ASSESSING THE EFFICIENCY OF ACCOUNTING FIRMS USING DATA ENVELOPMENT ANALYSIS WITH MULTI-ACTIVITY NETWORKS

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Abstract

Traditional means of performance measurement, however, are either based on few predefined factors that provide only a partial view of the system or limited to a single activity and thus ignore the interaction between activities. To address this problem, a modified model for data envelopment analysis with multi-activity networks is proposed for accounting firm in this paper. We assess 298 Taiwanese accounting firms with three parallel-connected activities having two series-connected processes and two share factors for their performance management. After evaluating the effectiveness of the model, our results show that Taiwanese accounting firms obtain great advantages in the service process and suggest that Taiwanese accounting firms should focus on firm production for human resource arrangement and training expense and labor cost shares.

Keywords: Certified Public Accountant, Performance Measurement, Data Envelopment Analysis, Network Data Envelopment Analysis, Multi-activity, Efficiency Evaluation
1 INTRODUCTION

Globalization and rapid technological development have required decision makers to focus more on managing resources (e.g., human capital) to be globally competitive. Therefore, measures for systematically gathering information from accounting firms should be developed to evaluate effectiveness and efficiency in disclosure or provision assurance (Brierley and Gwilliam, 2001, 2003). However, the development of such measures involves several challenges (Hitt et al. 2001; Johnson and Kaplan, 1987; Berliner and Brimson, 1988; Bihimani and Brimson, 1989). One critical issue is the need to develop a system that represents and measures the performance of the accounting firm. Only maximizing the profit of one system (e.g., accounting and auditing) of an accounting firm does not guarantee the maximum overall profit of the firm. An effective system for measuring performance has become more difficult to develop because of the increased complexity of the structure of an accounting firm. In terms of increased complexity, in contrast to normal inputs, some variables (e.g., training expenses and labor costs) are apportioned to different activities and should therefore be considered from the perspective of shared resources. Furthermore, without considering the structures of activity, putting all variables (e.g., variables for auditing-oriented and variables for management advisory-oriented activities) directly into the same model will cause homogenous validation, thus, evaluation may cause the bias in the efficiency results. Moreover, the performance measurement system must consider multiple performance factors to create meaningful performance reports. Managers always used to rely on financial or operational reports to calculate the ratio of single output to single input to evaluate performance, but such ratio provides insufficient information in the modern business environment (Banker et al., 2003). In addition, factors with different oriented purposes may significantly vary from one activity to another depending on the strategies of the organization.

As results, this study aims to construct a model to evaluate the performance of an accounting firm with activities from accounting and auditing (A&A), tax service (TAX) and management advisory services (MAS) through the black box system with examining the structure of the activities and processes of the firm. The model must be general enough to cover an accounting firm with multiple activities (i.e., A&A, TAX, and MAS). The proposed model provides efficiency indices based on the overall performance of firm activities while still accounting for the interrelation of services. The model also considers two-stage processes (i.e., production and service), which are commonly associated with the problems faced by accounting firms, to reflect the effect of production and service processes.

This paper provides a threefold contribution to the assessment of accounting firms. First, this paper proposes a method to evaluate the efficiency of an accounting firm with a complex network structure, including that of its multiple activities. Second, this study incorporates apportioned input costs into the evaluation model, which considers training expenses and labor costs as share inputs to evaluate the firm given that these costs cannot be used to determine apportionment ratios for different
activities. Third, this study proposes an evaluation method that considers the production and service efficiency of the accounting firm, and does not change its predetermined quality in the short run. The model incorporates more factors and thus enables a more comprehensive and thorough performance evaluation yields more meaningful and reasonable results.

The rest of this paper is organized as follows. Section 2 reviews related research on accounting firms. Section 3 describes the model of the accounting firm problem, particularly in terms of the multi-activity structure, share input, and service quality. Section 4 explains the evaluation of 298 Taiwanese accounting firms from the Financial Supervisory Commission of Taiwan. Section 5 offers suggestions for future research.

2 LITERATURE REVIEW

Traditional methods of performance measurement include balanced score cards (Bhagwat and Sharma, 2006; Ittner et al., 2003), spider diagrams, agency theory (Sarens, 2007) and z-charts. However, several of these methods are based on qualitative data and are affected by the subjective views of participants and thus produce ambiguous results. In addition, these previous studies have examined accounting firms through descriptive statistics (Chang et al., 2009; Chang et al., 2011; Cheng, 2010) and determined and analyzed the key factors that enhance the performance of accounting firms. However, the accounting industry or other industry-related topics are difficult to comprehensively analyze. Thus, the performance of different organizations remains difficult to compare because the weight of factors vary with the organization. DEA is considered the better approach to organizing and analyzing data because it allows firm efficiency to evolve over time, requires no prior assumption about the specification of the best-practice frontier, and manipulates the setting for practice.

Recently, studies on the performance evaluation of accounting firms through DEA have mostly used traditional DEA or network DEA models with relatively simple structures (Banker et al., 2003; Banker et al., 2005; Cheng, 2010), that is, with only one activity (i.e., assuming that such an activity is regarded as a black box). For example, Cheng (2010) used DEA to evaluate the efficiency of accounting firms and to conduct multiple-input and -output analyses. Cheng (2010) used the Charnes–Cooper–Rhodes (CCR) DEA model (Charnes et al., 1984) to evaluate the efficiency of accounting firms. Huang (2001) used the Banker–Charnes–Cooper (BCC) DEA model (Banker et al., 1984) to evaluate the same efficiency and found that technical efficiency positively affects the profitability of accounting firms. Banker et al. (2005) and Chang et al. (2009a) used the Malmquist index to measure changes in productivity and efficiency. Banker et al. (1999) used DEA to assess the efficiency of 100 American accounting firms and found that the efficiency of these firms is gradually improving, although high inefficiency still exists. Few of these studies discussed the processes and activities associated with performance and efficiency according to assessment based on a black box system (i.e., single-activity) (Banker et al., 2005; Chang et al., 2009a; Chang et al., 2011; Cheng 2010). Although, these studies effective to assess their efficiency, however, the single-activity method
cannot assume these processes and activities as independent because they (i.e., the single-activity method) ignored each activity was affected by other activities in operations.

In summary, these previous studies have assessed the performance of accounting firms in terms of their input–output efficiency (Banker et al., 2003; Banker et al., 2005; Cheng, 2010), however, no empirical study has explored the productivity and share inputs of the activities of each department and considered multiple-activity with shared inputs in our best knowledge.

3 PROBLEM DESCRIPTION AND MODELING FORMULATION

This study aims to construct a DEA model to assess the performance of accounting firms in terms of their relative efficiency. The DEA model can identify inefficient activities and processes and provide suggestions for improvement on the basis of the overall efficiency of the accounting firm. This section presents cases in which an accounting firm faces several production activities at the same time, such as in accounting firms that provide auditing, tax, and management services. The profits of an accounting firm are determined by the following three activities: (1) accounting and auditing activity (A&A), which includes initial public offering insurance and other financial insurance; (2) taxation activity (TAX), which includes income tax insurance, tax and business litigation services, and other tax services; and (3) management advisory activity (MAS), which includes consulting services, industrial and commercial registration, and other management services.

By using DEA models, this study assumes that all required data, except for shared variables, are complete and deterministic. Such data include the structure of the accounting firm being evaluated and the inputs and outputs for evaluating efficiency. Different with these previous studies viewed the analysis of operation performance and efficiency as a black box system (Banker et al., 2005; Chang et al., 2009; Chang et al., 2011; Cheng, 2010). These traditional DEA models evaluates decision marking unit (DMU) efficiency by transforming inputs from a black box into outputs (Figure 1, dashed line) but disregards the parallel structure of their activities and service procedures. An accounting firm that is efficient in A&A may not be efficient in TAX or MAS; hence, the efficiency ratings for different activities must be distinguished. When an accounting firm jointly performs activities and processes that are technologically different, the multi-activity DEA model separates these activities and processes into different technologies (Mar Molinero, 1996; Tasi and Molinero, 2002; Yu et al., 2013).

Following the previous discussion, managers decrease inputs and increase outputs while maintaining the provided human capital at its predetermined level on service quality in the short term. The predetermined service quality cannot be changed (i.e., in the short run), and as an intermediate role, the input-oriented perspective is suitable for transforming operation inputs into the required service quality (hereafter, production process is used). Furthermore, managers are responsible for improving the operations of the accounting firm while maintaining the quality of its services (fixed at a predetermined level by staff). This output-oriented perspective is more suitable for the service
process. The predetermined service quality can be considered as the output for the production process and as the input for the service process.

Each activity was divided into a series of production and service processes (i.e., two adjacent processes connected) to accurately evaluate the performance of the accounting firm after the three-activity were determined (Yu et al., 2013; Hosseinzadeh et al., 2009). Given that capability (i.e., this study uses the service quality of human capital as a capacity item) cannot be expanded within a short time, output consumption may substantially differ from output production. To illustrate this constraint in our model, which used service quality as an intermediate variable, the value of human capital must be constant in both the outputs of the production process and the inputs of the service process. Besides, operating expenses are also considered as an intermediate input or output. Different with human capital, operating expenses (service revenue) must be treated as a normal input or output. If human capital cannot easily be adjusted in the short term, the input-oriented approach is more suitable in modeling the first process (i.e., the production process), whereas the output-oriented approach is more suitable for the second process (i.e., the service process).

Figure 1. Structure of Activities of an Accounting Firm.

Suppose that there are \( j, v = 1, \ldots, N \) accounting firms, and that each firm engages in \( k \) activities (i.e., A&A (denoted as \( p \)), TAX (denoted as \( t \)) and MAX (denoted as \( m \))). Let \( x_{aj}^{(k)} \) denote \( a-\text{th} \) (\( a=1, \ldots, n_a^{(k)} \)) input variable of \( k-\text{th} \) activity of \( j-\text{th} \) accounting firm, while \( x_{sj} \) are \( s-\text{th} \) (\( s=1, \ldots, n_s \)) share input variable of \( j-\text{th} \) accounting firm. For production process, each firm produces the \( d-\text{th} \) intermediate human capital output variable (i.e., non-discretionary) of
activity of \( j \)-th accounting firm (i.e., \( y^{(k)}_{dj} \)) and \( g \)-th intermediate normal output variable of \( k \)-th activity of \( j \)-th accounting firm (i.e., \( y^{(k)}_{gj} \)). For service process, the final output variable of \( k \)-th activity of \( j \)-th accounting firm will be produced. It is assumed firm \( k \) allocates some portion, \( \mu_{gj}^k \), of the shared quantities \( x_{sj} \) to each activates and the share ratio should be bounded into the upper bound \( \bar{\mu}_{sj} \) and lower bound \( \underline{\mu}_{sj} \). The measure of overall operation effectiveness for accounting firm \( j \) can be estimated by solving the Model (1)

To emphasize the importance of each process, we break down the human capital of the intermediate process for the production and service processes and assume that the weights of the two processes are equal to \( 1/2 \) and the weights of three activities are equal to \( 1/3 \) as well. The objective function of the \( j \)-th accounting firm can be expressed as Eq. (1.1). The details of constraint can not be elaborated for the limited space.

\[
\text{Max} \quad \frac{1}{3} \left[ \frac{\beta_j^{(p)} + \bar{\beta}_j^{(p)}}{2} + \frac{\beta_j^{(s)} + \bar{\beta}_j^{(s)}}{2} + \frac{\beta_j^{(m)} + \bar{\beta}_j^{(m)}}{2} \right] \tag{1.1}
\]

a. A&A Production Process Constraint Set
\[
\sum_{i=1}^{N_j} z_{ij}^{(p)} x_{ai}^{(p)} \leq (1 - \beta_j^{(p)}) x_{aj}^{(p)}, a = 1, \ldots, n_a^{(p)}, \tag{1.2}
\]
\[
\sum_{i=1}^{N_j} z_{ij}^{(p)} y_{ai}^{(p)} = y_{ai}^{(p)}, d = 1, \ldots, n_d^{(p)}, \tag{1.3}
\]
\[
\sum_{i=1}^{N_j} z_{ij}^{(p)} y_{gi}^{(p)} \geq y_{gi}^{(p)}, g = 1, \ldots, n_g^{(p)}, \tag{1.4}
\]

b. A&A Service Process Constraint Set
\[
\sum_{i=1}^{N_j} z_{ij}^{(s)} y_{ai}^{(s)} = y_{ai}^{(s)}, d = 1, \ldots, n_d^{(s)}, \tag{1.5}
\]
\[
\sum_{i=1}^{N_j} z_{ij}^{(s)} y_{gi}^{(s)} \leq y_{gi}^{(s)}, g = 1, \ldots, n_g^{(s)}, \tag{1.6}
\]
\[
\sum_{i=1}^{N_j} z_{ij}^{(s)} y_{ji}^{(s)} \geq (1 + \bar{\beta}_j^{(s)}) y_{ji}^{(s)}, f = 1, \ldots, n_f^{(s)}, \tag{1.7}
\]

c. TAX Production Process Constraint Set
\[
\sum_{i=1}^{N_j} z_{ij}^{(t)} x_{ai}^{(t)} \leq (1 - \beta_j^{(t)}) x_{aj}^{(t)}, a = 1, \ldots, n_a^{(t)}, \tag{1.8}
\]
\[
\sum_{i=1}^{N_j} z_{ij}^{(t)} y_{ai}^{(t)} = y_{ai}^{(t)}, d = 1, \ldots, n_d^{(t)}, \tag{1.9}
\]
\[
\sum_{i=1}^{N} z_{y_{ij}^g}^{(i)} y_{ij}^{(g)} \geq y_{ij}^{(g)}, \quad g = 1, ..., n_{g}^{(i)},
\]

\[d. \text{TAX Service Process Constraint Set}\]
\[
\sum_{i=1}^{N} z_{y_{ij}^{g}}^{(i)} y_{ij}^{(g)} = y_{ij}^{(g)} d = 1, ..., n_{d}^{(i)},
\]
\[
\sum_{i=1}^{N} z_{y_{ij}^{g}}^{(i)} y_{ij}^{(g)} \leq y_{ij}^{(g)} g = 1, ..., n_{g}^{(i)},
\]
\[
\sum_{i=1}^{N} z_{y_{ij}^{g}}^{(i)} y_{ij}^{(g)} \geq (1 + \bar{\beta}_{j}^{(i)}) y_{ij}^{(g)} f = 1, ..., n_{f}^{(i)},
\]

\[e. \text{MAS Production Process Constraint Set}\]
\[
\sum_{i=1}^{N} z_{v_{ij}^{a}}^{(m)} x_{a_{ij}}^{(m)} \leq (1 - \beta_{j}^{(m)}) x_{a_{ij}}^{(m)} a = 1, ..., n_{a}^{(m)},
\]
\[
\sum_{i=1}^{N} z_{v_{ij}^{d}}^{(m)} y_{ij}^{(d)} = y_{ij}^{(d)} d = 1, ..., n_{d}^{(m)},
\]
\[
\sum_{i=1}^{N} z_{v_{ij}^{g}}^{(m)} y_{ij}^{(g)} \geq y_{ij}^{(g)} g = 1, ..., n_{g}^{(m)},
\]
\[f. \text{MAS Service Process Constraint Set}\]
\[
\sum_{i=1}^{N} z_{v_{ij}^{d}}^{(m)} y_{ij}^{(d)} = y_{ij}^{(d)} d = 1, ..., n_{d}^{(m)},
\]
\[
\sum_{i=1}^{N} z_{v_{ij}^{g}}^{(m)} y_{ij}^{(g)} \leq y_{ij}^{(g)} g = 1, ..., n_{g}^{(m)},
\]
\[
\sum_{i=1}^{N} z_{v_{ij}^{f}}^{(m)} y_{ij}^{(f)} \geq (1 + \bar{\beta}_{j}^{(m)}) y_{ij}^{(f)} f = 1, ..., n_{f}^{(m)},
\]

\[g. \text{Shared Inputs for Three Activities}\]
\[
\sum_{i=1}^{N} \mu_{s}^{(p)} z_{s}^{(p)} x_{s} + \sum_{j=1}^{N} \mu_{s}^{(t)} z_{s}^{(t)} x_{s} + \sum_{j=1}^{N} \mu_{s}^{(m)} z_{s}^{(m)} x_{s} \leq
\]
\[
\left[(1 - \beta_{j}^{(p)}) \mu_{s}^{(p)} + (1 - \beta_{j}^{(t)}) \mu_{s}^{(t)} + (1 - \beta_{j}^{(m)}) \mu_{s}^{(m)}\right] x_{s}, \quad s = 1, ..., n_{s},
\]
\[
\mu_{s}^{(p)} + \mu_{s}^{(t)} + \mu_{s}^{(m)} = 1; \forall v \in j; j = 1, ..., N
\]
\[
\forall z_{s}^{(p)}, z_{s}^{(t)}, z_{s}^{(m)} \geq 0
\]
\[
\bar{\mu}_{s}^{(k)} \leq \mu_{s}^{(k)} \leq \bar{\mu}_{s}^{(k)}; k = p, t, m; v = 1, ..., N
\]

Where \( z_{j}^{(k)} \) and \( \bar{z}_{j}^{(k)} \) are intensity variables associated with the production service and service process, respectively. In addition, \( \alpha_{j}^{(k)} \) and \( \bar{\alpha}_{j}^{(k)} \) are denoted front process and rear process,
respectively, of efficiency scores in \( j \)-th accounting firm of \( k \)-th activity.

\[
\alpha_j^{(k)} = 1 - \beta_j^{(k)}; k = a, t, m
\]

\[
\tilde{\alpha}_j^{(k)} = 1 - \tilde{\beta}_j^{(k)}; k = a, t, m
\]

4 EMPIRICAL STUDY

In this section, we use the Models (1) of DEA model to evaluate the efficiency results of the accounting firm shown in Figure 1 to determine if this model can accurately measure the efficiency of an accounting firm with different activity and production conditions.

4.1 Input and Output

The data are obtained from the audit quality database of the Taiwan Economic Journal, which collects its data from the Annual Survey of Accounting Firms in Taiwan published by the Financial Supervisory Commission of Taiwan. A total of 954 accounting firms were listed on the database in 2010. Firms with incomplete data are removed from the list, leaving us with 298 firms to analyze. This study focuses on three activities of accounting firms: A&A, TAX, and MAS. We use a suffix to differentiate the activity types shown in Table 1. Each activity has two shared inputs, namely, training expense and labor costs. These shared data are collected from an accounting firm instead of an activity. The variables in the network are indivisible. Table 1 outlines the variable parameters, whereas descriptive statistics of the data are presented in Table 2.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Common</th>
<th>Inputs</th>
<th>Shared</th>
<th>Human Capital</th>
<th>Intermediate</th>
<th>Common</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&amp;A</td>
<td>Employee for A&amp;A (x_p^1; in persons)</td>
<td>Training expense (x_{s1}; in NT dollars)</td>
<td>Labor costs (x_{s2}; in NT dollars)</td>
<td>Human Capital Index for A&amp;A (y_{d1}^p)</td>
<td>Operating Costs for A&amp;A (y_{g1}^p; in NT dollars)</td>
<td>A&amp;A Revenue (y_{f1}^p; in NT dollars)</td>
<td></td>
</tr>
<tr>
<td>TAX</td>
<td>Employee for TAX (x_t^1; in persons)</td>
<td>Training expense (x_{s1}; in NT dollars)</td>
<td>Labor costs (x_{s2}; in NT dollars)</td>
<td>Human Capital Index for TAX (y_{d1}^t)</td>
<td>Operating Costs for TAX (y_{g1}^t; in NT dollars)</td>
<td>TAX Revenue (y_{f1}^t; in NT dollars)</td>
<td></td>
</tr>
<tr>
<td>MAS</td>
<td>Employee for MAS (x_m^1; in persons)</td>
<td>Training expense (x_{s1}; in NT dollars; in NT dollars)</td>
<td>Labor costs (x_{s2}; in NT dollars)</td>
<td>Human Capital Index for MAS (y_{d1}^m)</td>
<td>Operating Costs for MAS (y_{g1}^m; in NT dollars)</td>
<td>MAS Revenue (y_{f1}^m; in NT dollars)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Measures of Inputs and Outputs of Accounting Firms.
<table>
<thead>
<tr>
<th>Activity/Shared</th>
<th>Variables</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&amp;A</td>
<td>$x_1^p$</td>
<td>29</td>
<td>180</td>
<td>1</td>
<td>2124</td>
</tr>
<tr>
<td></td>
<td>$y_{dl}^p$</td>
<td>63</td>
<td>181</td>
<td>12</td>
<td>2389</td>
</tr>
<tr>
<td></td>
<td>$y_{g1}^p$</td>
<td>6397175</td>
<td>46072158</td>
<td>10842</td>
<td>631663833</td>
</tr>
<tr>
<td></td>
<td>$y_{f1}^p$</td>
<td>39318224</td>
<td>323787344</td>
<td>1</td>
<td>4463383137</td>
</tr>
<tr>
<td>TAX</td>
<td>$x_1'$</td>
<td>8</td>
<td>28</td>
<td>1</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td>$y_{dl}'$</td>
<td>914</td>
<td>4759</td>
<td>14</td>
<td>55629</td>
</tr>
<tr>
<td></td>
<td>$y_{g1}'$</td>
<td>1511582</td>
<td>6877565</td>
<td>35376</td>
<td>93678958</td>
</tr>
<tr>
<td></td>
<td>$y_{f1}'$</td>
<td>19407329</td>
<td>88671804</td>
<td>1</td>
<td>916371923</td>
</tr>
<tr>
<td>MAS</td>
<td>$x_1^m$</td>
<td>11</td>
<td>34</td>
<td>1</td>
<td>416</td>
</tr>
<tr>
<td></td>
<td>$y_{dl}^m$</td>
<td>976</td>
<td>5017</td>
<td>14</td>
<td>59398</td>
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<td></td>
<td>$y_{g1}^m$</td>
<td>1964027</td>
<td>9048578</td>
<td>10842</td>
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<td></td>
<td>$y_{f1}^m$</td>
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<td>70645195</td>
<td>1</td>
<td>981857588</td>
</tr>
<tr>
<td>Shared</td>
<td>$x_{s1}$</td>
<td>364528</td>
<td>2704322</td>
<td>300</td>
<td>35226871</td>
</tr>
<tr>
<td></td>
<td>$x_{s2}$</td>
<td>36249111</td>
<td>253978070</td>
<td>12199</td>
<td>3374973734</td>
</tr>
</tbody>
</table>

Table 2. Descriptive Statistics of Inputs from Three Activities of Accounting Firms in 2010.

Cheng et al. (2009) indicate that human capital is based on the quality of service produced during a given period. The human capital index must be calculated based on the level of education (EDU)\(^1\), experience (STAFF35)\(^2\), certification (LICENSE)\(^3\), and training (TRAINING)\(^4\). Furthermore, the range of the two shared inputs must be queried from the expertise of accounting, illustrating that the training expenses of the three activities must not be less than 10% of the overall training expenses. The share ratio of the training expense also cannot be higher than 80% of the overall training expense. For example, if the training expense of A&A takes 80% of the overall training expense, the training expenses of TAX and MA must only take 20% of the overall training expense. The range of the labor cost must not be less than 25% of the overall labor costs and cannot be higher than 45% of the overall labor costs. We use the statistical methods of principal components analysis (PCA) without rotation.

\(^1\) Based on the research designs of DeFond (1992) and Francis and Wilson (1988), the education level (EDU) variable is defined as the average number of years to obtain a degree in accounting, which is calculated as follows: (number of auditors with doctorates for activity $k \times 23$ + number of auditors with master’s degree for activity $k \times 18$ + number of auditors with bachelor’s degree for activity $k \times 16$ + number of employees with a senior high school diploma for activity $k \times 12$ + number of employees with other education level for activity $k \times 9$) / year-end number of employees for $k$-th activity.

\(^2\) The work experience of employees (STAFF35) is calculated by dividing the number of employees older than 35 years for activity $k$ by the year-end number of practicing partners for activity $k$ (Kumra and Vinnicomber, 2008).

\(^3\) The professional qualification level of employees (LICENSE) is measured by the number of employees with a CPA license for activity $k$ divided by the year-end number of practicing CPAs for activity $k$.

\(^4\) The logarithm of expenditures of the training variable (TRAINING) is determined by analyzing components without rotation to combine the four variables of each activity and to extract a common factor to capture the overall level of the service quality of the $k$-th activity.
to combine these four driving factors from a set of variables. The simplest true eigenvector–based multivariate analysis, PCA explains the variances among data by exploring their internal structures. This analysis produces a significant common factor called the human capital index. The eigenvalues of all three activities are greater than 1.0 and can thus be used to describe the data thoroughly. Factors with eigenvalues less than 1.0 are obscure and difficult to identify. Cheng et al. (2009) indicates that the human capital index can be expressed by Equation (4):

$$y_{d1}^{(k)} = \beta_0 + \beta_1(EDU) + \beta_2(STAFF35) + \beta_3/LICENSE + \beta_4/TRAINING + e_l$$  \hspace{1cm} (4)

### 4.2 Efficiency Measurement

Each production, activity, and service efficiency can be obtained through Model (1).

<table>
<thead>
<tr>
<th>#</th>
<th>$\alpha^p$</th>
<th>$\bar{\alpha}^p$</th>
<th>A&amp;A</th>
<th>$\alpha'$</th>
<th>$\bar{\alpha}'$</th>
<th>TAX</th>
<th>$\alpha''$</th>
<th>$\bar{\alpha}''$</th>
<th>MAS</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.40</td>
<td>1.00</td>
<td>0.70</td>
<td>0.69</td>
<td>1.00</td>
<td>0.84</td>
<td>0.34</td>
<td>1.00</td>
<td>0.67</td>
<td>0.74</td>
</tr>
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<td>2</td>
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<td>1.00</td>
<td>0.63</td>
<td>0.34</td>
<td>1.00</td>
<td>0.67</td>
<td>0.67</td>
<td>1.00</td>
<td>0.84</td>
<td>0.71</td>
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<tr>
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<td>1.00</td>
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<tr>
<td>19</td>
<td>0.11</td>
<td>0.84</td>
<td>0.48</td>
<td>0.23</td>
<td>1.00</td>
<td>0.61</td>
<td>0.84</td>
<td>1.00</td>
<td>0.92</td>
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<tr>
<td>298</td>
<td>0.03</td>
<td>1.00</td>
<td>0.52</td>
<td>0.23</td>
<td>1.00</td>
<td>0.62</td>
<td>0.04</td>
<td>0.79</td>
<td>0.42</td>
<td>0.51</td>
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<tr>
<td>Average</td>
<td>0.325</td>
<td>0.996</td>
<td>0.660</td>
<td>0.335</td>
<td>0.997</td>
<td>0.666</td>
<td>0.291</td>
<td>0.982</td>
<td>0.636</td>
<td>0.654</td>
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<tr>
<td>Std Dev</td>
<td>0.295</td>
<td>0.025</td>
<td>0.148</td>
<td>0.276</td>
<td>0.050</td>
<td>0.141</td>
<td>0.267</td>
<td>0.074</td>
<td>0.144</td>
<td>0.110</td>
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<td>Max</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
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<tr>
<td>Min</td>
<td>0.000</td>
<td>0.784</td>
<td>0.457</td>
<td>0.002</td>
<td>0.135</td>
<td>0.111</td>
<td>0.002</td>
<td>0.417</td>
<td>0.329</td>
<td>0.451</td>
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</table>

Table 3. Descriptive Statistics of Inputs from Three Activities of Part of Accounting Firms in 2010.

Table 3 shows that the production of accounting firms is more efficient than their service processes regardless of activity, implying that these firms must reduce their staff in such a way that their human capital remains the same. At the same time, the operation cost must compensate for the improvement of the production process. Compared with conventional evaluation approaches, multi-activity network DEA provides substantial information on each activity or process. This advantage has rarely been discussed by previous studies. Nine (# 6, # 54, # 106, # 133, # 146, # 190, # 193, # 205, and # 257) of the 298 overall efficiency scores of accounting firms have reached the value of 1 (i.e., inefficiency scores are zero), indicating that the efficiency scores of each activity have also reached the value of 1. This result indicates that these accounting firms can be categorized through benchmarking. Accounting firm #1 in Table 3 has an efficiency of $\alpha^p$ (i.e., 0.4) smaller than that of $\bar{\alpha}^p$ (i.e., 1.0), indicating that the service process of the firm reaches the benchmark of this industry but its production process does not reach the best practice. This accounting firm must reduce its number of employees to improve the efficiency of its production. Although the firm has reduced its
staff for A&A, it can still incur additional operation expenses brought by passive expenses, which subsequently reduce its service process efficiency. Therefore, reducing investment in staff increases the efficiency scores of accounting firms. By contrast, accounting firm # 19 in Table 3 has a $\alpha^p$ (i.e., 0.84) higher than $\alpha^o$ (i.e., 0.11) and cannot reach the frontier. Therefore, the firm has to focus on its operational cost rather than on employee reduction. The efficiency of the production process is lower than that of the service process in most companies, indicating that investing in staff to produce business cost still produces certain effects. Compared with other accounting firms with high human capital indices, small-scale accounting firms can allocate their staff and operation expense profiles. Moreover, overstaffed accounting firms encounter difficulties in adjusting their input and output ratios.

5 CONCLUSIONS

This study divides the activities of the accounting industry into three activities to explore the direct and interaction effects of each activity and process. These effects may influence the efficiency of accounting firms. A modified multi-activity network DEA approach that simultaneously manages A&A, TAX, and MAS activities is used to evaluate the technical efficiency of accounting firms in Taiwan. This model not only considers the interaction between various activities and processes that make up the operation of accounting firms but also provides solutions to share and dimensionality problems. The problems associated with normal inputs and intermediate products are simultaneously considered by the integrated framework of the model. The allocation of human capital and cost shares is considered the main influencing factor for accounting firms in Taiwan. The service process is more efficient than the production process. Companies easily adjust their input–output sharing ratio to improve their operating income by comparing the efficiencies of their production and service processes. This study examines the structure of the activities and processes of these firms to fill the research gap and to provide useful information for practitioners and other researchers. However, this study also has limitations. First, we consider only some of the firms in our reference database. The database lists 954 accounting firms, but we consider only 298 firms after disregarding firms with incomplete data and without operating income. We collect our empirical data from the audit quality database of the Taiwan Economic Journal, which collects its data from the Annual Survey of Accounting Firms in Taiwan. However, we are prohibited from obtaining detailed data because the firms want to protect their trade secrets. Second, the diversity of human capital can further be discussed in future research. Thirdly, the important weight of each activity can be determined only by other approaches. Finally, revision of the methodology to include the above-mentioned limitations is suggested future studies.

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REFERENCE


Cheng, F.M. (2010), Association between Professional Training · Total Technical Efficiency and Operating Results : Evidence from Taiwanese Audit Firms. National Yunlin University of Science and Technology.


Mar Molinero, C. (1996), On the joint determination of efficiencies in a data envelopment analysis

Sarens, G. (2007), Agency theory as predictor of the size of the internal audit function in Belgian companies, Working Paper, UNIVERSITEIT GENT.
