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人力資本與經營績效

Human Capital and Operating Performance

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摘要：由於全球對會計專業規範的日益嚴苛，以及執業環境的惡化，會計師事務所如何在市場上占有一席之地，是一門值得深思的課題，尤其是事務所特別依賴著以知識為基礎的人力資本來執行其審計服務，然而，有關於事務所之經營績效為何，以及人力資本的優劣究竟在事務所之經營績效上扮演何種角色，卻少見研究探討之。因此，本文首先採用資料包絡法，分析事務所效率與規模報酬等經營績效，其次，利用資源基礎觀點，進而探討高品質人力資本是否會影響事務所之經營績效。本文按生產技術水準將樣本分為大型及小型等兩類事務所，結果顯示，就效率而言，大型事務所樣本下之四大表現較優，且主因係該管理者有較佳的資源運用能力。小型事務所則以員工 9 人(含)以上事務所表現較佳，惟與四大情況不同，其原因並非源自於管理者能力，而係有較佳的生產規模所致。就規模報酬而言，大型事務所中的四大，多數均處於最適的生產規模中，從年度趨勢來看，非四大事務所有積極調整規模的現象。小型事務所中，員工 9 人以下事務所大多處於規模報酬遞增，而員工 9 人(含)以上事務所則多數於規模報酬遞減之生產狀態下。就高品質

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人力資本能否影響事務所績效而言，結果顯示，無論是大型或小型事務所，若所內有愈多經驗豐厚之高階專業人力，愈能提昇技術效率，且若事務所教育訓練支出愈多者，其技術效率亦愈能有所增加，惟無論是大型或小型事務所，所內有愈多高學歷的高階專業人力，均無法顯著增加其技術效率。
關鍵詞：人力資本；會計師事務所；績效

Abstract: Recently, increasingly severe regulation and stringent market competition deteriorate the operating environment in which auditors practise. Accordingly, it is undoubtedly an important lesson for auditors to adapt to the practicing situation to survive and to sustain competitive advantages in the audit market. As a professional organization, audit firm offers various services by knowledge-based human capital. However, few prior studies address the operating performance of audit firm and the role played by human capital in creating the operating performance. To fill the gap, this study estimates the efficiency and return to scale by Data Envelop Analysis. Then, this study investigates the effects of high quality human capital upon operating performance in terms of resource-based view. Total observations used in this study are grouped into large and small firms by production technical level. Empirical results indicate that Big 4 international firms and small firms with number of employee equal to and more than 9 possess higher efficiency. For return to scale, most of the Big 4 international firms are in the optimal scale of production. Non-Big 4 firms adapt their scale aggressively in the long-run tendency. Of the small firms, firms with number of employee less than 9 are in the increasing return to scale and firms with number of employee equal to and more than 9 are in the decreasing return to scale. Finally, audit firms with more experienced upper-level professionals improve their technical efficiency significantly. In addition, audit firms with more expenditure on educational training significantly increase technical efficiency. However, for either large or small firm, more upper-level professionals with high academic degree are unable to improve their technical efficiency.
Keywords: Human capital; Audit firm; Performance.

1. Introduction

The environment in which auditors operate has changed drastically during the past few years of this new century. In the demand side of audit service, many audit clients either closed their businesses or moved to Mainland China, southern Asia emerging countries, such as Philippines or Vietnam, for new opportunities due to the faltering regional economy in Taiwan. Traditional audit market is impacted adversely and becomes more competitive as a result of the shrinkage of auditing practices. Further, the Fair Trade Commission, Executive Yuan, abolished the long-standing audit fee standard, set up by the Taiwan Certified Public Accountants Association in 1998. This exacerbates traditional audit market competition accordingly. In the supply side of audit service in Taiwan, there are much more qualified public practicing accountants after the rise of passing rate of uniform certified public accountants (CPA) examination in 1990's (Lee, Shih, and Tsai, 2003). Besides, in 1998, the establishment of tax agent system impacts small firms adversely due primarily to cheaper fees charged by and easy of access to tax agent. As a result, competition within and outside of the public accounting profession further deteriorates the practicing environment.

More important, today's regulatory environment (e.g., passage of Sarbanes-Oxley Act of 2002) [2] broadens and intensifies pressures on audit firms to enhance the quality, effectiveness, and efficiency of the services offered

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[2] For example, Sarbanes-Oxley Act of 2002 establishes the Public Company Accounting Oversight Board (PCAOB) to oversee public accounting firms. Annual inspection is conducted with respect to registered public accounting firm that regularly provides audit reports for more than 100 issuers. Inspection not less frequently than once every 3 years is conducted with respect to registered public accounting firm that regularly provides audit reports for 100 or fewer issuers. The PCAOB inspection report issued to 316 smaller public accounting firms (100 or fewer issuer clients) through July 2006 indicates that 189 inspected firms (60 percent) have audit deficiencies (Hermanson, Houston, and Rice, 2007). As PCAOB, the Taiwan Disciplinary Committee of Certified Public Accountant (CPA), Taiwan Disciplinary Retrial Committee of CPA, Assessment Committee of Taiwan Institute of CPA, and Accounting Research and Development Foundation in Taiwan perform the discipline of CPA, peer review and the establishment of accounting and auditing principle, respectively. In recent years, the discipline of CPA has been increasingly tighter than ever due primarily to material audit failures occurring once in a few years in Taiwan. Hence, there is a tendency of rigorous regulation over CPA in the global public accounting profession.

(Vera-Muñon, Joanna, and Chow, 2006). Auditors become risk averse and conservative in accepting audit engagement and other service provision (Fu, Chang, and Chen, 2005). Moreover, many audit clients are proceeding with the strategy of globalization and e-commerce for competitive advantages in the changing market. Complex transactions and global marketing deployment result in auditing process and procedure more difficult than ever. In addition, when providing services, auditors face a huge challenge in their professional judgement under the tendency of using a set of globally accepted accounting principle, the International Financial Reporting Standards. Accordingly, it is undoubtedly an important lesson for auditor to adapt to the changing and stringent environment to survive and to sustain competitive advantages in audit market.

From the resource-based view of firm, performance differences across firms can be attributed to the variance in the firm's resources and capabilities (Penrose, 1959; Wernerfelt, 1984; Prahalad and Hamel, 1990; Peteraf, 1993). Among the resources owned, which one enables the firm to outperform others? Barney (1991) notes resources that are valuable, rare, unique, and difficult to imitate can provide the basis for firms' sustained competitive advantages. Under the new economy landscape, Grant (1996) suggests that knowledge, existent primarily in human capital, is the critical ingredient for gaining a competitive advantage. Pfeffer (1994) points out that human capital has long been regarded as a critical resource in most firms. Thus, it is the human capital that constitutes the most consentaneous item in the measurement of intellectual capital by researchers, such as Hubert (1996), Bontis (1998), and Guthrie (2001). [3] In addition, prior studies document that human capital attributes, such as education, experience, and skills and characteristics of top managers, affect a firm's outcomes significantly (Huselid, 1995; Wright, Smart, and McMahan, 1995; Pennings, Lee, and

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[3] Intellectual capital refers to the sum of knowledge and competency that creates value and gains competitive advantage for an organization (Roos and Roos, 1997; Stewart, 1997). Measurement dimensions of intellectual capital differ for different researchers. In addition to the major item of human capital, other components of intellectual capital include organization capital, flow capital, innovation capital, customer capital, and relationship capital. For further detail, we refer to Edvinsson and Malone (1997), Roos, Roos, and Dragonetti (1997), Stewart (1997), Bontis (1998), Bassi and Buren (1999), Dzinkowski (2000) and Guthrie (2001).

Witteloostuijn, 1998; Carpenter, Sanders, and Gregersen, 2001; Ling and Jaw, 2006).

Audit firm is typically a professional service organization (Morris and Empson, 1998), primarily providing financial statements audit services, tax services and management consultation services by CPA and assistants with professional knowledge (Gibbins and Wright, 1999). [4] Accordingly, it is expected that human capital influences audit quality and in turn operating performance of the audit firm. In particular, under the severely regulatory environment, audit firms need to create, integrate, share and use knowledge about their client's control activities and corporate governance to improve audit efficiency and upgrade audit quality (Vera-Muñon, Kinney, and Bonner, 2005). In effectively implementing these knowledge-based activities, human capital plays a critical role (De Carolis, 2003).

To our knowledge, only a few prior studies address the effects of human capital on performance of an audit firm. Bröcheler, Maijoor, and Witteloostuijn, (2004) examine the relationship between auditor human capital and audit firm survival in the Dutch audit market for 1930-1992. Pennings, Lee and Witteloostuijn, (1998) investigate the effects of human capital and social capital on survival of audit firm. In the behavior accounting research, some exploit experimental methodology to examine the performance difference of audit judgement for auditors with and without experience in bankruptcy forecast (Moriarity, 1979), in payroll control system (Ashton and Brown, 1980), in analytical review process (Libby and Frederick, 1990), and in internal control of sales transaction cycle (Tubbs, 1992). However, these prior studies focus on the performance of some specific auditing task not on the operating performance of

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[4] Maister (1993) and Greenwood and Lachman (1996) define professional service firms (PSF) as an organization that renders services such as law, accounting and audit, consultation, advertisement, and software. Morris and Empson (1998) use the term PSF to refer to an organization that trades mainly on the knowledge of its human capital, that is, its employees and the producer-owners, to develop and deliver intangible solutions to client problems. In addition to being classified as a PSF, audit firm is also referred to as knowledge-based organization (Drucker, 1998), knowledge-intensive organization (Starbuck, 1997), or human capital-intensive organization (Coff, 1997).

an audit firm. Under the increasingly severe regulation in public accounting profession, audit firm needs to upgrade audit efficiency and quality to sustain competitive advantage by rich human capital it owns. Accordingly, this study aims to address the effects of high quality human capital on operating performance of audit firm. With the results obtained, this study fills the gap left by prior studies and contributes to the literature in human capital of audit firm.

Bröcheler, Maijoor, and Witteloostuijn, (2004) note that performance determinants of audit firm, human capital, and smaller audit firm are three areas left underdeveloped in the audit market research due to data unavailability. [5] Although data about audit firm have been publicly available in Taiwan since 1989, most prior studies focus on the demand side of auditing. In contrast, topics of supply side of auditing, such as administration of audit firm, are less investigated (Lee, Shih, and Tsai, 2003; Chen and Lee, 2006; Cheng, Wang, and Weng, 2000a; Cheng, Wang, and Weng, 2000b). In methodology, the most commonly used method to measure performance is regression model. In addition to more restrictions imposed, [6] this method cannot identify the best performance unit due to its mean estimation standard (that is, higher than mean value is defined as the superior and defined as the inferior if less than mean value) (Cooper, Seiford, and Tone, 2006). In contrast, data envelopment analysis (DEA), a nonparametric method, subjects to less restrictions and can identify exactly, [7] among the units

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[5] To present, prior studies examining the topics of supply side of auditing, that is operating performance of audit firm, differ from this study. For example, Lee, Shih, and Tsai (2003), Banker, Chang, and Kao (2002), Banker, Chang, and Cunningham (2005), and Chen and Lee (2006) investigate the operation of audit firm from different dimension and their main themes are different from this study. Next, Cheng, Wang, and Weng (2000a) and Banker, Chang, and Cunningham (2003) address the scale economy of audit firm by a parametric method (cost function and revenue function), different from the non-parametric method (DEA) used in this study. Examining the human capital of audit firm, however, Pennings, Lee, and Witteloostuijn (1998) and Bröcheler, Maijoor, and Witteloostuijn (2004) focus on the effect of human capital on survival opportunity. Finally, Cheng, Wang, and Weng (2000b) investigate the determinants of operating performance (technical efficiency) of audit firm. They do not take into account the effect of human capital on performance. Thus, their topic investigated differs from this study.

[6] As a non-parametric method, DEA needs no priori information about the distribution form of production function and error term. In contrast, a parametric method has to assume the distribution form of production function and error term.

[7] For example, the restrictions include linear function relation between input and output variables,

assessed, which one or ones has the best performance. In one topic, this study examines the effect of human capital upon operating performance by the regression analysis. In another topic, this study employs the DEA to investigate the efficiency and return to scale to capture which audit firms possess full efficiency and what return to scale production are for most audit firms. With the results from DEA, this study fills the gap left by prior studies.

The remainder of this study proceeds as follows. We describe the research design in Section 2. Section 3 presents empirical results and Section 4 concludes this study.

2. Research Design

2.1 Hypotheses

Public accounting firms, a typical "professional services" organization, offer a wide range of services to clients (Morris and Empson, 1998). These firms depend on the knowledge and professional expertise of partners and staff (Gibbins and Wright, 1999). [8] Therefore, knowledge is a key determinant of the sustainable competitive advantage (Stimpson, 1999) and a critical factor determining the performance of audit firm (Morris and Empson, 1998). Knowledge can be classified as articulable or as tacit (Polanyi, 1967; Lane and Lubatkin, 1998). Articulable or explicit knowledge can be codified and thus can be written and easily transferred (Liebeskind, 1996). Tacit knowledge, however, is not articulable and therefore cannot be easily transferred (Teece, Pisano, and Shuen, 1997). According to Maister (1993), tacit knowledge is integral to professional skills. As a result, tacit knowledge is often unique, difficult to imitate,

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normal distribution of residual term, and the performance measurement of single output only.

[8] Researchers use diverse expressions to define knowledge. For instance, Goldstein (1993) defines knowledge as an adequate understanding of facts, concepts, and their relationship, and as the basic foundation of the information a person needs to perform a task. Bartol and Srivastava (2002, 65) consider knowledge to include information, ideas, and expertise that are relevant for tasks performed by individuals, teams, work units, and the organization as a whole. As focusing on individual's knowledge, this study defines knowledge as the specialty and expertise needed to perform audit firm's job efficiently and effectively.

and uncertain (Mowery, Oxley, and Silverman, 1996).

In terms of the transfer means, explicit knowledge can be shared through verbal or written communication. On the other hand, tacit knowledge is typically shared through socialization, such as highly interactive conversations, apprenticeship (e.g., observation), storytelling, analogies, and shared experiences and activities (Nonaka, 1994; Nonaka and Takeuchi, 1995; Zack, 1999; Stenmark, 2000; Smith, 2001). As tacit knowledge cannot be codified and can only be observed through its application and acquired through practice, its transfer is slow, costly, and uncertain (Kogut and Zander, 1992). In addition, knowledge transfer involves both transmission and receipt. Knowledge receipt must take into account the absorptive capacity of the recipient or the recipient's ability to integrate new and outdated information (Cohen and Levinthal, 1990). Some knowledge, such as financial information, can be transferred and integrated. However, some specific knowledge or personal-oriented knowledge, such as information of leader's character or charm, can neither be transferred nor integrated (Jensen and Meckling, 1992; Grant, 1996).

In a professional service organization, education, experiences, together with innate personal characteristics, are considered to be main elements of expertise (Bonner and Lewis, 1990). D'Aveni (1996) notes that the value of professionals' education often holds throughout their careers. Thus, after completing their advanced educational requirements, most professionals enter their careers as apprentices (for example, as residents/interns in medicine, or as associates in law). In these roles, they continue to learn and thus, they gain significant tacit knowledge through 'learning by doing' (Pisano, 1994). As a result, professionals gain explicit (articulable) knowledge through formal education or professional training and gain tacit knowledge through on-the-job learning and practical experience (Hitt et al., 2001). Most professional service firms, such as audit firm or law firm, always are formed as a partnership. In such an organization structure, those who learn the most and who are highly effective in applying that knowledge are eventually rewarded with partner status and thus own stakes in a firm. On their road to partnership, these professionals acquire considerable knowledge, much of which is tacit (Szulanski, 1996). In the public accounting profession,

professionals in an audit firm include partners, managers, senior auditor, and staff assistants. They gain explicit knowledge, such as accounting, auditing, and taxes rules, through formal academic education and continuing professional education and accumulate tacit knowledge through practical experience and personal characteristics.

According to the resource-based view of firm, resources that are valuable, rare, unique, and difficult to imitate can provide a basis for the firms' sustained competitive advantages (Barney, 1991). Apparently, not all audit firms with knowledge-based human capital gain sustained competitive advantages in the market. Partner/practicing public accountant plays dual role as the chief executive officer and owner in an audit firm and manager is a potential partner of the firm. Both partner and manager, upper-level professionals, have a greater incentive to use their human capital for firm growth and performance than do other employees (Pennings, Lee, and Witteloostuijn, 1998). Accordingly, we assert that human capital from the upper-level professionals is the key factor for audit firm to gain sustained competitive advantages in the market. In addition, knowledge, competency, management notion, and personal charm of the upper-level professionals differ due to their varied family education, formal academic education, and work experience. Human capital of the upper-level professionals is unique, difficult to imitate, and irreplaceable (Stewart, 1997). Whether the upper-level professionals constitutes the key resources, as defined in the resource-based view of firm, to gain sustained competitive advantages depends on their competency to create much more added-values for the firm. In other words, whether manpower of the upper-level professionals is valuable to the firm is the key resource to audit firm.

As stated previously, professionals gain explicit knowledge through formal education and tacit knowledge through work experience. Upper-level professionals endowed with a high level of human capital, high education level and much experience, are more likely to deliver consistent and high-quality services (Mincer, 1974). Further, Maister (1993) states that a professional firm's ability to attract and retain clients depends not only on its competence to produce high-quality services, but also on its connections to potential clients. In addition,

upper-level professionals graduating from the top institutions often develop and maintain elite social networks that can be valuable—as a source of clients (D'Aveni and Kesner, 1993). Experienced upper-level professionals build relationships with current and potential clients and, over time, develop social capital through their client networks (Nahapiet and Ghoshal, 1998). Thus, upper-level professionals with high education level and more experience are expected to create added values for the firm and constitute one of the critical factors gaining sustained competitive advantages. As a result, we expect that an audit firm with more experienced and high education level upper-level professionals improves operating performance and develop the following hypotheses.

H1: In an audit firm, the more upper-level professionals with high academic education level, the higher the operating performance.

H2: In an audit firm, the more experienced upper-level professionals, the higher the operating performance.

Shultz (1961) states that human capital is the capital fostered by the knowledge and skill gained from education and training. 9 Psacharopoulos (1985) points out that investment in education and training foster the formation of human capital and it advances the productivity of employees. When the contribution of employees is more important, company invests more on human capital with which to upgrade their productivity and enhance the company's performance (Youndt et al., 1996; Parnes, 1984). From the perspective of human capital, education and training are regarded as a critical path to invest the human capital. For a company, training is an important investment in human capital. Training not only advances the productivity of employee but also increases the company's performance (Garc ía, 2005). In addition, literatures of human resources practice state that human

9 Both education and training are two main ways to accumulate or invest human capital. However, Becker (1975) points out that various activities that affect future monetary income or mentality through the enhancement of human capital are regarded as investment of human capital. Broadly defined, investment of human capital includes education, training, medical care, health, seeking for employment, and immigration.

resources system, including educational training, is unique and inimitable. Synergies resulting from the system advance a firm's competency and constitute a critical factor for the firm to gain sustained competitive advantages in the market place (Lado and Wilson, 1994; Snell, Youndt, and Wright, 1996).

For an audit firm, how to provide service of high quality and to gain sustained competitive advantages in the market? As stated previously, probably the key factor resides in professionals of high quality, that is, abundant human capital. In addition to gain knowledge through work experience, professional accumulates expertise through on-the-job training. In the course of an audit engagement, knowledge and expertise about client's operating environment, industry, business model, and operations are typically distributed unevenly among audit team members. This is because auditors are routinely assigned to different engagements that vary in terms of complexity and industry (Ramsay, 1994; Davidson and Gist, 1996; Rich, Solomon, and Trotmanm, 1997; Harding and Trotman; 1999; Murthy and Kerr, 2004). Hence, when a new professional is recruited, a professional is promoted, or accounting/auditing standard or related law/rule is promulgated or amended, an audit firm communicates related knowledge and professional skills to professional through educational training. This makes the professional possess necessary competence to finish audit job and to perform it efficiently and effectively.

Hence, it is expected that educational training upgrades the knowledge and competency of the professional and in turn enhance his/her job quality (Huang and Tzeng, 2001). Educational training thus is a supporting system to advance human capital. This system not only advances the human capital level of an audit firm, especially the firm-specific human capital, but also improves the firm's operating performance. Accordingly, we expect that the more the expenditure on educational training of each professional, the higher the expertise, effectiveness and efficiency of his/her job. As a result, operating performance of the audit firm is thus enhanced and we hypothesize:

H3: In an audit firm, the more expenditure on educational training, the higher the operating performance.

2.2 Data

2.2.1 Sample Selection

Empirical data used in this study are obtained from the 2001-2003 Census Report of Public Accounting Firms in Taiwan, published by the Financial Supervisory Commission, Executive Yuan. For consistent comparison criteria, observations with audit firm age less than one or with erroneous data or with incomplete data are deleted. In addition, following Cheng, Wang, and Weng, (2000b), we exclude audit firms having no revenue either in their financial attest service (*FIN*), tax service (*TAX*), or consulting and corporate registration services (*ADV*). For 2001-2003, the final number of observation is 571, 534, and 539, respectively. Table 1 displays the annual sample distribution.

Table 1
Sample Distribution

	2001	2002	2003
Original number of observations	781	762	723
Observations with firm age less than 1	31	21	9
Observations with erroneous data [a]	45	62	58
Observations with incomplete data [b]	37	49	45
Observations with no revenues in financial attest service (*FIN*), tax service (*TAX*), or consulting and corporate registration services (*ADV*)	97	96	72
Final number of observations	571	534	539

[a] For example, audit firm with no operating expense or audit firm no practicing public accountant or audit firm with the number of practicing public accountant fewer than three but with positive attest revenues from public company.
[b] For example, audit firm without any employee or without fixed assets or without total cost.

2.2.2 Sample Classification

Testing the substitution between labor input and capital input of audit firms, Chang and Chen (2005) indicate that technological level between audit firms with and without offering services to public company differs and in turn their patterns of production function vary as well. Sample period of Chang and Chen (2005), 1989 to 2000, is different from this study, 2001 to 2003. In addition, Chen and Lee (2006) further divide audit firms without offering services to public company

into two categories, partnership and proprietorship. To obtain homogeneous sample, that is, observations with the same production technology level, this study replicates Chang and Chen (2005) for the sample period of 2001 to 2003. With the results, this study verifies whether different audit firms reveal different patterns of production function.

Chang and Chen (2005) exploit the Box-Cox transformation procedure to examine the functional form of audit firm. As known, the function form of production between constant elasticity of substitution (CES) and variable elasticity of substitution (VES) differs and the former is a log-linear form and the latter a linear form. Box and Cox (1964) provides a technique to discriminate between linear and log-linear functional forms.

Chang and Chen (2005) define mean capital assets available to each employee (*rK/L*) as non-labor capital expenditure divided by the number of employee. Average salary (*w*) is estimated by the sum of salary expenses, training expenses, pension and fringes divided by the number of employee. Then they specify the relation between capital assets available to each employee (*rK/L*) and average salary (*w*) as follows.

$$(rK/L)^{\lambda} = \alpha_0 + \alpha_1 (w)^{\lambda} \tag{1}$$

where λ is the parameter of the power transformation on the variable.

By the Box-Cox procedure, equation (1) can be rewritten as follows.

$$[((rK/L)^{\lambda} - 1)/\lambda] = \alpha_0^{'} + \alpha_1^{'}[((w)^{\lambda} - 1)/\lambda] + u_i \tag{2}$$

where u_i is the normally distributed error term.

Equation (2) can be assessed by the maximum likelihood techniques. As noted by Lovell (1973), the differential equation of (2) defines a class of production functions. When λ approximates zero, equation (2) approaches CES model. If λ approximates one, then equation (2) reduces to the VES model. According to equation (2) and given λ, the maximum likelihood estimate of the variance of residual is obtained by the regression of $(rK/L)^{\lambda}$ on $(w)^{\lambda}$. Except for

the constant term, Box and Cox (1964) derive a maximum logarithmic likelihood for determining the functional form parameter as follows.

$$L_{\max}(\lambda) = -(N/2)\ln\hat{\sigma}^2(\lambda) + (\lambda - 1)\sum_{i=1}^{N}(rK/L) \tag{3}$$

where N is the sample size.

The maximum logarithmic likelihood over the entire parameter space can be found by estimating the λ in equation (3). By the following equation, we have the 95% confidence interval of λ.

$$2[L_{\max}(\hat{\lambda}) - L_{\max}(\lambda)] < \chi_1^2(\alpha) = 3.84 \tag{4}$$

where χ_1^2 denotes the chi-square statistic with one degree of freedom.

Table 2 lists the functional form of audit firm estimated from equation (2) to equation (4) for 2001-2003. Total observations are divided into audit firms with and without public company services, which means that the audit firm renders and does not render financial statements audit service to the public company. Further, audit firms without public company service are portioned into partnership and proprietorship firms. As shown, confidence intervals of λ for the audit firms with and without public company services do not overlap, which indicating that their functional forms of production differ materially. In contrast, confidence intervals of λ for the partnership and proprietorship firms overlap. Hence, we cannot identify any significant difference in the functional form of production between partnership and proprietorship firms. Meanwhile, we conduct additional tests to examine whether the value of λ differ from zero or one for audit firms with public company services, without public company services, partnership firms, or proprietorship firms. The untabulated results indicate that all values of λ are different from zero or one significantly. Consistent with Chang, Yang, and Chen, (2004), our results demonstrate that no definite functional form of production exists in the audit firms. As a result, we decide to utilize a non-parametric method that imposes no assumption and least restriction on the functional form of production, that is, DEA. Thus, it is feasible for us to examine the efficiency and return to scale of audit firm by the DEA.

As can be seen from the column of audit firms without public company service in Table 2, no significant difference exists in the functional form of production between partnership and proprietorship audit firms. To obtain audit firms with identical technology level for analyzing efficiency and return to scale, total observations are partitioned into two categories in terms of providing financial statements audit service to public company. For ease of subsequent exposition, audit firms with public company services are referred to as large firms and those without public company services are referred to as small firms.

Table 2

Estimating Results of Functional Form of Audit Firms for 2001-2003

	Total audit firms		Audit firms without public company service	
	With public company service	Without public company service	Partnership	Proprietorship
λ	0.479	0.199	0.185	0.206
Confidence interval of λ	0.329-0.629	0.159-0.238	0.113-0.257	0.159-0.253
N	171	1,473	437	1,036
Log likelihood	-2459	-21738	-6439	-15286
LR χ_1^2	4.34	15.40	11.28	24.12
Prob. $>\chi_1^2$	0.037**	0.000***	0.001***	0.000***

1.N = number of observations.
2.** , *** denotes significant at 5% and 1% level, respectively.

2.2.3 Classification of Groups for Comparison

To compare operating performance of different sized audit firms, we first conduct DEA to acquire efficiency scores for large and small firms. Then we compare efficiency scores by either leading group or total number of employee for large and small firms. As known, Big 4 international firms are regarded as a leading group. Hence large firms are divided into Big 4 and non-Big 4 groups to compare efficiency score. At present, Big 4 include KPMG, PricewaterhouseCoopers, Ernst & Young, and Deloitte & Touche. Dissolution of the late Arthur Andersen makes its local affiliate firm combine with the local

member of Deloitte & Touche to become the largest firm in Taiwan effective June 1, 2003. Thus, actually Big 4 comprises five international firms for 2001-2002. For small firms, no generally perceived leading group is available. Small firms are partitioned into two categories in terms of median of total number of employee, that is, firms with number of employee less and more than 9.

2.2.4 Detection of Outlier

Outlier refers to an observation diverting away from a cluster of data and is always incongruent with other dataset (Barnett and Lewis, 1995). Outlier does not have the attribute of general acceptability and thus is excluded from the statistical research (Davies and Gather, 1993). [10] In DEA, outlier materially affects the estimation of efficiency score and thus has to be detected and excluded. However, Simar (2003) argues that no optimal or magic detection procedure is available in the definition of detection method. Sampaio de Sousa and Stosic (2005) point out that most detection methods heavily depend on manual data inspection and are hard to apply in the large sample condition. Accordingly, to detect outlier efficiently, this study exploits the Wilson (1995) procedure and designs related program by Matlab. [11]

This study defines outliers as a decision making unit (DMU) under assessment that affects other DMUs and its total efficiency score is greater than 5. After detection, no outlier that materially affects efficiency of other firms is found in the large firm sub-sample. However, a few outliers exist in the small firm sub-sample. Number of outlier is 2, 1, and 4 for 2001, 2002, and 2003. Table 3

---

[10] Outlier is synonymous with deviate observation, extreme observation, influential observation, and abnormal observation.

[11] If a DMU under assessment with efficiency score that materially affects other DMU, Wilson (1995) argues, the DMU is probably an outlier with material influence and the detection procedure is as follows. (1) Compute the super efficiency score for all DMUs under constant return to scale assumption. That is, the DMU is excluded from the constraint set when efficiency for the DMU is computed. Thus efficiency score is not restricted to be 1 and DMU with efficiency score greater than 1 is probably the outlier. (2) For every possible outlier, compute the efficiency score under constant return to scale assumption in the situation that the DMU intended for computing efficiency score and the possible outlier are excluded from the constraint set. (3) For every possible outlier, compute its extent of effect on efficiency score of other DMU, including mean and total efficiency score.

displays the annual sample distribution with outlier excluded. As no outlier detected in the large firm, the number of observations remains unchanged. Total number of observations is still 171 and respective number of observations is 59, 58, and 54 for 2001, 2002, and 2003. After outliers are deleted, total number of observations of small firm is 1,466. For 2001-2003, annual number of observations is 510, 475, and 481 respectively. Thus we have total final number of observations 1,637.

Table 3

Sample Distribution with Outliers Deleted

Year	Large firm			Small firm			Total
	Big 4[a]	Non-Big 4	Subtotal	NE<9[b]	NE≧ 9[b]	Subtotal	
2001	5	54	59	273	237	510	569
2002	5	53	58	254	221	475	533
2003	4	50	54	258	223	481	535
Total			171			1,466	1,637

a Big 4 include KPMG, PricewaterhouseCoopers, Ernst & Young, and Deloitte & Touche.

b NE<9 denotes audit firms with number of employees fewer than 9 and NE≧9 denotes audit firms with number of employees equal to and more than 9.

2.3 Model and Variable Definitions

2.3.1 Analysis of Efficiency and Return to Scale

By definition in DEA, efficiency is referred to whether we may produce equal output with the least input or we may produce more output with equal input (Cooper, Seiford, and Tone, 2006). Originally, this measurement approach is established by Farrell (1957). [12] Then Charnes, Cooper, and Rhodes (1978) transform the engineering measurement of efficiency into an economic

[12] Farrell (1957) constructs a production frontier to envelop all data and use the frontier as a benchmark. The efficiency of other observation is measured along a ray from the observed production point to the production frontier. Thus, the production frontier-based approach is also referred to as a measurement of relative efficiency.

perspective estimate of efficiency (hereafter the CCR model). [13] Finally, Banker, Charnes, and Cooper (1984) extend the CCR model and split the technical efficiency into pure technical efficiency and scale efficiency (hereafter the BCC model). [14] Technical efficiency measures the resources utilization efficiency of an organization. It identifies the inefficiency resulting from either incorrect decision-making or poor administration of the management and /or from the waste of resources due to scale effects. In other words, we may ascribe the existence of full technical efficiency or technical inefficiency to the management's competency or/and scale effects.

If the efficiency measurement ascribes inefficiency to the management's competency only, we entitle the technical efficiency as pure technical efficiency and as scale efficiency if ascribes inefficiency to the scale effects only. In addition, an organization with full scale efficiency is in the optimal scale of production, that is, constant return to scale. While an organization with scale inefficiency, it is either in the increasing return to scale or in the decreasing return to scale. [15]

In general, we may estimate efficiency score from either input-orientated or output-orientated measure. [16] When the producer focuses on market demand and can adjust the amount of production element freely, Lovell (1993) suggests that efficiency score should be measured from the input-orientated measure. In contrast to the level of services offered, audit firm possesses more space to adjust

---

[13] Charnes, Cooper, and Rhodes (1978) employ dual transformation and under constant returns to scale assumption to transform the unit isoquant model of Farrell (1957) into ordinary linear programming model.

[14] Using the concept of distance function from Shephard (1970) and to derive the same model as CCR, Banker, Charnes, and Cooper (1984) add four assumptions: production possibility set with convexity, inefficiency postulate, ray unboundedness, and minimum extrapolation. Then, they relax the restriction of ray unboundedness assumption to establish a measurement model under variable returns to scale.

[15] If an audit firm with 1 employee produces 1 million outputs but produces 1.5 million outputs with 2 employees, then the firm is in the production condition of decreasing return to scale. Similarly, another audit firm produces 1 million outputs with 1 employee and produces 2 million outputs with 2 employees, and then the firm is in the condition of constant return to scale and optimal production scale.

[16] Conceptually, the input-orientated measure: given the same output quantity, whether we can produce it with the least input? However, the output-orientated measure: given the same intput, whether we can produce the most output quantity?

elements. Accordingly, this study measures the efficiency score from the input-orientated measure. Under this measure, technical efficiency, pure technical efficiency, and scale efficiency lies between 0 and 1. Take technical efficiency as an example. If the technical efficiency score of a DMU equals 1, the DMU has full technical efficiency, which means that given the output level the DMU uses the least amount of element. If the technical efficiency score is less than 1, technical inefficiency exists in the DMU. Given the output level, the DMU may decrease the amount of input element. In detail, some of the input resources yields no benefit and pertains to resource waste. Likewise, both pure technical efficiency and scale efficiency scores apply to the same exposition above. As stated previously, technical efficiency is further divided into pure technical efficiency and scale efficiency. Hence, their relationship is: technical efficiency score = pure technical efficiency score × scale efficiency score. [17]

First, we employ both the Charnes, Cooper, and Rhodes (CCR) model to estimate technical efficiency (*TE*) and Banker, Charnes, and Cooper (BCC) model

$$
\begin{aligned}
TE = \min \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) & \\
\text{s.t} \quad \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io} \qquad & i = 1,2,\ldots,m. \quad j = 1,2,\ldots,n. \\
\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro} \qquad & r = 1,2,\ldots,s. \\
\lambda_j, s_i^-, s_r^+ \geq 0 \qquad & \forall\ i,j,r.
\end{aligned}
\tag{5}
$$

---

[17] For example, audit firm A with 1 employee produces 1 million revenues but audit firm B produces 1 million revenues with 2 employees. In contrast to firm A, the technical efficiency score of firm B is 0.5. This indicates that firm B may reduces 50% input of manpower to produce the same revenues as firm A (i.e., 2 employees × 50% = 1 employee). As stated, technical efficiency score is the product of pure technical efficiency score and scale efficiency score. If firm B has 0.5 technical efficiency score resulting from pure technical efficiency (that is, pure technical efficiency score is equal to 0.5 and scale efficiency score is equal to 1), then its inefficiency is derived from inappropriate utilization of human resources by the management. That is, firm B has waste of manpower. However, if firm B has 0.5 technical efficiency score resulting from scale efficiency (that is, pure technical efficiency score is equal to 1 and scale efficiency score is equal to 0.5), then its inefficiency is derived from scale size. Specifically, firm B increases no revenue after the additional manpower of 1 employee.

to estimate pure technical efficiency (*PTE*), and as a result obtain scale efficiency *TE* denotes technical

(*SE*) by derivating the preceding two efficiencies. Displayed below is the CCR model. efficiency. ε is a non-Archimedean number and defined as a positive real number with extremely small value. x_{io} is the input of element i by a specific DMU. y_{ro} is the output of service r by a specific DMU. x_{ij} denotes the input of element i by audit firm j. y_{rj} denotes the output of service r by audit firm j. λ is the weight and s_i^-, s_r^+ denotes the input slacks, and the output slacks, respectively.

BCC model is as follows.

$$
\begin{aligned}
& PTE = \min \theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+) \qquad (6) \\
& \text{s.t} \quad \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io} \qquad i = 1,2,...,m. \quad j = 1,2,...,n. \\
& \qquad \sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro} \qquad r = 1,2,...,s. \\
& \qquad \sum_{j=1}^{n} \lambda_j = 1 \\
& \qquad \lambda_j, s_i^-, s_r^+ \geq 0 \qquad \forall\, i, j, r.
\end{aligned}
$$

PTE denotes the pure technical efficiency.

In theory, return to scale depicts the changes in output as all production elements change. Constant return to scale, for example, indicates that output will double if all production elements double. That is, if output changes in proportion to the change in production elements, then the production situation is a constant return to scale. In contrast, increasing return to scale denotes that average output improves increasingly as input elements increase. Decreasing return to scale means that average output reduces decreasingly as input element increases (Varian, 1996). Conceptually, the constant return to scale, increasing return to scale, and decreasing return to scale are equivalent to the parametric constant economy to scale, increasing economy to scale, and decreasing economy to scale. In order to

know the exact return to scale condition in which an organization locates, we need to compare the value of technical efficiency under the three returns to scale assumptions. This includes technical efficiency (*TE*), pure technical efficiency (*PTE*), and technical efficiency under non-increasing return to scale (TE^N). [18] The estimation model of TE^N is defined as follows (Banker, Chang, and Cooper, 1996).

$$
\begin{aligned}
TE^N &= \min \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \\
\text{s.t} \quad & \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io} \qquad i = 1,2,\ldots,m. \quad j = 1,2,\ldots,n. \\
& \sum_{i=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro} \qquad r = 1,2,\ldots,s. \\
& \sum_{j=1}^{n} \lambda_j \le 1 \\
& \lambda_j, s_i^-, s_r^+ \ge 0 \qquad \forall\, i, j, r.
\end{aligned}
\tag{7}
$$

Following Cheng, Wang, and Weng (2000b) and Banker, Chang, and Cunningham (2005), we identify the input and output variables needed to estimate the models above, that is, x and y. Output variables include revenue of financial attestation (*FIN*), revenue of tax services (*TAX*), and revenue of advisory services (*ADV*). [19] Revenue of audit of financial statements (*FIN*) is defined as revenue

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[18] If $TE=PTE$, the DMU is in the production of constant return to scale. If $PTE=TE^N$, the DMU is in the production of decreasing return to scale. However, If $PTE \neq TE^N$, the DMU is in the production of increasing return to scale (Banker et al., 2004).

[19] Both Cheng, Wang, and Weng (2000b) and Banker, Chang, and Cunningham (2005) incorporate audit revenues, tax revenues, and management consulting revenues as output variables. However, the tax revenues do not include revenues from audit of an income tax return. According to the Survey Report of Public Accounting Firm in Taiwan, the major five sources of revenue for an audit firm are from audit of an income tax return, audit of financial statements of public companies, audit of financial statements for granting a bank loan, audit of financial statements of nonpublic companies, and management consultation. To obtain a more appropriate source of revenues for exposition, this study reclassifies the revenues from audit of an income tax return into the tax revenues. The revenues from audit of financial statements of public companies, audit of financial statements for granting a bank loan, and audit of financial

from audits of financial statements for public company, nonpublic companies, and for granting a bank loan. Revenue of tax services (*TAX*) includes revenue from rendering audit of an income tax return, tax planning, administrative remedy of internal taxation, and other tax operations. We define revenue of advisory services (*ADV*) as revenue from offering management advisory service, corporate registration, and bookkeeping and accounting service.

Table 4
Definitions of Input and Output Variable

Variable	Definition
Input variable	
Total number of employee (*LAB*)	Sum of the number of partners, managers, senior auditors, and staff assistants.
Total fixed assets (*CAP*)	Fixed assets owned by a firm and assets leased by the firm less fixed assets rented out. ◦
Operating cost (*OPE*)	Stationery, printing, utilities, newspaper and magazine, and postage.
Output variable	
Revenue of audit of financial statements (*FIN*)	Revenue from audits of financial statements for public company, nonpublic companies, and for granting a bank loan.
Revenue of tax services (*TAX*)	Revenue from rendering audit of an income tax return, tax planning, administrative remedy of internal taxation, and other tax operations.
Revenue of advisory services (*ADV*)	Revenue from offering management advisory service, corporate registration, and bookkeeping and accounting service.

Next, this study modifies the input variables used in Cheng, Wang, and Weng, (2000b). Input variables used in this study include labor, capital, and operating cost and defined as total number of employee (*LAB*), total fixed assets (*CAP*), and operating cost (*OPE*), respectively. [20] Total number of employee (*LAB*) is

statements of nonpublic companies are grouped together and are referred to as revenue of financial attestation instead of as audit revenues.

[20] Input variables employed by Cheng, Wang, and Weng (2000b) include ending number of employees and net fixed assets. In addition to the input of manpower and fixed assets, audit firm incurs operating cost such as printing, postage, and stationery. Following Ou and Lin (2000) and Hsu et al. (2003) examining the knowledge-intensive organization, this study include not only labor and capital but also operating cost as the third input variable.

defined as sum of the number of partners, managers, senior auditors, and staff assistants. Total fixed assets (*CAP*) include fixed assets owned by a firm and assets leased by the firm less fixed assets rented out. Operating cost (*OPE*) is measured as expenditure on stationery, printing, utilities, newspaper and magazine, and postage. Table 4 lists the definitions of input and output variable.

2.3.2 Effect of Human Capital on Operating Performance

The resource-based view of firm suggests that firm depends on its critical or core resources to adapt to the changing environment and to create and sustain its competitive advantages (Penrose, 1959; Prahalad and Hamel, 1979; Wernerfelt, 1984). As stated previously, we argue that experienced upper-level professionals with high academic degree represent the critical resources with which an audit firm plays an important role in the market. To render professional service with quality, audit firm must be backed by a group of professionals with expertise. In general, professionals gain knowledge through formal education and through learning on the job. The human capital stock of formal education may be assessed by the education level acquired by the professionals. However, human capital acquired from learning on the job may be estimated through experience and the expenditure on educational training by an audit firm. Additionally, Cheng, Wang, and Weng (2000b) state that factors affecting technical efficiency of an audit firm include firm size, firm age, service concentration, and number of firm branch. In addition, CCR model (equation 5) comes from the assumption of long run optimal production scale (Wang and Lee, 2006). To achieve full technical efficiency constitutes the long term goal pursued by an enterprise. Accordingly, this study employs the technical efficiency assessed by CCR model to measure operating performance of an audit firm. Technical efficiency lies between 0 and 1, different from ordinary least square regression model with unlimited dependent variable. Accordingly, we exploit Tobit regression model instead. Taken together, we develop our empirical model as follows.

$$TE = \beta_0 + \beta_1 EDU + \beta_2 EXP + \beta_3 TRAIN + \beta_4 AGE + \beta_5 OFE + \beta_6 DIV + \beta_7 LNSZ + \beta_8 Y2002 + \beta_9 Y2003 + \varepsilon \quad (8)$$

Dependent variable is the technical efficiency (*TE*) used to measure the operating performance of an audit firm. Experimental variables include intensity of upper-level professionals with high academic educational degree (*EDU*), intensity of experienced upper-level professionals (*EXP*), and mean expenditure on educational training (*TRAIN*). In addition, firm age (*AGE*), establishment of branch (*OFE*), business diversification (*DIV*), firm size (*LNSZ*), and year dummy variable (*Y2002* and *Y2003*) are included as control variables. The following depicts the definitions of independent variables and their expected relationship with technical efficiency. Table 5 displays the definitions of variable used in Tobit regression model.

(1) Intensity of upper-level professionals with high academic educational degree (*EDU*)

Upper-level professionals with high academic educational degree possess quality expertise and competency to direct assistants to complete job assigned. Thus, we expect that the association between intensity of upper-level professionals with high academic degree and technical efficiency is positive. *EDU* is operationalized as the number of upper-level professionals with master or doctoral degree to the number of professional employees. Upper-level professionals include public practicing accountants and managers. Professional employees comprise public practicing accountants, managers, and staff assistants.

(2) Intensity of experienced upper-level professionals (*EXP*)

Experienced upper-level professionals not only direct assistants to complete assignments efficiently with their rich expertise but also expand client base through their abundant social network. As a result, a positive relation between experienced upper-level professionals and technical efficiency is expected. *EXP* is defined as a ratio of upper-level professionals older than 35 years. [21]

(3) Expenditure on educational training (*TRAIN*)

Some audit firms initiate educational training when a professional is promoted or professional standard/rule is amended. This leads him/her to familiar

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[21] With consulting partners in two audit firms, we define experienced upper-level professionals as professionals older than 35 years.

with the job assigned quickly and thus enhances his/her competency. Hence, the relationship between expenditure on educational training and technical efficiency is positive. We define *TRAIN* as total expenditure on educational training divided by ending number of professional employees.

(4) Firm age (*AGE*)

Cheng, Wang, and Weng (2000b) report a significantly positive relationship between firm age and technical efficiency of audit firms due in part to the learning-curve effects accumulated. The age of a CPA firm (*AGE*) is defined as the difference between data survey year and establishment year of audit firm plus 1.

(5) Establishment of branch (*OFE*)

Cheng, Wang, and Weng (2000b) report an inferior technical efficiency of audit firm with a branch, suggesting an inefficient management over the branch. We construct a dummy variable and set to 1 when a branch is established and 0, otherwise.

(6) Business diversification (*DIV*)

Based on the existence of economies of scope, Cheng, Wang, and Weng (2000b) suggest a significant negative between business diversification and technical efficiency of an audit firm. *DIV* is measured by an Entropy index over three largest business revenue earned by an audit firm: revenue of audit of financial statements (*FIN*), revenue of tax services (*TAX*), and revenue of advisory services (*ADV*).

(7) Firm size (*LNSZ*)

Cheng, Wang, and Weng (2000b) find a positive relationship between size and technical efficiency of an audit firm. Presumably, an audit firm is able to enjoy economies of scale when its size expands. In this study, *LNSZ* is measured as nature log of total number of employees (*SIZE*) in an audit firm. Total employees include public practicing accountants, managers, staff assistants, and the administrative staff.

(8) Year dummy variable (*Y2002* and *Y2003*)

As technical efficiency is estimated annually, we construct year dummy variable to capture the effects of different efficiency frontier and outside

environment in different year. Following Tseng, Kao, and Ho (2005) and Wang and Lee (2006), we establish dummy variable of *Y2002* and *Y2003*. If *Y2002* =1, it denotes year 2002 and *Y2003*=1 denotes year 2003. If *Y2002*=*Y2003*=0, it denotes year 2001.

Table 5

Definitions of Variable in Tobit Regression Model

Variable	Definition
Dependent variable	
Technical efficiency (*TE*)	In DEA, technical efficiency score estimated by CCR model.
Experimental variables	
Intensity of upper-level professionals with high academic educational degree (*EDU*)	(sum of the number of public practicing accountants and managers with master or doctoral degree) ÷ (sum of the number of public practicing accountants, managers, and staff assistants)
Intensity of experienced upper-level professionals (*EXP*)	(sum of the number of public practicing accountants and managers older than 35 years) ÷ (sum of the number of public practicing accountants, managers, and staff assistants)
Expenditure on educational training (*TRAIN*)	Annual expenditure on educational training ÷ (sum of the number of public practicing accountants, managers, and staff assistants)
Control variables	
Firm age (*AGE*)	Data survey year - establishment year of audit firm + 1
Establishment of branch (*OFE*)	When a branch is established *OFE*=1 and 0, otherwise
Business diversification (*DIV*)	(ratio of revenues from audit of financial statements) × log(1 ÷ ratio of revenues from audit of financial statements) + (ratio of revenues of tax services) × log(1 ÷ ratio of revenues of tax services) + (ratio of revenues of advisory services) × log(1 ÷ ratio of revenues of advisory services)
Firm size (*LNSZ*)	Nature log of total number of public practicing accountants, managers, staff assistants, and the administrative staff.
Year dummy variable (*Y2002* and *Y2003*)	If *Y2002* =1, it denotes year 2002 and *Y2003*=1 denotes year 2003. If *Y2002*=*Y2003*=0, it denotes year 2001.

3. Empirical Results

3.1 Descriptive Statistics and Correlation Coefficients

Descriptive statistics of input and output variable are displayed in Table 6 and 7 for large and small firm, respectively. As can be seen from Table 6, except

Table 6

Descriptive Statistics of Input and Output Variable for Large Firm

	LAB	*CAP*	*OPE*	*FIN*	*TAX*	*ADV*
2001 (N=59)						
Mean	157	107,028,028	59,394,203	105,610,861	58,996,936	30,069,486
Max.	1,651	1,420,741,872	938,147,783	1,405,686,316	715,508,031	627,760,591
Min.	13	280,974	1,944,781	232,541	2,862,049	454,802
Median	52	32,642,335	11,121,261	13,479,387	20,469,586	6,388,361
S.D.	337	258,912,177	167,331,672	301,348,368	127,622,754	94,423,605
2002 (N=58)						
Mean	168	108,574,552	65,002,175	117,224,118	55,705,394	32,102,336
Max.	1,542	1,124,719,558	1,040,000,000	1,631,239,155	707,898,321	455,003,305
Min.	15	1,200,000	1,562,318	170,000	3,861,700	208,500
Median	50	30,490,189	11,911,545	13,495,500	19,256,218	5,353,063
S.D.	353	237,938,577	182,658,841	335,021,381	120,466,181	85,148,757
2003 (N=54)						
Mean	170	99,857,270	68,670,405	135,812,127	58,240,849	34,814,881
Max.	2,001	1,919,303,645	1,212,204,071	2,694,310,845	562,961,475	586,589,875
Min.	10	693,083	2,436,646	106,506	2,046,030	762,815
Median	50	30,264,871	13,562,306	16,258,338	20,307,099	6,067,686
S.D.	393	286,323,010	203,783,663	451,109,624	124,271,411	104,837,834

1.N = number of observations. *LAB* = total number of employee. *CAP* = total fixed assets. *OPE* = operating cost. *FIN* = financial attestation revenue. *TAX* = tax revenue. *ADV* = advisory service revenue.
2.All variable are expressed in new Taiwan dollar except *LAB*.

both total fixed assets (*CAP*) and tax revenue (*TAX*), total number of employee (*LAB*), operating cost (*OPE*), financial attestation revenue (*FIN*), and advisory

service revenue (*ADV*) of large firm, on average, increase year by year. For the small firm, shown in Table 7, operating cost (*OPE*) increases annually. However, total number of employee (*LAB*), total fixed assets (*CAP*), financial attestation revenue (*FIN*), tax revenue (*TAX*), and advisory service revenue (*ADV*) either remain intact or fluctuate over time.

Table 7

Descriptive Statistics of Input and Output Variable for Small Firm

	LAB	*CAP*	*OPE*	*FIN*	*TAX*	*ADV*
2001 (N=510)						
Mean	11	9,428,046	2,049,575	1,375,350	3,650,960	1,551,527
Max.	58	70,302,833	23,105,878	12,380,223	34,457,170	18,459,491
Min.	1	11,976	83,141	21,598	4,990	499
Median	8	7,636,017	1,387,138	798,424	2,535,297	688,686
S.D.	9	8,062,489	2,095,905	1,723,509	3,865,816	2,243,945
2002 (N=475)						
Mean	11	9,999,314	2,066,758	1,439,179	3,727,934	1,505,310
Max.	93	52,754,963	19,127,110	25,000,000	44,007,939	19,496,790
Min.	2	420,000	20,000	10,000	30,000	1,000
Median	8	8,009,970	1,350,367	800,000	2,508,120	610,000
S.D.	11	8,091,044	2,294,592	2,312,479	4,403,262	2,377,551
2003 (N=481)						
Mean	11	9,534,635	2,068,803	1,409,333	3,691,514	1,580,123
Max.	72	137,327,218	21,592,465	24,814,334	48,595,744	20,731,860
Min.	2	108,807	55,836	14,242	50,148	1,003
Median	8	7,183,120	1,378,192	797,109	2,449,218	608,393
S.D.	10	10,103,863	2,279,356	2,049,970	4,372,807	2,624,836

1.N = number of observations. *LAB* = total number of employee. *CAP* = total fixed assets. *OPE* = operating cost. *FIN* = financial attestation revenue. *TAX* = tax revenue. *ADV* = advisory service revenue.

2.All variable are expressed in new Taiwan dollar except *LAB*.

In order to examine the isotonicity required by DEA, that is, increase in input accompanied by non-decrease in output, this study estimates the Pearson

correlation coefficients for input and output variables twice to examine their correlation. The untabulated estimates indicate that the Pearson correlation coefficients for large and small firms reach 1% significance level. This implies either no negative correlation or low correlation.

Table 8

Descriptive Statistics of Independent Variables Used in Regression Model

	EDU	*EXP*	*TRAIN*	*AGE*	*DIV*	*SIZE*	*LNSZ*
Panel A: Large firm (N=171)							
Mean	0.07	0.20	4,571	19	0.92	165	3.97
Max.	0.59	1.00	51,080	44	1.10	2,001	7.46
Min.	0.00	0.05	0	2	0.19	10	1.79
Median	0.06	0.18	1,595	17	0.95	50	3.81
S.D.	0.07	0.11	8,283	10	0.15	359	1.16
Panel B: Small firm (N=1,466)							
Mean	0.08	0.28	4,466	12	0.80	11	1.89
Max.	1.00	1.00	100,886	54	1.10	93	4.42
Min.	0.00	0.00	0	2	0.19	1	0.00
Median	0.00	0.22	669	11	0.83	8	1.79
S.D.	0.15	0.22	10,572	7	0.20	10	0.78

1.N = number of observations. *EDU* = intensity of upper-level professionals with high academic degree. *EXP* = intensity of experienced upper-level professionals. *TRAIN* = expenditure on educational training. *AGE* = firm age. *DIV* = business diversification. Both *SIZE* and *LNSZ* denote firm size and *LNSZ* is expressed as nature log of *SIZE*.

2.*TRAIN* is expressed in new Taiwan dollar.

Descriptive statistics of independent variables used in the Tobit regression model are shown in Table 8. As can be seen from Panel A, on average, large firm has intensity of upper-level professionals with high academic degree (*EDU*) of 0.07, intensity of experienced upper-level professionals (*EXP*) of 0.20, expenditure on educational training (*TRAIN*) of $4,571, firm age (*AGE*) of 19, and firm size (*SIZE*) of 165. For small firm, shown in Panel B, average intensity of upper-level professionals with high academic degree (*EDU*) is 0.08, mean intensity of experienced upper-level professionals (*EXP*) is 0.28, mean expenditure on educational training (*TRAIN*) is $4,466, mean firm age (*AGE*) is 12, and mean firm size (*SIZE*) is 11. Meanwhile, this study estimates the Pearson

correlation coefficients (untabulated) for independent variables in the Tobit regression model. For both large and small firm, the correlation coefficients among independent variables are not high enough needed for further treatment.

Table 9

Efficiency Estimates and Pair-Wise Comparisons for Large Firm

	Large firm		Non-parametric test		
	Big 4	Non-Big 4	M-W U stat.	W. W stat.	p-value
2001					
TE	0.97(0.07)	0.83(0.15)	64	1549	0.05**
PTE	1.00(0.00)	0.89(0.12)	55	1540	0.03**
SE	0.97(0.07)	0.93(0.10)	99	1584	0.33
N	5	54			
2002					
TE	0.96(0.06)	0.85(0.13)	69	1500	0.08*
PTE	1.00(0.00)	0.89(0.11)	48	1479	0.02**
SE	0.96(0.06)	0.96(0.07)	127	1558	0.87
N	5	53			
2003					
TE	0.98(0.04)	0.89(0.12)	56	1331	0.15
PTE	1.00(0.00)	0.92(0.11)	48	1323	0.09*
SE	0.98(0.04)	0.97(0.06)	86	1361	0.67
N	4	50			

1.N = number of observations. *TE* = technical efficiency. *PTE* = pure technical efficiency. *SE* = scale efficiency. M-W U stat. stands for Mann-Whitney U statistic. W. W stat. stands for Wilcoxon W statistic.

2.Value in parenthesis denotes standard error of efficiency estimates.

3.Big 4 include KPMG, PricewaterhouseCoopers, Ernst & Young, and Deloitte & Touche.

4.*, ** Significant at the 10% and 5% level, respectively.

3.2 Analysis of Efficiency

Table 9 reports the efficiency estimates and pair-wise comparisons by group for large firm. As indicated, on average, there are significant differences in pure technical efficiency (*PTE*) between Big 4 and non-Big 4 each year. Also, difference in technical efficiency (*TE*) between Big 4 and non-Big 4 is significant every year except 2003. However, there is no significant difference in scale efficiency (*SE*). As known, technical efficiency (*TE*) is composed of pure technical efficiency (*PTE*) and scale efficiency (*SE*). Results above indicate that the superior technical efficiency (*TE*) of Big 4 results from pure technical efficiency (*PTE*) not from scale efficiency (*SE*). In addition, for 2001-2003, annual pure technical efficiency (*PTE*) is 1, a full pure technical efficiency. This implies that Big 4 provide the same service level as non-Big 4 with less input even if scale size is not taken into consideration. That is, the management of Big 4 utilizes resources more efficiently

Table 10

Efficiency Estimates and Pair-Wise Comparisons for Small Firm

	Small firm		Non-parametric test		
	NE< 9	NE≧ 9	M-W U stat.	W. W stat.	p-value
2001					
TE	0.62(0.20)	0.65(0.16)	28822	66223	0.03**
PTE	0.72(0.17)	0.71(0.19)	31203	59406	0.49
SE	0.86(0.16)	0.93(0.09)	23819	61220	0.00***
N	273	237			
2002					
TE	0.62(0.19)	0.67(0.16)	22645	55030	0.00***
PTE	0.75(0.17)	0.73(0.18)	26717	51248	0.36
SE	0.83(0.18)	0.93(0.07)	20601	52986	0.00***
N	254	221			
2003					
TE	0.60(0.19)	0.65(0.17)	23774	57185	0.00***
PTE	0.72(0.17)	0.71(0.19)	27371	52347	0.36

Table 10

Efficiency Estimates and Pair-Wise Comparisons for Small Firm

	Small firm		Non-parametric test		
	NE< 9	NE≧ 9	M-W U stat.	W. W stat.	p-value
SE	0.83(0.18)	0.93(0.08)	18585	51996	0.00***
N	258	223			

1.N = number of observations. *TE* = technical efficiency. *PTE* = pure technical efficiency. *SE* = scale efficiency. M-W U stat. stands for Mann-Whitney U statistic. W. W stat. stands for Wilcoxon W statistic.

2.Value in parenthesis denotes standard error of efficiency estimates.

3.NE<9 denotes audit firms with number of employees less than 9 and NE≧9 denotes audit firms with number of employees equal to and more than 9.

4.**, *** Significant at the 5% and 1% level, respectively.

The efficiency estimates and pair-wise comparisons by group for small firm are listed in Table 10. As shown, on average, there are significant differences in both technical efficiency (*TE*) and scale efficiency (*SE*) between audit firms with number of employee less than 9 and more than 9. However, no significant difference exists in the pure technical efficiency (*PTE*). In theory, technical efficiency (*TE*) is composed of pure technical efficiency (*PTE*) and scale efficiency (*SE*). Results above indicate that the superior technical efficiency (*TE*) of audit firms with number of employee more than 9 results mainly from scale efficiency (*SE*) not from pure technical efficiency (*PTE*). For example, in 2001, the mean scale efficiency (*SE*) of audit firms with number of employee less than 9 and more than 9 is 0.86 and 0.93, respectively. This implies that audit firms with number of employee more than 9 provide the same service level as that of less than 9 with less input. However, the superior performance comes from better production scale owned by the firm not from efficient utilization of resources by the management.

3.3 Analysis of Return to Scale

Table 11 displays the number of audit firm under different return to scale. As shown in column A, most of the Big 4 are under constant return to scale (CRS) and optimal production scale, 60%, 60%, and 75% for the three years studied. For

non-Big 4 firms, most are under decreasing return to scale (DRS) in 2001 (39%), under increasing return to scale (IRS) in 2002 (38%), and under constant return to scale (CRS) in 2003 (50%). In terms of tendency, this indicates that non-Big 4 adapt their scale size aggressively and thus make most of them under optimal production scale in 2003.

For small firm, shown in column B, most of the firms with number of employees fewer than 9 and that of equal to and more than 9 are under increasing return to scale (IRS) and decreasing return to scale (DRS), respectively. In terms of annual tendency, 11% of audit firms with number of employees less than 9 are under constant return to scale (CRS) in 2001 and only 6% and 7% in 2002 and 2003, suggesting that adjustment of firm size is needed. No evident annual tendency is observed for audit firms with number of employees equal to and more than 9. During 2001-2003, 12% of the firms are under constant return to scale (CRS) in 2001 but only 6% in 2002.

Table 11

Number of Audit Firm Under Different Return to Scale

	A. Large firm		B. Small firm	
	Big 4	Non-Big 4	NE< 9	NE≧ 9
2001				
DRS	2(40%)	21(39%)	10(4%)	137(58%)
CRS	3(60%)	16(30%)	30(11%)	29(12%)
IRS	0(0%)	17(31%)	233(85%)	71(30%)
2002				
DRS	2(40%)	14(26%)	29(11%)	179(81%)
CRS	3(60%)	19(36%)	15(6%)	14(6%)
IRS	0(0%)	20(38%)	210(83%)	28(13%)
2003				
DRS	1(25%)	11(22%)	20(8%)	144(65%)
CRS	3(75%)	25(50%)	18(7%)	22(10%)
IRS	0(0%)	14(28%)	220(85%)	57(26%)

1.DRS, CRS, and IRS denote decreasing return to scale, constant return to scale, and increasing return to scale condition, respectively.

2.Value in parenthesis stands for the ratio of audit firm under DRS, CRS, or IRS.

3.Big 4 include KPMG, PricewaterhouseCoopers, Ernst & Young, and Deloitte & Touche.

4.NE<9 denotes audit firms with number of employees less than 9 and NE≧9 denotes audit firms with number of employees equal to and more than 9.

3.4 Empirical Results for Regression Model

Table 12 reports the empirical results of Tobit regression model. As shown in column A, the coefficient on intensity of experienced upper-level professionals (*EXP*) is positive significantly (z-statistic=2.01). This means that more experienced upper-level professionals upgrade the operating performance of large firm. Consistent with expectation, result above lends a support to H2. Next, the coefficient of expenditure on educational training (*TRAIN*) is significantly positive (z-statistic=2.89). This indicates that more expenditure on educational training improve the operating performance of large firm. Consistent with expectation, result above supports H3. However, the coefficient on intensity of

Table 12

Empirical Results of Tobit Regression Model

$TE = \beta_0 + \beta_1 EDU + \beta_2 EXP + \beta_3 TRAIN + \beta_4 AGE + \beta_5 OFE + \beta_6 DIV + \beta_7 SIZE + \beta_8 Y2002 + \beta_9 Y2003 + \varepsilon$

	Sign expected	A. Large firm			B. Small firm		
		Coeff.	Z-statistic	p-value	Coeff.	Z-statistic	p-value
Intercept		0.7811	12.81	0.00***	0.5683	20.14	0.00***
EDU	+	-0.1740	-1.13	0.26	0.0026	0.07	0.95
EXP	+	0.2042	2.01	0.04**	0.1066	3.88	0.00***
TRAIN	+	2.59E-06	2.89	0.00***	9.79E-07	2.20	0.03**
AGE	+	0.0005	0.41	0.68	0.0015	2.26	0.02***
OFE	−	-0.1021	-3.97	0.00***	-0.0547	-3.78	0.00***
DIV	+	-0.0886	-1.79	0.07*	-0.1268	-5.10	0.00***
LNSZ	+	0.0434	4.63	0.00***	0.0671	8.43	0.00***
Y2002	?	0.0246	1.10	0.27	0.0051	0.45	0.65
Y2003	?	0.0453	1.92	0.06*	-0.0156	-1.36	0.17
N			171			1,466	

Log likelihood	122.31	461.05
Avg. log likelihood	0.72	0.31
Adjusted R^2	0.1875	0.0669

1.N = number of observations.
TE = technical efficiency and used to proxy operating performance.
EDU = intensity of upper-level professionals with high academic degree.
EXP = intensity of experienced upper-level professionals.
TRAIN = expenditure on educational training.
AGE = firm age.
OFE = dummy variable of establishment of branch firm.
DIV = business diversification.
LNSZ = firm size.
Y2002 and *Y2003* denote dummy variable of year 2002 and 2003.
2.Z-statistics have been corrected by variance-covariance matrix of White (1980).
3.*, **, *** Significant at the 10%, 5% and 1% level, respectively.

upper-level professionals with high academic degree (*EDU*) is negative but insignificant (z-statistic=-1.13). This implies that audit firm with more professionals with high academic degree is unable to improve its operating performance. Thus, H1 is not supported.

Empirical results of Tobit regression model for small firm are displayed in column B of Table 12. Similar to that reported for large firm, the coefficient on intensity of experienced upper-level professionals (*EXP*) is positive significantly (z-statistic=3.88). This means that more experienced upper-level professionals upgrade the operating performance of small firm, which lends a support to H2. Next, the coefficient of expenditure on educational training (*TRAIN*) is significantly positive (z-statistic=2.20), suggesting that more expenditure on educational training improve the operating performance of large firm. Consistent with expectation, result above supports H3. However, the coefficient on intensity of upper-level professionals with high academic degree (*EDU*) is positive but insignificant (z-statistic=0.07). It seems that small firm with more professionals with high academic degree is unable to improve its operating performance. Thus, H1 is not supported.

3.5 Sensitive Analysis

DEA model is sensitive to the input and output variable selected. Different

input and output variable leads to varied results. To obtain robust findings, we apply DEA to another set of input and output variable. As those used and defined in the preceding section, input variables include total number of employee (*LAB*), total fixed assets (*CAP*) and operating cost (*OPE*). However, we use auditing and non-auditing revenue as our output variable. Auditing revenue includes revenue from audit of financial statements for public company, audit of financial statements for nonpublic companies, audit of financial statements for granting a bank loan, and audit of an income tax return services. Non-auditing revenue includes revenue from tax planning, administrative remedy of internal taxation, other tax operations, management advisory service, corporate registration, and bookkeeping and accounting service.

Table 13
Efficiency Estimates and Comparison Results for Different Group of Observations: Another Set of Input and Output Variables

	A. Large firm				B. Small firm			
	Big 4	Non-Big 4	M-W U stat.	Sig. level	NE< 9	NE≧ 9	M-W U stat.	Sig. level
2001								
TE	0.96	0.81	53	0.02**	0.56	0.59	27674	0.00***
PTE	1.00	0.86	38	0.01***	0.67	0.65	30237	0.20
SE	0.96	0.94	104	0.40	0.84	0.92	21708	0.00***
2002								
TE	0.95	0.81	58	0.03**	0.56	0.61	22922	0.00***
PTE	1.00	0.86	38	0.01***	0.71	0.65	22729	0.00***
SE	0.95	0.95	132	0.98	0.81	0.95	15003	0.00***
2003								
TE	0.98	0.86	49	0.10*	0.55	0.61	22102	0.00***
PTE	1.00	0.90	48	0.09*	0.68	0.65	25896	0.06*
SE	0.98	0.96	75	0.41	0.81	0.94	13612	0.00***

1.The first two columns in Panel A list efficiency scores by DEA for large firm as a whole. Then, mean technical efficiency (*TE*), pure technical efficiency (*PTE*), and scale efficiency (*SE*) are estimated for Big 4 and Non-Big 4 subsamples. The latter two columns in Panel A report the Mann-Whitney U statistic and its significant level. The Mann-Whitney, a non-parametric method, tests whether the efficiency has similar values for Big 4 versus Non-Big 4.

2.The first two columns in Panel B list efficiency scores by DEA for small firm as a whole. Then, mean technical efficiency (*TE*), pure technical efficiency (*PTE*), and scale efficiency (*SE*) are estimated for audit firms with number of employees fewer than 9 (NE<9) and equal to and more than 9 (NE≧9) subsamples. The latter two columns in Panel B report the Mann-Whitney U

statistic and its significant level. The Mann-Whitney, a non-parametric method, tests whether the efficiency has similar values for NE<9 versus NE≧9.

3.At present, Big 4 include KPMG, PricewaterhouseCoopers, Ernst & Young, and Deloitte & Touche. Dissolution of the late Arthur Andersen makes its local affiliate firm combine with the local member of Deloitte & Touche to become the largest firm in Taiwan effective June 1, 2003. Thus, Big 4 actually comprises five international firms for 2001-2002.

4.NE<9 denotes audit firms with number of employees fewer than 9 and NE≧9 denotes audit firms with number of employees equal to and more than 9.

5.*, **, *** Significant at the 10%, 5% and 1% level, respectively.

Table 13 reports the efficiency estimates and comparison results for different group of observations basing on another set of input and output variables. Except the pure technical efficiency (*PTE*) of small firm, testing results are qualitatively the same as that reported in Table 10. Next, using another set of input and output variables, this study displays the Tobit regression results in Table 14 with column A and B for large and small firm, respectively. As shown, the coefficients of intensity of experienced upper-level professionals (*EXP*) and expenditure on educational training (*TRAIN*) are positive significantly but the coefficient of intensity of upper-level professionals with high academic degree (*EDU*) is positive insignificantly. In sum, these results are consistent with those reported in Table 12.

4. Conclusions

In recent years, global regulation over public accounting profession is increasingly rigorous and the environment in which an audit firm operates has been increasingly hostile. Under the new landscape, how to survive and sustain competitive advantages in audit market constitutes a critical and worthy of pondering lesson for the audit firm. As a professional organization, audit firm depends on knowledge-based human capital with which to perform various services. To our knowledge, few prior studies address the operating performance of audit firm and the role played by human capital with different attributes. Using the resource-based view of firm and DEA, this study analyzes the operating performance of an audit firm, including efficiency and return to scale. Next, we examine the association between human capital and operating performance.

In the analysis of efficiency of large firm, empirical results indicate that Big 4 provides the same service level as non-Big 4 with less input and thus has superior technical efficiency, resulting primarily from the efficient utilization of resources by the management not from scale effect. For the small firm, audit firms with number of employees equal to and more than 9 outperform that of less than 9. However, this superior performance comes from better production scale instead. The analysis of return to scale for large firm indicates that most of the Big 4 firms are under optimal production scale each year but non-Big 4 firms change over time. In terms of annual tendency, non-Big 4 firms adapt their scale size aggressively. For small firm in each year, most of the firms with number of employee less than 9 are under increasing scale of return but most of the firms with number of employee equal to and more than 9 are under decreasing scale of return.

Table 14

Empirical Results of Tobit Regression Model: Another Set of Input and Output Variables

	A. Large firm			B. Small firm		
	Coeff.	Z-statistic	p-value	Coeff.	Z-statistic	p-value
Intercept	0.5825	6.93	0.00***	0.4941	17.62	0.00***
EDU	-0.0222	-0.12	0.91	0.0054	0.15	0.88
EXP	0.2206	1.85	0.06*	0.0847	3.25	0.00***
TRAIN	2.75E-06	2.76	0.01***	7.52E-07	1.66	0.10*
AGE	0.0009	0.76	0.45	0.0014	2.15	0.03**
OFE	-0.0958	-3.31	0.00***	-0.0578	-4.09	0.00***
DIV	0.0466	0.65	0.52	-0.0706	-2.86	0.00***
LNSZ	0.0491	4.81	0.00***	0.0665	8.51	0.00***
Y2002	0.0187	0.77	0.44	0.0020	0.18	0.85
Y2003	0.0243	0.95	0.34	-0.0126	-1.11	0.27
Log likelihood		109.28			479.80	
Avg. log likelihood		0.64			0.33	
Adjusted R^2		0.1634			0.0563	

1.*TE* = technical efficiency and used to proxy operating performance.
EDU = intensity of upper-level professionals with high academic degree.
EXP = intensity of experienced upper-level professionals.
TRAIN = expenditure on educational training.
AGE = firm age.
OFE = dummy variable of establishment of branch firm.
DIV = business diversification.
LNSZ = firm size.

Y2002 and *Y2003* denote dummy variable of year 2002 and 2003.
2.Z-statistics have been corrected by variance-covariance matrix of White (1980).
3.*, **, *** Significant at the 10%, 5% and 1% level, respectively.

Empirical results from Tobit regression model report that, for either large or small firm, more experienced upper-level professionals and more expenditure on educational training upgrade the firm's technical efficiency. However, for both large and small firm, more professionals with high academic degree are unable to increase the firm's technical efficiency. Empirical data used in this study pertains to cross-sectional ones. Future study may further examine the effects of human capital on next period's operating performance (that is, deferred effect), provided that panel data are available. To our knowledge, few prior studies investigate the operating performance of audit firm and the performance effect of human capital. Hence, this study contributes to the related literature additionally. Findings obtained in this study provide managerial implications for the practitioners to advance their operating performance.

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