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Application of a hybrid genetic algorithm and neural network approach in activity-based costing

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Abstract

Activity-based costing (ABC) has received extensive attention since it achieves improved accuracy in estimating costs, by using multiple cost drivers to trace the cost of activities to the products associated with the resources consumed by those activities. However, it has some problems. The first problem is that ABC does not have general criteria to select relevant cost drivers. Second, ABC assumes linearity between the uses of activities and the assigned quantities of indirect cost. When cost behavior shows a nonlinear pattern, conventional ABC may distort product costs. This paper proposes hybrid artificial intelligence techniques to resolve these two problems. Genetic algorithms are used to identify optimal or near-optimal cost drivers. In addition, artificial neural networks are employed to allocate indirect costs with nonlinear behavior to the products. Empirical results show that the proposed model outperforms the conventional model.

Keywords: Activity-based costing; Genetic algorithms; Artificial neural networks; Cost-driver optimization; Cost estimating relationships

1. Introduction

Cost allocation is a very important task involved in many engineering and business decisions. In this sense, activity-based costing (ABC) has received extensive attention during the past decade because it was developed for overcoming the problems of the traditional costing system through more a reasonable cost allocation process. Conventional ABC, however, has some problems to be resolved. The first problem is that ABC does not have general criteria to select relevant cost drivers. This problem is related to the cost-drivers optimization (CDO) problem and associated with the efficiency of costing systems. Second, conventional ABC generally assumes a linear cost function. The linear cost function is a function where the graph of total costs versus a single cost driver forms a straight line within the relevant range. Horngren, Foster, and Datar (1997) pointed out that a cost function, in practice, is not always linear, but sometimes shows nonlinear behavior. They described a nonlinear function as a cost function where the graph of total costs versus a single cost driver does not form a straight line within the relevant range. In this aspect, conventional ABC may distort product costs when a cost behavior shows a nonlinear behavior. Thus, the second problem is associated with cost estimating relationships (CERs), and it is also related to the effectiveness of costing systems.

Prior researchers have endeavored to overcome these problems of conventional ABC. Some of these studies showed that the estimating performance of artificial neural network (ANN) outperforms that of linear regression for optimal cost allocation in ABC (Bode, 1998a,b; Creese & Li, 1995; Garza & Rouhana, 1995; Lee, 1993; Lee & Ahn, 1993; Smith & Mason, 1997). Other studies proved the efficiency of heuristic search techniques to select optimal cost drivers (Babad & Balachandran, 1993; Levitan & Gupta, 1996). However, they did not consider these two problems simultaneously.

This study proposes a hybrid model composed of genetic algorithms (GAs) and ANN to resolve the above two problems of conventional ABC simultaneously. First, GA portion of the model is proposed as an optimization method of relevant cost drivers. Second, ANN portion of the model is used to reflect a nonlinear cost function for the cost allocation process. In the hybrid model, the GA globally searches and seeks an optimal or near-optimal ANN topology.

The paper is organized as follows: Section 2 reviews

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related prior studies. Section 3 presents a description of our hybrid model of GA and ANN. In addition, Sections 4 and 5 describe the process of experiments and experimental results. Finally, Section 6 discusses the conclusions and the limitations of the study and future research issues.

2. Prior research

In general, traditional costing systems, volume-based costing systems usually with a single cost driver, distort the cost allocation process because they allocate costs by only one criterion such as direct labor-hour, machine-hour, or unit of production. Indirect costs, however, do not always behave in proportion to the single cost driver in practice. In addition, if cost drivers are not selected appropriately, traditional approach does not accurately allocate indirect costs to the products. This may cause distorted decision-making.

ABC is the costing method that assigns costs to activities using multiple cost drivers, then allocates costs to products based on each product's use of these activities (Maher & Deakin, 1994). ABC differs from traditional costing systems in two ways (Cooper, 1989). Cost pools are defined as activities rather than as production cost centers. In addition, the cost drivers are used to assign activity costs to products, which differs from traditional costing systems. ABC reduces the risk of distortion because it uses multiple activities as cost drivers based on CER.

There are two practical issues related to the proper allocation of indirect cost for ABC systems. The first issue is how to select proper cost drivers for cost allocation. It focuses on the efficiency of ABC because optimal cost drivers save the information-gathering cost without sacrificing major accuracy in cost estimation. It is a task currently handled by application of human judgment for the purpose of selecting appropriate cost drivers from the larger set of available candidate drivers (Schniederjans & Garvin, 1997). The second issue is how to determine the cost relationship. It focuses on the accurate estimation of a cost function. It is related to the effectiveness of ABC systems because effectiveness can be achieved by the proper cost function for cost allocation. Incorrect estimation of the cost function will have repercussions in the areas of cost management and control (Horngren et al., 1997).

Prior research has tried to resolve these two problems. For the CDO problem, Maher and Deakin (1994) suggested the following three criteria to select relevant cost drivers: causal relation, benefits received, and reasonableness. However, their criteria were abstract and subjective. Babad and Balachandran (1993) attempted to optimize cost drivers in ABC using greedy algorithms. They also identified a priority order, according to which low-priority and relatively insignificant activities with their associated drivers would be combined to save costs without sacrificing much accuracy in cost estimation. In addition, Levitan and Gupta (1996) tried to optimize the selection of relevant cost drivers using the GA in ABC systems. In their study, the GA and the greedy algorithm are used to solve two cases from the published literature. They concluded that a GA approach achieved superior results to the greedy algorithm for both cases. They found that the GA not only reduces information-gathering costs through fewer drivers, but also produces more accurate costs even with fewer drivers.

A more recent study of Schniederjans and Garvin (1997) proposed the combined analytic hierarchy process (AHP) and zero–one goal programming to select relevant cost drivers in ABC. They showed how the AHP approach could bring consistency to the cost driver selection process. They also illustrated how the AHP weighting can be combined in the zero–one goal programming model to include resource limitations in the cost driver selection process.

For the CERs, many researchers have made advances in the cost allocation process. Several studies reported that ANN outperforms linear regression for cost estimation (Creese & Li, 1995; Garza & Rouhana, 1995; Lee, 1993; Lee & Ahn, 1993). Smith and Mason (1997) suggested that ANN has advantages when dealing with data for which there is little a priori knowledge of the appropriate CER to select for regression modeling. Bode (1998a) reported that ANN after grouping of data outperforms linear and nonlinear regression for cost estimation. He suggested that ANN produces better cost predictions than conventional costing methods when the following conditions are satisfied: a sufficient case-base, known cost-driving attributes, few cots drivers, and no explicit knowledge about cost effects. In addition, Bode (1998b) suggested that ANN could be used for R&D management. He carried out the estimation of final cost of a new product under development, a typical R&D management application, using ANN.

In this section, we describe prior studies which tried to resolve the CDO and the CER problems in ABC systems. However, they did not consider these problems simultaneously. There has been much research interest since these two problems are interrelated for the estimation of product costs. This study proposes the hybrid GA and ANN model to resolve the CDO and the CER problems simultaneously. Section 3 presents our research model.

3. The hybrid model of GA and ANN

The GA is a search algorithm based on *survival of the fittest* among string structures (Goldberg, 1989). Recently, the GA has been investigated and shown to be effective in exploring a complex space in an adaptive way, guided by the biological evolution mechanisms of *reproduction*, *crossover*, and *mutation* (Adeli & Hung, 1995).

The first step of the GA is problem representation. The problem must be represented in a suitable form to be handled by the GA. Thus, the problem is described in terms of genetic code, like DNA chromosomes. The GA often