labor, full time project leader, outside consultancy, and miscellaneous. In contrast, the benefits of ERP (B) that calculated in Equation (2) are derived from revenue increase (RI) and costs saving such as annual purchase material saving (CS_m), inventory saving (CS_i), and direct labor saving (CS_l). Indeed, the variables of total benefit are calculated considering the increase rate of sales (s) which has been estimated by fuzzy rule based system as earlier. The increased sales (S') is calculated by Equation (3).

$$B = (CS_m + CS_i + CS_l) + RI \quad (2), \quad S' = S(\mu, \sigma) \times (1 + s) \quad (3)$$

where $S(\mu, \sigma)$ is the yearly sales with a mean μ and standard deviation σ . The cost savings are computed considering the increased sales (S'), cost unit (c), cost saving rate (r) as shown in Equations (4)-(6).

$$CS_m = S' + c_{material} + r_{material} \quad (4), \quad CS_i = S' + c_{inventory} + r_{inventory} \quad (5), \quad CS_l = S' + c_{labor} + r_{labor} \quad (6)$$

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

$$S(\mu, \sigma) \times s \times p \quad (7) \quad NPV = -(C_{x1} + \dots + C_{xn}) + \sum_{n=1}^t \frac{[B - (C_{y1} + \dots + C_{yn})]}{(1+i)^n} \quad (8)$$

In relation to investment analysis, the Monte Carlo simulation is the method that appropriate for estimating the impact of ERP critical factors to the project result by randomizing value from each of the uncertain variables and calculating the objective or target value of the investment model (Hacura, Jadamus-Hacura and Kocot, 2001). This method uses random numbers from probability distributions to compute the probability distribution of NPV, which meant not only produce one value of NPV.

SIMULATION, RESULTS AND DISCUSSION

Once the tangible and intangible values have been associated in a model of cost-benefit, then the investment model spreadsheet is produced by compiling the revenue elements and cost elements. For instance, the revenue element of ABC Company consists of total of sales with the yearly amount before ERP adoption is 800 units with standard deviation 18% and the price per unit of US\$10000. The implementation cost elements are structured by onetime costs (C_{xn}) and ongoing costs (C_{yn}) as US\$598000 and US\$27000 per year respectively, while the cost unit for the target of cost savings consists of average of annual direct labor cost per unit product (50 labor) of US\$10, annual purchase material cost per unit product of US\$1500, annual material inventory value per unit product of US\$500. By using the commercial software Crystal Ball Version 7.2.1, a simulation generates the probability distribution of net present value (NPV) of the ERP investment in 3 years horizon and discount rate i of 10% as shown in Fig.4.

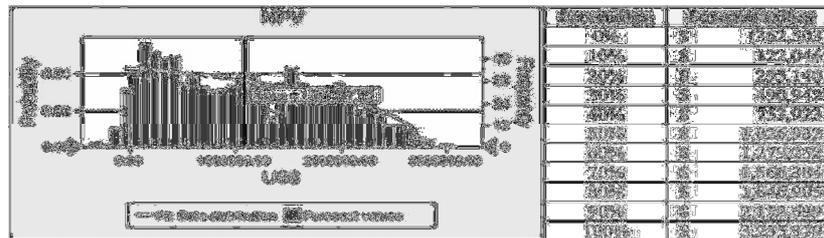


Fig 4. The simulation results for the NPV of ERP investment with percentiles analysis

The distribution of the NPV of ERP investment has the mean value of US\$1,081,367 and the standard deviation US\$766,476, which varies between US\$(362,053) and US\$3,235,379. As shown in percentile analysis, the ERP investment in three years horizon has more than 90% certainty level the NPVs will be positive and there is still probability that the ERP investment will be loss with amount of less than 5%. Summarizing, although this result assists the managers to decide the ERP investment, the ABC managers should consider the failure probability by ensuring the good performance of ERP.

CONCLUSION

The purpose of this paper is to propose an approach to relate both tangible and intangible value of ERP investment into a model of cost-benefit analysis by utilizing the FRBS. Furthermore, the Monte Carlo simulation calculates the probability distribution of expected NPV with regard to the analysis of the feasibility that considers uncertainty factors. The simulation result showed that applying this proposed approach is an effective way to assess and manage the key factors of the ERP success or failure.

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REFERENCES

- Barjis, J., Díaz, A., Lorenzo, O., and Claes, B. (2010). ERP Implementation Strategies: The Importance of Process Modeling and Analysis. In *Enterprise and Organizational Modeling and Simulation*, W. Aalst, J. Mylopoulos, N. M. Sadeh, M. J. Shaw, and C. Szyperski (eds), 95-112: Springer Berlin Heidelberg.
- Hacura, A., Jadamus-Hacura, M., and Kocot, A. (2001). Risk analysis in investment appraisal based on the Monte Carlo simulation technique. *The European Physical Journal B - Condensed Matter and Complex Systems* 20, 551-553.
- Hendricks, K. B., Singhal, V. R., and Stratman, J. K. (2007). The impact of enterprise systems on corporate performance: A study of ERP, SCM, and CRM system implementations. *Journal of Operations Management* 25, 65-82.
- Jang, J.-S. R., and Gulley, N. (1997). *Fuzzy Logic Toolbox User's Guide* The MathWorks, Inc.
- Law, C. C. H., and Ngai, E. W. T. (2007). ERP systems adoption: An exploratory study of the organizational factors and impacts of ERP success. *Information & Management* 44, 418-432.
- Murphy, K. E., and Simon, S. J. (2001). Using cost benefit analysis for enterprise resource planning project evaluation: a case for including intangibles. In *System Sciences, 2001. Proceedings of the 34th Annual Hawaii International Conference on*, 11 pp.
- Robert Jacobs, F., and Ted' Weston, J. F. C. (2007). Enterprise resource planning (ERP)--A brief history. *Journal of Operations Management* 25, 357-363.
- S. Jacobson, J. S., M. D'Aquila, K. Carter (2007). *The ERP Market Sizing Report, 2006-2011*. Boston, MA: AMR Research.
- Umble, E. J., Haft, R.R, M.M. Umble (2003). Enterprise resource planning: implementation procedures and critical success factors. *European Journal of Operational PID123esearch* 146, 241-257.
- Ustundag, A., KilInç, M. S., and Cevikcan, E. (2010). Fuzzy rule-based system for the economic analysis of RFID investments. *Expert Systems with Applications* 37, 5300-5306.
- Wier, B., Hunton, J. E., and HassabElnaby, H. R. (2007). Enterprise Resource Planning & Non-Financial Performance Incentives: The Joint Impact on Corporate Performance. *International Journal of Accounting Information Systems* 8, 165-190.
- Willis T.H. and Willis-Brown, A. H. (2002). Extending the value of ERP. *Industrial Management & Data Sytems* 102, 35-48.
- Wright, S., and Wright, A.M (2001). Information system assurance for enterprise resource planning systems: implementation and unique risk considerations. *Journal of Information Systems* 16,5-15.
- Wu, F., Liu, C., Li, H. Z., Gao, K., and Tian, J. (2006). The Benefits Evaluation of ERP Project Investment Based on Real Options. In *Systems, Man and Cybernetics, 2006. SMC '06. IEEE International Conference on*, 4078-4083.
- Xiaohong, Z., and Gang, S. (2009). A Study of the Critical Factors That Impact Users Satisfaction in ERP Implementations in China. In *Information Science and Engineering (ICISE), 2009 1st International Conference on*, 2824-2826.
- Zadeh, L. A. (1965). Fuzzy Sets. *Information and Control* 8, 338-353.
- Zhang, Z., Lee, M. K. O., Huang, P., Zhang, L., and Huang, X. (2005). A framework of ERP systems implementation success in China: An empirical study. *International Journal of Production Economics* 98, 56-80.
- Zhao, Y.-m., Tong, Y.-x., and Sun, Y. (2009). Research on Risk Management of Communication Projects Based on AHP. In *Computational Intelligence and Software Engineering, 2009. CiSE 2009. International Conference on*, 1-4.