2005

A Framework for IT Investment Evaluation in Emerging Economies

Narcyz Roztocki
SUNY - New Paltz, roztockn@newpaltz.edu

Heinz Roland Weistroffer
Virginia Commonwealth University, hrweistr@vcu.edu

A Framework for IT Investment Evaluation in Emerging Economies

Narcyz Roztocki
State University of New York at New Paltz
roztockn@newpaltz.edu

Heinz Roland Weistroffer
Virginia Commonwealth University
hrweistr@vcu.edu

ABSTRACT

This paper proposes a framework for evaluating information technology investments. The proposed framework integrates value chain analysis with fuzzy logic, activity based costing, and multi-criteria decision analysis. This framework should be particularly useful for organizations in emerging economies, where an uncertain business environment is often combined with a lack of dependable, historical accounting data.

Keywords

Activity-based costing, emerging economies, fuzzy logic, value-chain analysis, multi-criteria decision making

INTRODUCTION

Evaluation of investments in information technology (IT) is a complex and challenging issue (Dos Santos, 1991; Thatcher and Oliver, 2001). Evaluating IT investments in emerging economies is an even more difficult task, due to generally even less predictable changes in the social, political, and economic infrastructure.

In spite of its popularity, the value chain model, which defines a company as a system of related activities (Porter and Millar, 1985), is only seldom used in real businesses. Difficulties in reliably tracing costs to organizational processes (Hergert and Morris, 1989) and traditional cost accounting methods, which fail to provide reliable cost information (Ness and Cucuzza, 1995), prevent broad, practical application of value chain analysis.

In order to more reliably estimate the cost of activities in the value chain, some authors propose the use of activity-based costing (ABC) (Dekker, 2003; Shank and Govindarajan, 1992). ABC uses various activities and multiple cost drivers to trace overhead directly to cost objects such as products or services, and is thereby able to avoid the cost distortions generated by traditional costing systems (Cooper, 1988, 1989; Johnson, 1991).

Recently, an integrated value chain model using ABC was proposed for evaluating IT investments (Roztocki and Weistroffer, 2004a, 2004b). Unfortunately, because companies in emerging economies often operate in a business environment characterized by uncertainty, evaluating IT investments using standard ABC may not always be practicable. Furthermore, managing global IT presents a unique set of additional challenges, such as regulatory differences, integration impediments in data sharing, and dissimilarities in cultural environment (Ives and Jarvenpaa, 1991).

Fuzzy ABC is an extension of standard ABC, designed specifically for companies operating in an uncertain business environment (Nachtmann and Needy, 2001). For this reason it appears that the value chain model integrated with fuzzy logic would be a promising tool for evaluating IT related investments in emerging economies.

In addition to improvements in cost structure, many companies in emerging economies need to consider additional, less tangible, factors. For example, telecommunications systems may have rather marginal impact on operational costs but add substantially to flexibility and improve coordination in world trade. An investment in IT which allows for better integration and coordination with business partners may not lead to short term, tangible cost savings, but nevertheless may result in an increased customer base. Thus, in evaluating multiple, alternative IT investment options, leading perhaps to different expected levels of cost savings and other less tangible benefits (or costs), multiple criteria decision making methods (see for example Figueira, Greco, and Ehrgott (2005)) can help in deciding among these options.

The purpose of this paper is to present a framework for such an evaluation method. This paper represents an extension of earlier work, which focused primarily on tangible cost savings (Roztocki and Weistroffer, 2005).

THEORETICAL BACKGROUND

Our framework presented in this paper synthesizes four concepts: value chain analysis, ABC, fuzzy logic, and multi-criteria decision making.

As stated above, the value chain model views a company as a collection of related activities (Porter and Millar, 1985), which allow the company to achieve its business objectives. These activities feed into each other or support each other, and create business value. Activities directly involved in creating products or services are called primary activities, while those activities not directly involved in creating products or services, but necessary in order to effectively carry out the primary activities, are called support activities. The value created in the company is determined by three key factors: the price customers are willing to pay for end products or services; the cost of raw material; and the cost of activities in the value chain. In essence, a company is generating profit if the prices customers are willing to pay exceed the combined cost of raw material and costs of activities in the value chain. In theory, the value chain model should be very useful in helping management increase competitiveness by focusing on value activities and making these activities more efficient, thus reducing cost. As pointed out in the introduction though, in reality, traditional costing systems make it difficult for many companies to fully assess the cost of their value chain activities (Ness and Cucuzza, 1995).

ABC attempts to address shortcomings of traditional costing systems which typically allocate overhead to products and services based on direct labor hours (Cooper, 1988, 1989; Johnson, 1991). In the ABC approach, overhead expenses, such as for example administrative salaries, are first traced to activities. Then, looking at multiple cost drivers, such as number of orders processed or shipping distance, costs are assigned from activities to cost objects. Examples of possible cost objects are products or services. Thus, ABC follows a two stage cost assignment procedure, where the first stage fits in very well with value chain analysis.

Fuzzy logic was introduced to represent vagueness and uncertainty prevalent in human reasoning (Irani, Sharif, Love, and Kahraman, 2002). In contrast to traditional logic it is less dependent on precise data. One of the biggest challenges during ABC implementation is lack of precise and reliable accounting data. Consequently, applying fuzzy logic concepts to ABC in companies operating in an uncertain business environment seems to be a natural fit (Nachtmann and Needy, 2001).

Most real-life decisions, including most business decisions, involve multiple decision criteria, which are often conflicting, thus requiring decision makers to look for satisfactory compromise solutions. These decision situations become even more complicated when decision criteria are vaguely defined or difficult to measure, such as intangible costs and benefits. Multi-criteria decision making (MCDM) techniques address these decision situations (Figueira, Greco, and Ehrgott, 2005**)**. In addition, many MCDM approaches specifically allow for multiple decision makers to be involved in the decision making process. Therefore, multi-criteria approaches appear to be practicable for assessing IT investments where subjective opinions of multiple experts are present.

For all these reasons the synthesis of these four concepts appears to be very promising for evaluating IT investments in emerging economies.

PROPOSED FRAMEWORK

The proposed framework for evaluating IT-related investments requires four major steps. The first step is to identify a company's major activities and to construct its value chain. The second step is to estimate the cost for performing each of these activities, based on standard ABC. If necessary, ABC analysis can be supported by fuzzy logic. The third step is to assess the potential impact of the IT investment on the costs of each activity in the value chain, again employing fuzzy logic. Finally, the fourth step is to evaluate expected changes in the cost structure, and to weigh expected potential cost savings and other expected benefits in order to decide on the desirability of the proposed investment. Figure 1 depicts the major steps.

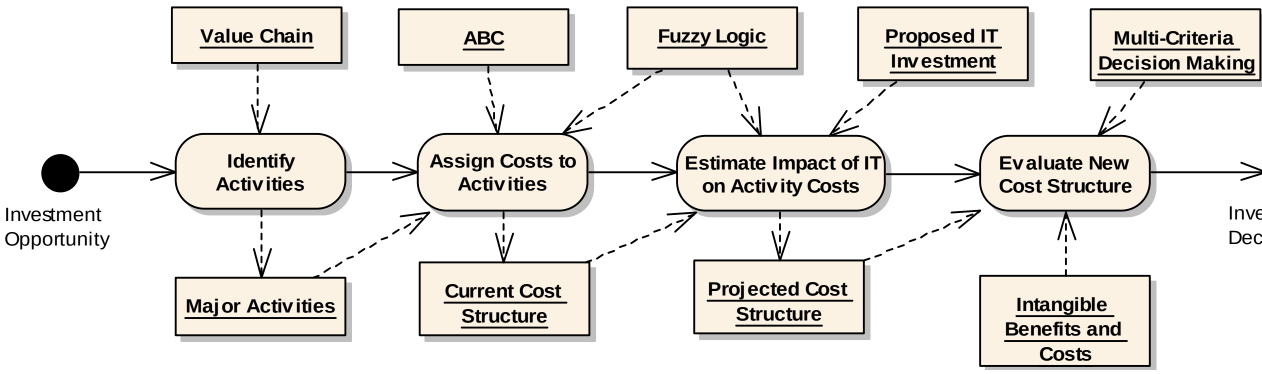

Figure 1. Four-Step Framework

The application of fuzzy logic reduces dependency on exact numbers by allowing the use of expressions such as "the IT investment has greater impact" or "lesser impact" (Irani, Sharif, Love, and Kahraman, 2002). This kind of rather vague statements can be captured by a fuzzy set *membership function* (Zadeh, 1965), which uses numbers between 0 and 1 to denote the degree of membership. *Defuzzification* (Wang and Luoh, 2000) subsequently allows to arrive at a "crisp" cost structure.

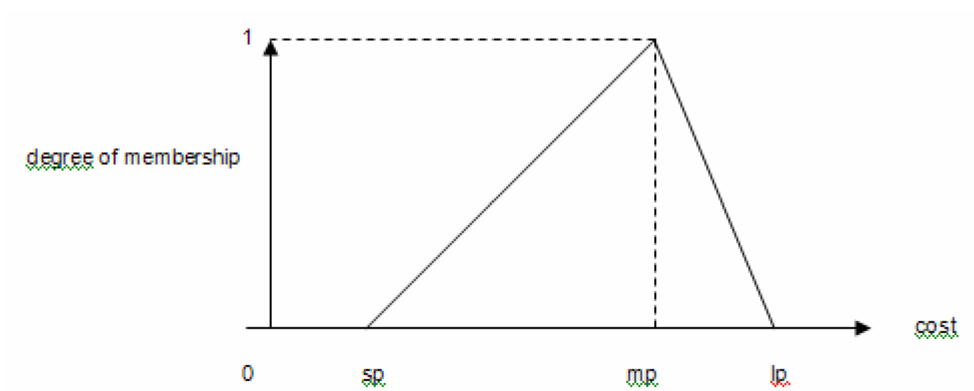

Figure 2. Triangular Membership Function

In our illustration, we use a *triangular fuzzy numbers (TFN)* membership function (Van Laarhoven and Pedrycz, 1983). This particular membership function has the advantage of simplicity and is easier to handle than more complex, trapezoidal or bell-shaped membership functions (Nachtmann and Needy, 2003). The TFN membership function is represented by three values: SP (smallest possible), MP (most promising), and LP (largest possible) (Nachtmann and Needy, 2001), as depicted in Figure 2. TFN are commonly used for business related applications, such as capital budgeting (Chiu and Park, 1998), since they are intuitive and relatively easy to handle. In essence, the parameter MP represents the most likely activity costs after the IT investment, while the parameters SP and LP represent the optimistic and pessimistic view respectively. The TFN function may be skewed toward SP or LP (as shown in Figure 2).

Figure 3 shows the use of fuzzy logic for assessing the potential impact of an IT investment on activities. LP, MP, and SP activity costs are estimated for the post IT investment time period. In order to better decide if the proposed IT investment will be cost effective, these three projected activity costs can be recombined into a single value by using defuzzification. In the triangular membership function, a *center of gravity* defuzzification can be achieved by averaging SP, MP, and SP (Wang and Luoh, 2000).

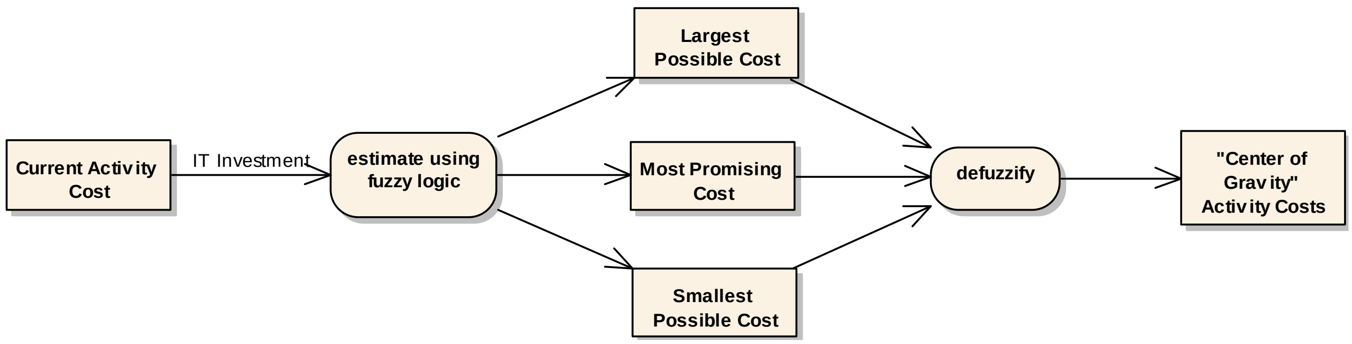

Figure 3. Fuzzy Logic Estimation

The final step in the framework requires an evaluation of the expected new cost structure, together with other, less tangible, costs and benefits, to reach a decision on the desirability of various IT investment options. Such evaluations may be conducted at different management levels: at the operational level, the tactical level and the strategic level (see Irani et al. (2002)), looking at short term, medium term and long term expectations. One well known method that allows for not only incorporating multiple, possibly conflicting criteria, but also multiple decision makers, with perhaps varying importance or weight in an organization, is the analytic hierarchy method (Saaty, 2000). Figure 4 shows a possible decision hierarchy.

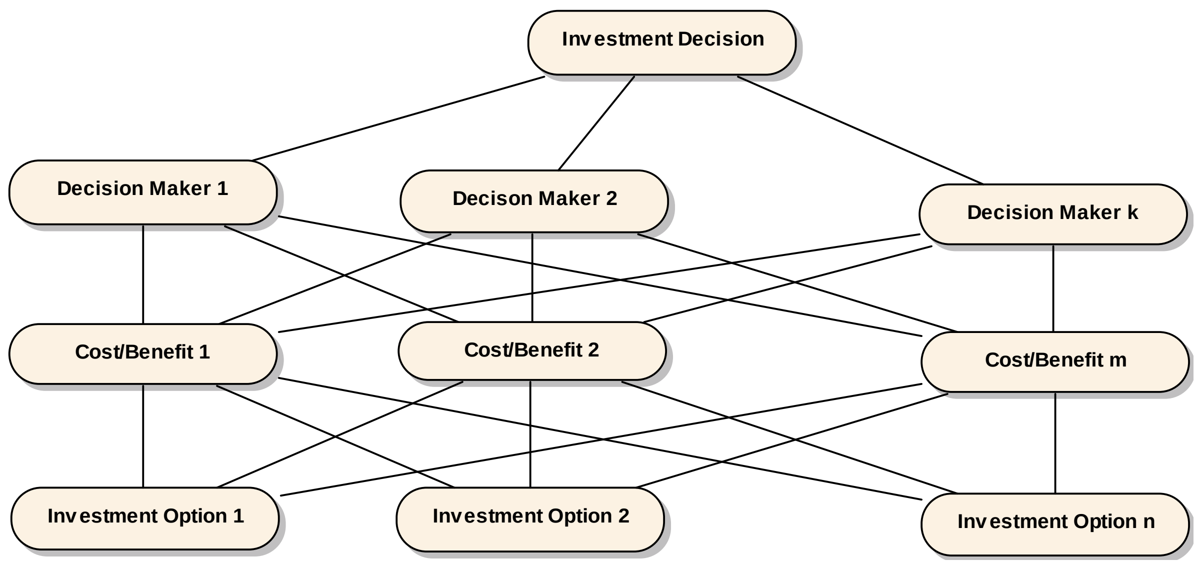

Figure 4. Decision Hierarchy

At the top of the hierarchy is the ultimate investment decision. At the level below, each decision maker is assigned a level of importance/impact on the investment decision. At level three, the various cost/benefits (including intangible costs and benefits) are assessed by each of the decision makers, where the ultimate impact of a specific cost or benefit is derived by adding the weighted ratings of all the decision makers. At the bottom level are the investment options, which are evaluated with respect to each of the cost/benefits. These ratings are weighted by the impacts that the cost/benefit will have on the investment decision, and adding the weighted ratings, a desirability value for each investment option is derived.

ILLUSTRATION

Evaluating IT investments using the proposed framework begins with identifying a company's major business activities. After establishing the value chain, cost estimates for performing all activities are obtained by using a standard ABC system. Then fuzzy logic is used to project the cost of each activity for after the planned IT investment is completed. For each activity in the company's value chain, three values (the smallest possible (SP), the most promising (MP), and the largest possible (LP)) costs are estimated as depicted in Table 1. Interviews with key personnel and outside consultants are used to derive these three estimation values for each activity (Nachtmann and Needy, 2001).

Activity	Current Activity Cost	Projected SP Activity Cost	Projected MP Activity Cost	Projected LP Activity Cost
Market Products	$120,000	$80,000	$100,000	$120,000
Process Orders	$60,000	$40,000	$60,000	$80,000
Conduct Material Procurement	$50,000	$40,000	$50,000	$60,000
Handle Inventory	$80,000	$60,000	$80,000	$100,000
Manage Production	$250,000	$200,000	$230,000	$260,000
Perform Quality Control	$40,000	$20,000	$40,000	$60,000
Distribute Final Products	$80,000	$70,000	$80,000	$90,000
Administrate Payments	$70,000	$60,000	$70,000	$80,000
Conduct Engineering Work	$150,000	$130,000	$150,000	$170,000
Perform Business Management	$100,000	$100,000	$100,000	$130,000
Total	$1,000,000	$800,000	$960,000	$1,150,000

Table 1. Current and Projected Operating Costs One Year after IT Investment

The IT investment in our example is expected to particularly impact the activities related to marketing the company's products and managing the production. It is expected that the new system will allow for better collection of all kinds of data, permit data mining, and thus facilitate more focused marketing, which in turn will result in cost savings. In contrast, the tangible benefits for other activities are expected to be rather modest, as is reflected in Table 1.

Subsequently, the three projected activity costs are defuzzified into a single value, to more easily assess the worth of the IT investment. Using the triangular membership function, a "center of gravity" defuzzification can be achieved by simply averaging the three numbers SP, MP, and LP (Wang and Luoh, 2000). Table 2 compares the current activity costs and projected activity costs after defuzzification.

Activity	Current Activity Cost	Projected Activity Cost
Market Products	$120,000	$100,000
Process Orders	$60,000	$60,000
Conduct Material Procurement	$50,000	$50,000
Handle Inventory	$80,000	$80,000
Manage Production	$250,000	$230,000
Perform Quality Control	$40,000	$40,000
Distribute Final Products	$80,000	$80,000
Administrate Payments	$70,000	$70,000
Conduct Engineering Work	$150,000	$150,000
Perform Business Management	$100,000	$110,000
Total	$1,000,000	$970,000

Table 2. Current and Projected Defuzzified Operating Costs One Year after IT Investment

In many cases, especially where the cost savings are not entirely convincing (as in our illustration), management needs to also consider the intangible benefits and costs. In order to perform a systematic evaluation of the desirability of the IT investment, management needs to identify those intangible benefits or costs that will potentially affect the success of the organization. These intangible benefits or costs, which depend on a company's specific situation and characteristics and are mission and strategy driven, represent the decision criteria for evaluating the IT investment options, along with the expected tangible cost savings.

For the purpose of our illustration, we assume that the following criteria, in addition to the expected, tangible cost savings, have been identified as being the potentially most impacting on the continued success of the organization:

(1) ***System Connectivity*** is the ability to link with other systems. This feature may result in improved communication within the company as well as with business partners. In addition, system connectivity may increase the accuracy and timeliness of information for decision-making.

(2) ***System Flexibility*** refers to the ability of adjusting the system for business growth and other changes (for example, changes in demand).

(3) ***System User-Friendliness*** refers to how easy it is to use the system. This feature may result in reduced training costs and increased user satisfaction with the new system.

(4) ***System Security*** refers to the level of vulnerability to potential threats resulting in system failure.

To continue with our illustration, we assume that three decision makers (with varying influence) have been identified to evaluate the importance of the decision criteria with respect to the investment decision. The assessment of potential cost savings due to the IT investment has already been shown, and the evaluation of the IT investment option with respect to the other decision criteria is assumed to be done by experienced IT professionals. (See Wooldridge and Weistroffer (2004) for the involvement of different stakeholders in the decision process). Based on all of this, a decision hierarchy can be developed as shown in Figure 5.

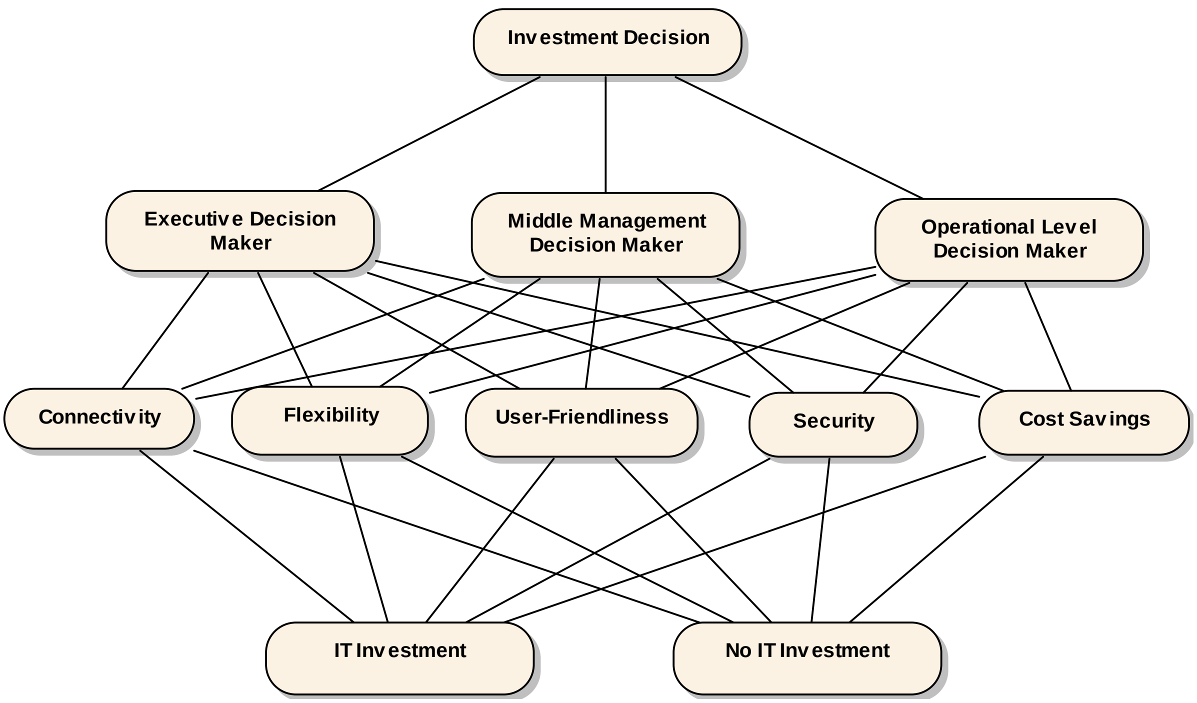

Figure 5. Hierarchy for Illustrative Example

Using the multi-criteria approach, many companies in emerging economies may decide to progress with their IT investment even if the expected direct cost saving from the new system are not substantial.

CONCLUSIONS, LIMITATIONS AND FUTURE WORK

This paper proposes evaluating IT investment in emerging economies combining value chain analysis, ABC, fuzzy logic, and MDCM. As previously pointed out, our framework appears to be particularly useful for companies in emerging economies, which often do not possess detailed accounting records. Many of these companies compete over price, and therefore need to show tangible cost savings. However, tangible cost savings by themselves may not be sufficient, and other factors, such as intangible benefits of IT investments, must also be considered.

One limitation of this paper is that, for simplicity, we consider only one time period in our activity cost estimation. In reality, the cost of activities in the value chain will change over time. For example, an investment in IT may initially result in an increase of certain activity costs, but these costs will diminish after the system has been in place for some time. Therefore, in many cases decision makers would need to widen our approach to a multiyear investment period.

Our framework is primarily a thought model, based on observations and experience. The illustrative example shows the possible application of the framework, but we have not yet done any empirical validation. Building on the framework presented in this paper, we plan extensive field studies in a number of companies in emerging economies.

REFERENCES

1. Chiu, C.-Y. and Park, C.S. (1998) Capital budgeting decisions with fuzzy projects, *The Engineering Economist,* 43, 2, 125-150.
2. Cooper, R. (1988) The rise of activity-based costing – part one: What is an activity-based cost system? *Journal of Cost Management,* 2, 2, 45-54.
3. Cooper, R. (1989) The rise of activity-based costing - part four: What do activity-based cost systems look like? *Journal of Cost Management*, 3, 1, 38-49.
4. Dekker, H. C. (2003) Value chain analysis in interfirm relationships: A field study, *Management Accounting Research,* 14, 1, 1-23.
5. Dos Santos, B. (1991) Justifying investments in new information technologies, *Journal of Management Information Systems*, 7 4, 71-89.
6. Figueira, J., Greco, S., and Ehrgott, M. (2005) Multiple Criteria Decision Analysis: State of the Art Surveys, Springer.
7. Hergert, M. and Morris, D. (1989) Accounting data for value chain analysis, *Strategic Management Journal*, 10, 2, 175-188.
8. Irani, Z., Sharif, A., Love, P.E.D., and Kahraman, C. (2002) Applying concepts of fuzzy cognitive mapping to model: The IT/IS investment evaluation process, *International Journal of Production Economics*, 75, 1-2, 199-211.
9. Ives, B. and Jarvenpaa, S.L. (1991) Applications of global information technology: Key issues for management, *MIS Quarterly*, 15, 1, 33-49.
10. Johnson, H. T. (1991) Activity-based management: past, present, and future, *The Engineering Economist,* 36, 3, 219-238.
11. Nachtmann, H. and Needy, K.L. (2001) Fuzzy activity based costing: A methodology for handling uncertainty in activity based costing systems, *The Engineering Economist,* 46, 4, 245-273.
12. Nachtmann, H. and Needy, K.L. (2003) Methods for handling uncertainty in activity based costing systems, *The Engineering Economist*, 48, 3, 259-282.
13. Ness, J.A. and Cucuzza, T.G. (1995) Tapping the full potential of ABC, *Harvard Business Review*. 73, 4, 130-138.
14. Porter, M.E. and Millar V.E. (1985) How information gives you competitive advantage, *Harvard Business Review*. 63, 4, 149-160.
15. Roztocki, N. and Weistroffer, H.R. (2004a) Evaluating information technology investments in emerging economies using activity-based costing, *Electronic Journal of Information Systems in Developing Countries,* 19, 2, 1-6.
16. Roztocki, N. and Weistroffer, H. R. (2004b) Using activity-based costing for evaluating information technology related investments in emerging economies: A framework, *Proceedings of the Tenth Americas Conference on Information Systems*, August 5-6, New York, NY, 642-645.
17. Roztocki, N. and Weistroffer, H.R. (2005) Fuzzy logic value chain analysis: Information technology investment evaluation in emerging economies, *Proceedings of ISOneWorld,* March 30-April 1, Las Vegas, Nevada.
18. Saaty, T.L. (2000) Fundamentals of the Analytic Hierarchy Process, RWS Publications.
19. Shank, J.K. and Govindarajan, V. (1992) Strategic cost management and the value chain, *Journal of Cost Management*, 5, 4, 5-21.
20. Thatcher, M.E. and Oliver, J.R. (2001) The impact of technology investments on a firm's production efficiency, product quality, and productivity, *Journal of Management Information Systems,* 18, 2, 17-45.
21. Van Laarhoven, P. J.M., and Pedrycz, W. (1983) A fuzzy extension of Saaty's priority theory, *Fuzzy Sets and Systems*, 11, 3, 229-241.
22. Wang, W.-J. and Luoh, L. (2000) Simple computation of the defuzzifications of center of sum and center of gravity, *Journal of Intelligent and Fuzzy Systems,* 9, 1-2, 53-59.
23. Wooldridge, B. and Weistroffer, H.R. (2004) Supporting government performance by capturing the values and expertise of key stakeholders: A Delphi/decision support system approach to local revenue planning, *Journal of Public Budgeting, Accounting and Financial Management,* 16, 3, 362-376.
24. Zadeh, L.A. (1965) Fuzzy Sets, *Information and control,* 8, 3, 338-353.