IT Capital Accumulation and Productivity Growth
in Public Accounting Firms: A Research Note

Abstract: In this study we apply the tripartite decomposition of productivity growth proposed by Kumar and Russell [1] to estimate and evaluate the contribution of firms’ IT capital accumulation to their productivity growth. Analyzing a panel data on 52 public accounting firms in Taiwan for 10 years from 1993 to 2002, our results indicate that the productivity growth of these accounting firms was primarily due to their accumulation of IT capital. In addition, our results indicate that services diversification towards non-audit services and workforce quality contributed to accounting firms’ IT capital accumulation which, in turn, led to their productivity growth.

Index Terms— Public accounting firms, productivity growth, IT capital, service diversification, workforce quality.
1. Introduction

The public accounting industry has undergone dramatic transformation since the mid 1990s [2]. Even small accounting firms are joining international networks and alliances [3]. Increasing globalization along with clients’ expanding use of information technology (IT) has increased the need for sophisticated, multinational auditing capabilities along with a significant demand for new value-added non-audit services (NAS) that go beyond the traditional audit services (AS) provided by public accounting firms [4]. Although the big firms tend to lead the way, public accounting firms of all sizes have invested a considerable amount of resources to revamp their IT systems and infrastructure [5], [6] to meet the changing patterns in the demand for their services and improve performance. As clients continue to shift towards process automation, public accounting firms which make use of new IT in providing services will be rewarded with tremendous gain in productivity [7].

Although previous research has examined the impact of IT investments on firm performance in various industries, there is scant empirical research that has examined the association between IT investments and productivity growth in professional services industries in which IT plays a prominent role [8], [9]. Using operations data from a large international accounting firm, Banker et al. [9] found that the accounting firm’s productivity is positively associated with its IT implementation. Like most previous studies, however, they didn’t analyze the sources of productivity gain of the accounting firm. Recently, Banker et al. [2] proposed a bipartite decomposition of the productivity growth into two components—relative efficiency change (i.e., a change in the distance of a firm’s position from the production frontier) and technical progress (i.e., a shift in the production frontier, the “best practice” technology of firms in the sample) using Data Envelopment Analysis (DEA). Applying their
decomposition approach to data from 64 large accounting firms in the U.S. for the years 1995 and 1999, Banker et al. [2] documented that the productivity growth of accounting firms is attributable to technical progress rather than an improvement in relative efficiency. In contrast, Chang et al. [10] investigated changes in productivity for 62 of the largest U.S. public accounting firms between the periods (2000-01) and (2003-04). These are the periods before and after enactment of Sarbanes-Oxley (SOX) in July of 2002. They observed that the productivity growth of public accounting firms was ascribed to the relative efficiency change. While both recent studies did not incorporate IT expenditures in their bipartite decomposition of productivity growth due to the lack of firm specific data on IT expenditures, Banker et al. [2] acknowledged the important role played by IT spending on productivity growth. Thus, in this study we extend Banker et al. [2] to consider the impact of IT investments on accounting firms’ productivity growth. We explicitly incorporate IT expenditures into the tripartite decomposition of productivity growth proposed by Kumar and Russell [1]. That is, we decompose the productivity growth into relative efficiency change, technical progress and IT capital accumulation (i.e., the effect of the change in IT capital-labor ratio (IT capital intensity) on productivity along the same production frontier).

In the second part of this study, we further investigate the relationship between cross-sectional variation of productivity growth and its underlying components, and changes in two important characteristics of accounting firms: services diversification and workforce quality. Accounting Today’s survey suggests that public accounting firms in the late 1990s started diversifying their operations away from low-margin audit services into relatively new, high-margin NAS [11]. NAS are those services unrelated to audit such as information systems design and implementation, appraisals
or valuations, management and human resources services, etc. There was great variation in the types of NAS provided by accounting firms and each service could be tailored to meet the specific needs of individual clients. Since accounting firms can differentiate themselves with respect to expertise in different areas, they are able to charge a premium for the NAS which, in turn, should lead to high productivity growth [2], [10], [11]. However, given the complexity of NAS compared to AS [12], accounting firms need to invest more in IT in order to facilitate NAS delivery as well as lower the cost of coordination across different service areas [13], [14], [15]. Therefore, services diversification should lead to the accumulation of IT capital.

We focus on workforce quality of accounting firms because the employment of high-quality, human resources is just as important as the investment in IT [16]. This is especially true when it comes to rendering of NAS since NAS requires more educated and experienced workers. Further, workforce quality conveys an advantage in IT adoption which facilitates the use of IT and leads to a greater accumulation of IT capital [17].

Analyzing revenue, employee, and IT expenditure data from *Annual Surveys of CPA Firms in Taiwan* for the 10 years from 1993 to 2002 for 52 public accounting firms, we find that these accounting firms, on average, experienced a productivity growth of about 79% over the 10 year period and the productivity growth was caused primarily by IT capital accumulation. In addition, in the regressions we find that accounting firms that had increasingly diversified their services from audit services toward NAS and had higher workforce quality enjoyed higher productivity growth than their peers because these firms leveraged a higher level of IT capital. We also find that large accounting firms tended to have higher productivity growth, greater technical progress, and more IT capital accumulation than small firms.
We organize the remainder of this study as follows. In the next section, we briefly describe the Data Envelopment Analysis (DEA) methodology used in the construction of the production frontier and the decomposition of productivity growth and then provide step-by-step details about the calculation of the productivity growth decomposition indexes using data from a hypothetical firm. In section 3, we present empirical estimation including a description of the data we used and a discussion of our empirical results. Finally, in section 4 we conclude the study.

2. Production Frontier and Productivity Growth Decomposition Indexes

2.1 Data Envelopment Analysis

We employ non-parametric Data Envelopment Analysis (DEA) to construct the production frontier and estimate relative efficiency scores for public accounting firms. Banker et al. [2], [9], Chang et al. [10], and Feroz et al. [18], among others, have used DEA to estimate the production frontier of public accounting firms or audit engagements. DEA was introduced by Charnes et al. [19] and has been proven to be an effective tool for evaluating the relative efficiency of peer decision making units (DMUs) when multiple performance measures are present [18], [20], [21].

Let $\langle Y_j, L_j, K_j \rangle$, $j=1,\ldots,N$, and $t = 0$ (the base period), 1 (the current period) be the observed output (total revenues), human labor input (number of employees) and IT capital input (IT expenditures) generated from an underlying production set $S' = \{(Y', L', K') \mid output \ Y' \text{ can be produced from inputs } L' \text{ and } K' \text{ at period } t\}$ for a sample of $N$ public accounting firms. Assume that the production set $S'$ exhibits constant returns to scale and is monotone increasing and convex. The production frontier (also referred to as the efficient frontier) in period $t$, $T'$ of $S'$ is constructed as the “best practice” technology determined by the following DEA model:
Then, following Fare et al. [21] and Kumar and Russell [1], the relative efficiency score $e_r'$ of public accounting firm $j=r$ in period $t$ based on the technology at period $t$ can be obtained using the following DEA model [19]:

$$e_r' = \text{Min } e$$

s.t. $\sum_{j=1}^{N} \lambda_j Y_j' \geq Y_r' / e$

$$\sum_{j=1}^{N} \lambda_j L_j' \leq L_r'$$

$$\sum_{j=1}^{N} \lambda_j K_j' \leq K_r'$$

$$e > 0, \lambda_j \geq 0, \forall j = 1, ..., N.$$ (2)

where $Y_j', L_j', K_j'$ as well as $e_r'$ are all scalars, and $\lambda_j$ are the best possible weights placed on each of $j = 1, ..., N$ with which public accounting firm $j=r$ is being evaluated [21]. Since the optimal value of $e_r' \leq 1$, firm $j=r$ in period $t$ is located on the frontier and rated as efficient if $e_r' = 1$. Otherwise, firm $j=r$ is located below the frontier and rated as inefficient. The amount of inefficiency is calculated as $1 - e_r'$.

2.2 Decomposition of Productivity Growth

There are numerous studies on the decomposition of productivity growth over the past decade. Fare et al. [22] proposed an approach that decomposed productivity growth into relative efficiency change and technical progress. They identified technical progress as the source of persistent productivity growth in the US over the period

---

1 See Cooper et al. [21] for a comprehensive discussion of various DEA models.
1979-1988. Later, Kumar and Russell [1] extended the bipartite decomposition method of Färe et al. [22] and incorporated physical capital into the analysis by proposing a tripartite decomposition of productivity growth into components attributable to relative efficiency change, technical progress, and capital accumulation. They found that capital accumulation was the primary factor driving productivity growth across countries during the period 1965-1990. In this study, we adapt the tripartite decomposition method of productivity growth proposed by Kumar and Russell [1] and decompose productivity growth into the contributions of relative efficiency change (Δ EFF), technical progress (Δ TECH), and IT capital accumulation (Δ ITCA) as follows:

$$\Delta PDT = \Delta EFF \times \Delta TECH \times \Delta ITCA$$

(3)

Where ΔPDT measures the growth in productivity i.e. the change in output per unit of labor from the base period to the current period; ΔEFF represents the change in a firm’s position relative to the production frontier. Because relative efficiency measures the distance of the firm’s position from the production frontier, its change reflects a movement toward or away from the production frontier and is therefore referred to as the catching up to the frontier; ΔTECH reflects the shift in the production frontier, which is defined as the best practice technology of firms in the sample. ΔITCA denotes the change in the IT capital-labor ratio (IT capital intensity) measuring the effect of the change in IT capital intensity on productivity growth along the same production frontier. A value greater than 1 in ΔPDT, ΔEFF, ΔTECH or ΔITCA indicates an improvement in that measure from the base period to the current period, and a value less than 1 indicates a deterioration in performance over time.

---

2 Kumar and Russell’s decomposition approach is one version of the Malmquist index.
3 See Kumar and Russell [1] for the derivation of the productivity growth decomposition indexes.
time. Following Kumar and Russell [1], the percentage in productivity growth, relative efficiency change, technical progress, and IT capital accumulation can be calculated as \((\Delta \text{PDT-1}) \times 100\), \((\Delta \text{EFF-1}) \times 100\), \((\Delta \text{TECH-1}) \times 100\), and \((\Delta \text{ITCA-1}) \times 100\), respectively.

2.3 Detailed calculation of productivity growth indexes using data from a hypothetical firm

We present step-by-step details about the calculation of productivity growth indexes of equation (3) using data from a hypothetical firm as a reference for readers who wish to implement the decomposition framework in other contexts. Table 1 summarizes relevant data values on the hypothetical firm.

[Insert Table 1 about here]

**Step one: Calculation of productivity growth** \((\Delta \text{PDT})\)

From Table 1, we observe that in the base period revenue \((Y^0)\) and employee \((L^0)\) of the hypothetical firm are 10 and 20, respectively. We can calculate the labor productivity \((y^0, \text{revenue per employee})\) for the base period as revenue in the base period \((Y^0)\) divided by employee in the base period \((L^0)\). That is, \(y^0 = \frac{Y^0}{L^0} = \frac{10}{20} = 0.50\). Similarly, we can calculate the labor productivity \((y^1)\) for the current period as \(y^1 = \frac{Y^1}{L^1} = \frac{27}{30} = 0.90\). To calculate the labor productivity growth \((\Delta \text{PDT})\) from the base period to the current period, we divide revenue per employee in the current period \((y^1)\) by revenue per employee in the base period \((y^0)\) as follows:

\[
\Delta \text{PDT} = \frac{y^1}{y^0} = \frac{0.90}{0.50} = 1.80
\]

Thus, the percentage change in the labor productivity of the hypothetical firm from the base period to the current period is 80%. It is computed as \((1.80 - 1) \times 100 = 80\%\).

**Step two: Construction of production frontiers and estimation of relative...**
efficiency scores

As described earlier, we use DEA to construct the production frontier and estimate relative efficiency scores. Since the tripartite decomposition framework of Kumar and Russell [1] imposes a constant returns to scale technology, we can illustrate what is involved graphically in Figure 1 by using \((k, y)\) space to draw the production sets, where \(k^t = K^t / L^t\) and \(y^t = Y^t / L^t\), \(t = 0, 1\), are the observed IT capital per employee (IT capital intensity) and revenue per employee (labor productivity), respectively. In Figure 1, \(T^0\) and \(T^1\) are assumed to represent the production frontier for the base period and for the current period, respectively. Points A and D with coordinates \((k^0 = 0.40, y^0 = 0.50)\) and \((k^1 = 0.60, y^1 = 0.90)\) denote observed values (IT capital intensity, labor productivity) of the hypothetical firm at the base period and at the current period, respectively.

As shown in Figure 1, the potential maximum revenue per employee in the base period \((\bar{y}^{0,0})\) derived from frontier \(T^0\) is 0.625 (see point B) when IT capital intensity in the base period is 0.40 (i.e., \(k^0 = 0.40\)). Therefore, the relative efficiency of the hypothetical firm at the base period \((e^0)\), represents its distance from frontier \(T^0\), can be calculated as the observed revenue per employee \((y^0 = 0.50)\) in the base period (see point A) divided by the corresponding potential maximum revenue per employee \((\bar{y}^{0,0} = 0.625)\) on frontier \(T^0\). That is, \(e^0 = y^0 / \bar{y}^{0,0} = 0.50/0.625 = 0.80\). Similarly, since the potential maximum revenue per employee in the current period \((\bar{y}^{1,1})\)

---

4 Professor William Cooper’s suggestion to illustrate the construction of production frontiers and estimation of relative efficiency scores graphically is gratefully acknowledged.

5 In the case of the single output, the relative efficiency score is simply the ratio of actual output to potential maximum output evaluated at the actual input level.
derived from frontier $T^d$ is 1.023 (see point F) when IT capital intensity in the current period is 0.60 (i.e., $k^1=0.60$), the relative efficiency score at the current period ($e^1$) is calculated as the observed revenue per employee in the current period ($y^1=0.90$) divided by the potential maximum revenue per employee in the current period ($\bar{y}^{1,1}=1.023$) on frontier $T^d$. That is, $e^1 = y^1 / \bar{y}^{1,1} = 0.90 / 1.023 = 0.88$.

**Step three: Calculation of relative efficiency change ($\Delta$ EFF)**

From Step two above, we know that the relative efficiency score for the hypothetical firm at the base period and at the current period is $e^0 = 0.80$ and $e^1 = 0.88$, respectively. We can calculate the relative efficiency change ($\Delta$ EFF) from the base period to the current period for the hypothetical firm as the ratio of its current period relative efficiency score ($e^1$) to its base period efficiency score ($e^0$) as follows:

$$\Delta \text{EFF} = e^1 / e^0 = 0.88 / 0.80 = 1.10.$$  

Therefore, the percentage change in relative efficiency is 10% which is computed as $(1.10 - 1) \times 100 = 10%$.

**Step four: Computation of technical progress ($\Delta$ TECH)**

Next, assume that the potential maximum revenue per employee of the hypothetical firm in the current period using the base period technology ($\bar{y}^{0,1}$) and in the base period using the current period technology ($\bar{y}^{1,0}$) derived from frontiers $T^0$ and $T^d$ are 0.947 (i.e., $\bar{y}^{1,0}=0.947$) and 0.833 (i.e., $\bar{y}^{0,1}=0.833$), respectively. As depicted in Figure 1, the difference between $\bar{y}^{0,0}=0.625$ (point B) as described in Step 1 and $\bar{y}^{0,1}=0.833$ (point E) and the difference between $\bar{y}^{1,0}=0.947$ (point C) and $\bar{y}^{1,1}=1.023$ (point F) as described in Step 1 are caused by the change in the production frontier (i.e., from $T^0$ and $T^d$). Therefore, following Fare et al. [21] we can estimate
the technical progress (ΔTECH) as the geometric mean of the two as a measure of
the effect of the frontier change as represented by:

\[
ΔTECH = \left[ \frac{\bar{y}^{1,1}}{\bar{y}^{0,0}} \times \frac{\bar{y}^{0,1}}{\bar{y}^{0,0}} \right]^{0.5} = \left[ \frac{1.023}{0.947} \times \frac{0.833}{0.625} \right]^{0.5} = 1.20
\]

(6)

The percentage of technical progress is 20%, which is computed as (1.20-1) x 100 =
20%

**Step five: Calculation of IT capital accumulation (ΔITCA)**

Similarly, since the difference between \(\bar{y}^{0,0} = 0.625\) (point B) and \(\bar{y}^{1,0} = 0.947\) (point C)
and the difference between \(\bar{y}^{0,1} = 0.833\) (point E) and \(\bar{y}^{1,1} = 1.023\) (point F) reflect the
effect of the change in IT capital intensity (i.e., from \(k^0\) to \(k^1\)) along the frontier, we
can again take the geometric mean of the two as a measure of IT capital accumulation
(ΔITCA) as shown below:

\[
ΔITCA = \left[ \frac{\bar{y}^{1,1}}{\bar{y}^{0,1}} \times \frac{\bar{y}^{1,0}}{\bar{y}^{0,0}} \right]^{0.5} = \left[ \frac{1.023}{0.833} \times \frac{0.947}{0.625} \right]^{0.5} = 1.36
\]

(7)

Thus, the percentage of IT capital accumulation from the base period to the current
period is 36%. It is computed as (1.36-1) x 100 = 36%.

Taken together equations (4), (5), (6), and (7), the change in labor productivity of
the hypothetical firm is multiplicative of its relative efficiency change, technical
progress and IT capital accumulation as represented by:

\[
ΔPDT = ΔEFF \times ΔTECH \times ΔITCA
1.80 = 1.10 \times 1.20 \times 1.36
\]

(8)

By construction, equation (8) indicates that these contributions to the growth in
productivity are multiplicative rather than additive. Taking logarithm on both sides
of equation (8), we obtain:
\[
\ln(\Delta PDT) = \ln(\Delta EFF) + \ln(\Delta TECH) + \ln(\Delta ITCA)
\]
\[0.584 = 0.095 + 0.182 + 0.307\] (9)

Where \(\ln(\Delta PDT)\) is the logarithm of \(\Delta PDT\), \(\ln(\Delta EFF)\) is the logarithm of \(\Delta EFF\), \(\ln(\Delta TECH)\) is the logarithm of \(\Delta TECH\), and \(\ln(\Delta ITCA)\) is the logarithm of \(\Delta ITCA\).

Thus, the left side is equal to the sum of the three terms on the right hand side of equation (9).

3. Empirical estimation and results

3.1 Data and sample

The data we use in this study are obtained from Annual Surveys of CPA Firms in Taiwan which is published by the Department of Statistics, Ministry of Finance in Taiwan. The database was constructed from the public accounting firms’ responses to questionnaires and surveys for all registered public accounting firms in Taiwan with the purpose of identifying the reference base for the government’s policy-making decisions. The dataset is suitable for our research because it contains information about the IT expenditure of individual accounting firms over time. IT-performance relationship may not be evident in cross-sectional or snapshot data analyses [23]. This longitudinal data on IT expenditures enables us to evaluate the impact of IT capital accumulation on productivity growth in accounting firms in Taiwan over time.

Our initial sample contains the 68 largest accounting firms in Taiwan. Eleven firms with incomplete data values on required line items are eliminated. Five other firms that do not appear consistently over the 10 year period 1993-2002 are also removed from our analyses. Thus, our final sample consists of a balanced panel of 52 (=68-11-5) accounting firms over the period 1993-2002. There are two main reasons that we focus on this period for our study. First, 1993 was the first year that
the data were made available and 2002 was the year prior to the year (2003) that Arthur Andersen and Deloitte and Touche in Taiwan merged reducing the Big 5 to Big 4. Second, many accounting firm invested substantially in IT systems and infrastructure during the middle and late 1990s such that IT capital began to play an essential role in helping accounting firms to meet the changing patterns in the demand for their services during that period [5], [6], [24].

Our dataset contains one aggregate output and two aggregate inputs. The aggregate output we consider is the total revenues measured in millions of NT dollars. The two aggregate inputs included in this study are total number of employees and total IT expenditures measured in millions of NT dollars. Table 2 reports descriptive statistics for revenue, employee, and IT capital for years 1993 through 2002. As can be seen from Table 2, mean deflated total revenues, number of employees and IT capital expenditures all increased monotonically over time. Specifically, mean (median) deflated total revenues grew approximately by 129% (154%) during the 10 year period while mean (median) total employees grew by about 49% (31%). Similarly, the mean (median) IT capital grew by about 238% (246%).

3.2 Empirical results

Table 3 reports the average percentage changes for each pair of consecutive years as well for the entire period from 1993 to 2002 in productivity (\(\Delta \text{PDT-1} \times 100\)) and its three underlying components: relative efficiency change (\(\Delta \text{EFF-1} \times 100\)), technology progress (\(\Delta \text{TECH-1} \times 100\)), and accumulation in IT capital (\(\Delta \text{ITCA-1} \times 100\)).

We observe from Table 3 that productivity and its three components for
accounting firms in Taiwan improved monotonically over time during our sample period from 1993 to 2002 except that the relative efficiency deteriorated a bit for 1996-1997. Further, we find that, over the 10 year period, accounting firms in Taiwan experienced an increase in labor productivity of about 79%, a gain in relative efficiency of about 2.93%, an improvement in technical progress of about 9.97%, and an increase in IT capital accumulation of about 59.87%. We accordingly conclude that the labor productivity growth of accounting firms in Taiwan over the period 1993-2002 is attributable primarily to IT capital accumulation.

Next, we investigate the relationship between cross-sectional variations (in productivity growth, relative efficiency change, technical progress, and IT capital accumulation) and the change of two important accounting firms’ characteristics: services diversification, and workforce quality. Due to competitive pressures, accounting firms have developed many unique and profitable new services to address their clients’ specific needs in the recent decade. A recent survey suggests that accounting firms in the late 1990s reduced their reliance on traditional AS and moved into the practice of NAS [11]. Given the differentiated market for NAS engagements, it is likely that firms that have progressively diversified their operations away from AS towards NAS were able to generate more revenues than other accounting firms that continued to focus on audit engagements [2], [25]. Therefore, the diversification of services is another critical characteristic affecting accounting firms’ productivity growth. However, while diversified services could increase economic benefits of firms, the benefits could be offset by the costs of coordinating resources in different service areas [26]. Since IT is widely used in practice to achieve more efficient coordination by lowering the costs of coordinating physical resources,
expertise, technical knowledge, and market information across different business areas [5], [13], [14], accounting firms that had high levels of services diversification may have invested more in IT. Consequently, services diversification could lead the accumulation of IT capital.

Workforce quality has long been argued as a critical resource in most professional service firms because it provides the basis for professional service firms to sustain their competitive advantages [25]. Since these competitive advantages produce positive returns [27], workforce quality could make a crucial contribution to the productivity growth of accounting firms. In addition, educated workers can facilitate the adoption of new IT; that is, high quality workforce conveys an advantage in IT adoption which may lead to the greater accumulation of IT capital [17], [28].

Based on the above argument, we specify the following regression model:

$$\ln(\text{change measure}) = \beta_0 + \beta_1 \Delta \text{DIV} + \beta_2 \Delta \text{EDU} + \beta_3 \text{SIZE} + \varepsilon$$

(10)

where $\ln(\text{change measure})$ is the logarithm of change measures denoting productivity growth, relative efficiency change, technical progress, and IT capital accumulation. $\Delta \text{DIV}$ proxies for the change in services diversification level and is defined as the change in the ratio of NAS revenues to total revenues from between consecutive pair years over the 10 year period 1993 to 2002 (i.e., from 1993 to 1994, 1994 to 1995, etc). $\Delta \text{EDU}$ represents the change in workforce quality and is calculated as the change in the average number of years of education of employees in an accounting firm between two consecutive pair years. Prior research documents that firm size (SIZE) affects performance [29]. Thus, we include SIZE as a contextual variable. SIZE is defined as the logarithm of total revenue. We expect $\beta_1$, $\beta_2$, and $\beta_3$ to be

---

6 We gratefully acknowledge the suggestion of an anonymous referee to include firm size instead of Big 5 vs. non-Big 5 firms as a contextual variable in order to make our results more general and comparable with data from other industries.
positive based on our earlier discussion.

We present descriptive statistics of these contextual variables by year in Table 4. Clearly, DIV, EDU and SIZE all increased over time, indicating that accounting firms in Taiwan diversified their services toward NAS, improved their workforce quality, and expanding their operation size over the 10 year period 1993-2002.

[Insert Table 4 about here]

The regression results of equation (10) are reported in Panel A and Panel B of Table 5 for consecutive pair year changes and changes between 1993 and 2002, respectively. Panel A of Table 5 shows that the coefficients of $\Delta$DIV and $\Delta$EDU are significantly positive for productivity growth, technical progress and IT capital accumulation, suggesting that diversified services towards NAS and high workforce quality contributed to high labor productivity growth, technical progress and IT capital accumulation. In addition, the coefficients of SIZE are significantly positive except for the regression of the change in relative efficiency, indicating that large accounting firms had greater productivity growth, higher technical progress, and more IT capital accumulation than small accounting firms during the period 1993-2002.

Similarly, we observe from Panel B of Table 5 that productivity growth of accounting firms is positively associated with the change in services diversification level ($\Delta$DIV) and there is a significantly positive association between IT capital accumulation and the change in services diversification level from between 1993 and 2002. This suggests that accounting firms that emphasized service diversification were the ones that enjoyed higher productivity growth and greater accumulation in IT capital rather than those that did not. In addition, productivity growth of accounting firms is positively associated with the change in workforce quality ($\Delta$EDU) and there is a significantly positive association between IT capital accumulation and the change
of workforce quality from between 1993 to 2002. The significant coefficients provide strong support that accounting firms that employed highly educated workers during 1993–2002 experienced significantly higher productivity growth and IT capital accumulation than those that did not. Further, the coefficients of SIZE are again significantly positive except for the regression of the change in relative efficiency, indicating that large accounting firms’ better performances in technical progress and IT capital accumulation led to their higher productivity growth than small accounting firms.

[Insert Table 5 about here]

Collectively, our results indicate that accounting firms that had increasingly diversified their services (i.e., grew more on NAS) and had higher workforce quality (i.e., employed more educated workers) during the period 1993 through 2002 enjoyed higher productivity growth than their peers because these firms leveraged higher IT capital. Due to their competitive advantage, larger accounting firms outperformed small accounting firms in productivity growth, technical progress and IT capital accumulation.

**4. Conclusion**

In this study we adapt the tripartite decomposition of productivity growth proposed by Kumar and Russell [1] and decompose productivity growth of accounting firms into components attributable to: (1) relative efficiency change, (2) technical progress, and (3) IT capital accumulation. Analyzing a panel data of 52 accounting firms in Taiwan for the years from 1993 to 2002, we find that these accounting firms enjoyed a significant increase in their productivity growth over the period 1993-2002. Specifically, the productivity gain is attributable mainly to the accumulation of IT
capital. This suggests that there is a need to incorporate IT capital accumulation in the measurement of productivity growth in order to properly capture the impact of IT investment on productivity growth. Our results also indicate that public accounting firms that had increasingly diversified their services toward NAS and had higher workforce quality enjoyed higher productivity growth than their peers because these firms leveraged a higher IT capital. Large accounting firms had relatively higher productivity growth, greater technical progress and more IT capital accumulation.

Our study adds to the literature in several ways. First, we adopt Kumar and Russell’s tripartite decomposition of productivity growth to identify the IT capital accumulation as a new unique component of labor productivity growth. This makes it possible for managers to directly estimate the magnitude of the contribution of IT capital accumulation to productivity growth, thus enabling them to quantify the payoff of IT investments made by their firms. Second, the impact of IT capital on firm performance differs across industries [23]. It is necessary to establish industry-specific evidence in order to better understand the role of IT in the production process and how it can lead to improved firm performance. Due to the lack of firm level IT data, little empirical research has investigated the contribution of IT capital accumulation to productivity growth in the public accounting industry [9]. Our study fills this void in the literature by documenting empirical evidence of IT impact on productivity growth for the public accounting industry. Third, while previous studies suggest that services diversification and workforce quality could affect the productivity growth of accounting firms, our study complements prior studies by documenting that accounting firms’ services diversification and workforce quality affect productivity growth mainly through the leverage of IT capital accumulation. Finally, accounting and auditing standards in Taiwan are very similar
to those in the U.S. due to the close economic and political relations between the two nations [30]. In addition, many large accounting firms such as the Big 5 (e.g., Arthur Andersen, KPMG, Price Waterhouse Coopers, Deloite & Touche, and Ernst & Young) in Taiwan are either members or affiliates of the U.S. Big 5 accounting firms, making the structure of the audit market in Taiwan similar to that in U.S. Given this similarity in the audit market between Taiwan and U.S., we believe that our findings not only advance our understanding of the dynamic of productivity change of CPA firms in Taiwan, but also provide implications to U.S. or U.S-influenced audit markets.

Our study has three major limitations. First, we use the average number of years of education to proxy for workforce quality ignoring the potential effect of the years of working experience with accounting firms. If this does not properly reflect workforce quality, our OLS regression results may be subject to measurement errors. Second, services quality such as clients’ satisfaction is an important contextual factor that can significantly affect productivity growth and its components. However, data on service quality is not available in our Taiwanese dataset. Third, our findings for accounting firms may not be applicable to other professional service industries such as banking and health care.
References


Figure 1: Illustration of Tripartite Decomposition