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Araştırma Makalesi

MEASURING THE PRODUCTIVITY OF AUDIT FIRMS IN TÜRKIYE: A MALMQUIST INDEX APPROACH

(TÜRKİYE'DEKİ DENETİM ŞİRKETLERİNİN VERİMLİLİĞİNİN ÖLÇÜLMESİ: MALMQUIST ENDEKSİ YAKLAŞIMI)

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ABSTRACT

This study evaluates the productivity of large audit firms in Türkiye conducting audits for Public Interest Entities (PIEs) between 2020 and 2023. Using Data Envelopment Analysis (DEA) to calculate the Malmquist Productivity Index (MPI), the research analyses total factor productivity (TFP) through efficiency and technological progress components. Data was collected from transparency reports and additional inquiries for 60 firms. Due to limited data disclosure, only the number of responsible auditors and partners were used as input variables, while audit and non-audit revenues served as outputs. Findings reveal a slight decline in TFP, driven by regression in technological progress despite improvements in efficiency. The "Big Four" firms outperformed others across all productivity metrics, benefiting from global expertise and technological investments. Local firms, which are not affiliated with any international network, faced challenges stemming from limited resources and slower adoption of technology, emphasizing the need for innovation and digitalization. By focusing on Türkiye's unique economic conditions, including inflation, and employing a robust DEA-based approach, the study contributes to the limited literature on audit firm productivity in emerging markets. It provides actionable insights for enhancing competitiveness and addressing inefficiencies, offering strategies for aligning with global standards and adapting to evolving regulatory demands.

Keywords: Audit Firm Productivity, Malmquist Productivity Index, Data Envelopment Analysis (DEA), Audit Market Concentration

JEL Classification: M42, C61

ÖZ

Bu çalışma, Türkiye'de Kamu Yararını İlgilendiren Kuruluşların (KAYİK'ler) denetimini 2020 ile 2023 yılları arasında gerçekleştiren büyük denetim firmalarının verimliliğini değerlendirmektedir. Çalışmada, Toplam Faktör Verimliliğini (TFP) etkinlik ve teknolojik ilerleme bileşenleri aracılığıyla analiz etmek için Veri Zarflama Analizi (DEA) kullanılarak Malmquist Verimlilik Endeksi (MPI) hesaplanmıştır. Veriler, 60 firmanın şeffaflık raporları ve ek bilgi taleplerinden elde edilmiştir. Veriye ulaşımdaki kısıtlar nedeniyle, yalnızca sorumlu denetçiler ve ortakların sayısı girdi değişkenleri olarak kullanılırken, denetim ve denetim dışı gelirler çıktı değişkenleri olarak değerlendirilmiştir. Bulgular, teknolojik ilerlemedeki gerilemenin etkinlikteki iyileşmelere rağmen TFP'de hafif bir düşüşe neden olduğunu ortaya koymuştur. "Büyük Dörtlü" firmalar, küresel uzmanlık ve teknolojik yatırımlardan yararlanarak tüm verimlilik ölçütlerinde diğer firmalardan daha iyi bir performans sergilemiştir. Uluslararası ağlara bağlı olmayan yerel firmalar, sınırlı kaynaklar ve teknolojinin daha yavaş benimsenmesi gibi zorluklarla karşılaşmış ve bu durum, yenilikçilik ile dijital dönüşümün önemini ortaya koymuştur. Türkiye'nin enflasyon gibi özgün ekonomik koşullarına odaklanan ve güçlü bir DEA tabanlı yaklaşım kullanan bu çalışma, gelişmekte olan piyasalarda denetim firması verimliliğine ilişkin sınırlı literatüre değerli katkılar sunmaktadır. Çalışma, rekabetçiliği artırma ve verimsizlikleri giderme konusunda uygulanabilir içgörüler sunarak, küresel standartlara uyum sağlama ve değişen düzenleyici taleplere adapte olma stratejileri önerilmektedir.

Anahtar Kelimeler: *Denetim Firmaları Verimliliği, Malmquist Verimlilik Endeksi, Veri Zarflama Analizi (VZA), Denetim Piyasası Yoğunlaşması*

JEL Kodları: *M42, C61*

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1. INTRODUCTION

The auditing sector plays a critical role in ensuring transparency, accountability, and trust in financial reporting. In Türkiye, as in many other countries, the auditing profession is governed by stringent regulations and standards, with a particular focus on auditing Public Interest Entities (PIEs). These entities, which include publicly traded companies and large organizations, require independent audits to provide assurance on their financial statements, thereby promoting investor confidence and market stability. The audit firms that conduct these audits—especially the large, globally affiliated firms—hold significant influence within the market of Türkiye (Table 1).

Over the past decade, Türkiye's auditing market has experienced significant regulatory changes, driven by the need to align with European Union (EU) regulations and international standards. These reforms, including the introduction of the Turkish Commercial Code (TCC) and the Capital Markets Law (CML), have expanded the scope of independent audits and reinforced the importance of high-quality auditing practices. As a result, Türkiye has seen the continued dominance of the "Big Four" firms—Deloitte, PwC, EY, and KPMG—which control a substantial market share in auditing PIEs.

Despite these developments, Türkiye's auditing market faces various challenges, particularly in terms of technological advancements and operational efficiency. While the "Big Four" are well-positioned to invest in technology and innovation, smaller local firms struggle with resource constraints and slower adoption of new technologies. This study aims to measure the productivity of Türkiye's audit firms, focusing on both large international and independent firms, using the Malmquist Productivity Index (MPI) to assess efficiency and technological progress over the period 2020–2023.

This research seeks to provide insights into the productivity dynamics of Türkiye's auditing market, offering a deeper understanding of the factors driving performance, competitiveness, and innovation. By focusing on the changing landscape of auditing in Türkiye, the study contributes valuable knowledge to the field of auditing research, particularly in emerging markets.

2. THE AUDIT MARKET IN TÜRKİYE

The audit market in Türkiye is characterized by significant concentration, with the "Big Four" firms—Deloitte, PwC, EY, and KPMG—maintaining a dominant position. These firms play a crucial role, particularly in auditing publicly traded companies and large enterprises, leveraging global expertise, advanced technologies, and their capacity to set quality benchmarks. According to Türel et al. (2017), the Big Four firms collectively audited 52% of companies in Türkiye between 2006 and 2015, underscoring their market dominance.

Market concentration is further evidenced by the Concentration Ratio (CR4), which consistently exceeds 70% for the Big Four. The CR4 formula, which was used to generate Table 1, is defined as: $CR_k = \frac{\sum_{i=1}^{k} Audit\ Revenue\ of\ Firm\ i}{Total\ Audit\ Revenue\ of\ All\ Firms} \times 100$

Where: k is the number of top firms (e.g., 4 for CR4). $Total\ Audit\ Revenue\ of\ All\ Firms$ is the sum of all firms' audit revenues.

Using this formula, Table 1 presents the concentration levels of the Big Four firms based on their audit revenue from 2020 to 2024. The data highlights the substantial market share held by these firms, with CR4 values consistently exceeding 70%, underscoring their dominant influence within Türkiye's audit market.

Table 1. Market Concentration of the Big Four in Türkiye's Audit Sector Based on Audit Revenue

Year	Total Revenue (Million TRY)	Revenue of Big Four (Million TRY)	CR4 (%)
2020	807.16	613.51	76.01
2021	1,104.84	826.45	74.80
2022	2,072.42	1,543.38	74.47
2023	4,470.68	3,472.99	77.68

Smaller local firms, primarily focusing on tax audits and consulting services, struggle to match the scale and technological sophistication of the Big Four, although they serve the critical SME (Small Medium Enterprise) segment. Internal factors like the number of partners, team size, and training hours positively influence these smaller firms' revenues and market shares, but their overall contribution remains limited.

Between 2010 and 2016, a total of 1,342 observations were audited by 151 auditors from 63 audit firms (Ocak, 2018). The numbers varied annually; for instance, in 2014, 35 non-Big Four audit firms audited financial statements, with a total

of 39 firms including the Big Four. However, these figures are notably lower compared to 2017 statistics from the Public Oversight Board, which reported 17,606 authorized auditors and 252 authorized audit firms. Ocak (2018) also highlights that Big Four auditors are busier compared to those in non-Big Four firms, further reinforcing the concentration of audit activity within these firms.

Regulatory oversight by the Public Oversight, Accounting, and Auditing Standards Authority (KGK) has strengthened compliance with international auditing standards. Legislative reforms, including updates to the Turkish Commercial Code (TCC) and Capital Markets Law (CML), have expanded the scope of independent audits, particularly for public interest entities (PIEs), aiming to enhance market transparency and investor confidence (Kandemir, 2015). However, the audit market faces challenges, such as disparities in technological adoption and operational efficiency between larger and smaller firms. Bridging these gaps requires investments in digital transformation, automation, and fostering international partnerships to enhance competitiveness and alignment with global standards.

In conclusion, while the Big Four dominate the Turkiye' audit market with their significant market share and resources, smaller firms and regulatory bodies play an essential role in maintaining the sector's diversity and integrity. Continued advancements in regulation, technology, and collaboration are crucial to sustaining market growth and improving audit quality.

3. LITERATURE REVIEW

Although there is a limited amount of research on productivity and efficiency in accounting and auditing firms compared to other industries, there is a growing corpus of literature on this topic. These investigations appear to have been conducted exclusively in a restricted number of countries such as US, UK, Taiwan, Canada, and China. The majority of studies utilized a singular sample of countries. These studies are carried out in US (Banker et al., 2003, 2005, 2007; H. Chang, Choy, Cooper, Parker, et al., 2009; H. Chang, Choy, Cooper, & Ruefli, 2009), Taiwan (H. Chang et al., 2011; Lee, 2009, 2014) and the UK (Barros et al., 2014; Djerdjouri & Kandiel, 2013). Furthermore, some studies conduct cross-country comparisons, such as between the US, China, and Taiwan (Chang et al. (2015), and between the US, the UK, and Canada (B.-G. Chang et al., 2015; Clark & Qiao, 2021). DEA-based Malmquist productivity indexes are the most prevalent method in productivity studies. The output variables that are most frequently utilized are those pertaining to revenue, while the input variables that are most commonly employed are those related to staff. The goals and findings of these studies are summarized as follows.

Cheng et al. (2000) employ DEA and the Tobit censored regression model to explore the association between firm-specific factors and technical efficiency in Taiwan's CPA (Certified Public Accountant) firms. They found that Taiwan's CPA companies could have cut inputs by 27.8 percent in 1994 and yet supplied the same services. Size, age, service concentration, CPA-to-employee ratio, and training expense per employee also affect efficiency, and organizations that have branches have lower efficiency compared to those that do not have branches. The productivity computation of this study relies on two inputs: the number of employees and the net fixed assets. And the outputs consist of four revenue types which are generated from the services of advisory, auditing, tax, and management.

Banker et al. (2003) estimated a translog function that captures the relationship between revenue and human resource inputs in US large 64 CPA firms during 1995–1999. Estimation of the model shows that CPAs have increasing returns to scale, validating recent merger and acquisition activity. Partners' average marginal revenue product climbed monotonically from 1995 to 1998, dipped somewhat in 1999, and was nine times that of other professionals. Over five years, CPAs' productivity increased. The outputs of the productivity calculation of the study are the revenues deriving from the services of accounting and Auditing, Tax, and Management Advisory and the inputs are the number of partners, other professionals, and other employees.

In their study Banker et al., (2005) DEA was used to evaluate the change in related efficiency for 64 of the top 100 US firms from 1995 to 1999. They found that the average public accounting firm grew 9.5 percent in productivity between 1995 and 1999. They uncover evidence that technical progress, not relative efficiency, drove productivity growth. Early management advisory service adopters and those that prioritized management advisory services over audit and tax services had far higher productivity increases. These firms also advanced industry technical progress. This study utilizes the number of partners, other professionals, and other employees as inputs. The considered outputs encompass revenues derived from services of accounting and auditing, tax, and management consultancy.

Using 1995–1998 data from the top 100 US accounting firms, as reported in Accounting Today, Banker et al. (2007) assess related efficiency change using DEA. This study employs DEA to assess technique and distribution efficiency by replacing input and output with income and costs. Between 1995 and 1998, US accounting firms had an inefficiency distribution, meaning they did not properly adjust their resources to the volatile market. This study employs the number of partners, other professionals, and other employees as inputs. The outputs considered are revenues from accounting and auditing services, tax services, and management advisory services.

Lee (2009) examines 173 medium-sized Taiwanese auditing firms' 2005 technical, pure technical, and scale efficiency. The average scale efficiency of all samples exceeds the average pure technical efficiency. Better operational efficiency is found in audit firms with larger company revenues and overall expenses. Finally, organizations with more personnel and partners have superior technological and scale efficiency. In their study, they utilized a total of 5 outputs and 4 inputs. The outputs include earnings from attestation, tax business, management consultation, corporation registration, and other business services. The four inputs utilized are: the number of branches, employees, partners, and the overall expenditures.

H. Chang, Choy, Cooper, Parker et al. (2009) examines productivity growth, technical progress, and efficiency change for the 56 major US CPA firms from 1996–1999 to 2003–2006, before and after the Sarbanes–Oxley Act. Malmquist indices of productivity growth, technical progress, and efficiency change are calculated using data envelopment analysis (DEA). The average productivity gain of CPA companies from pre- to post-SOX was 17 percent. The productivity increase is mostly due to technical progress, not in relative efficiency. Results show that "Big 4" audit firms lagged non-Big 4 audit firms in productivity growth and technical progress. Partner, other professional, and employee numbers are used as input to calculate productivity. They also used accounting, auditing, tax, and management advice revenues as output.

In response to Sarbanes–Oxley (SOX) Act criticism, (H. Chang, Choy, Cooper, & Ruefli, 2009) examines productivity efficiency changes for 62 of the major US public accounting firms during 2000–2001 and 2003–2004. They calculate Malmquist productivity and efficiency indexes with DEA. To distinguish between technical efficiency, which limits options, and firm performance efficiency, this measure is utilized. Results show that accounting firms' production efficiency has improved post-SOX, contrary to many critiques. The productivity calculation utilizes the inputs of the number of partners, other professionals, and employees, and the outputs of accounting, auditing, tax, and management advisory revenues.

Chang et al., (2011) categorize productivity growth into efficiency change, technical progress, IT capital accumulation, and human capital accumulation. They investigate 1993–2003 data from 51 Taiwanese public accounting firms and show that IT and human capital drove productivity growth. They conclude that technical progress and IT capital accumulation explain the productivity growth gap between Big Four and non-Big Four accounting firms. Their multiple regression results show that accounting firms that grew rapidly in non-audit services over the 11-year period had higher productivity growth due to greater IT capital and human capital accumulation than firms that focused on audit services. While output variables they used are the revenues from audit services and non-audit services, input variables are the number of employees, IT Capital, and human capital.

Djerdjouri & Kandiel (2013) evaluate productivity, efficiency, and technical changes in 43 UK accounting firms from 2009 to 2012. DEA and the Malmquist index are used to evaluate company performance for each of the four periods and compute the productivity index, efficiency, and frontier shifts (or technology) changes. The data show that except for the big four accounting firms the other firms fared badly throughout the four years and had an average efficiency index of 0.58, indicating suboptimal resource usage. The big four corporations outperform the others with an average efficiency score of 0.97. Although small, accounting firms' productivity grew 0.85 percent between 2009 and 2012, whereas the big four firms' output grew 1.38 percent. All firms' productivity increase is owing to technological progress, while the big four firms' is due to efficiency improvements. They used total revenue as output variable and number of offices, partners, and professionals as input variables.

Barros et al. (2014) evaluated UK audit companies' productivity change from 2005 to 2012. The Malmquist Index with a technological bias was used to analyse these changes. 2008 was a turning point for UK auditing. They adopted the European Statutory Audit Directive in April 2008 after previously following its own regulatory system. This study compared audit company productivity before and after the regulatory change. Their findings show inconsistent productivity growth in UK auditing firms. Additionally, the productivity change of UK auditing firms is not dictated regulated. They also contend that the typical growth accounting method, which assumes Hicks-neutral technological progress, is unsuitable for auditing corporate productivity studies. The study incorporated three distinct outputs, namely income generated from auditing and accounting, tax services, and miscellaneous sources. The three inputs utilized in the study are the number of offices, partners, and staff.

Lee (2014) examines CPA firms' operating efficiency from industry-specific customer groupings. From the 2010 Public Accounting Firms Service Investigation Report database, 49 partnership CPA firms make decisions. The paper uses data envelopment analysis, independent sample t tests, and multiple regression. It provides a reference for CPA business operators to improve efficiency. It also assesses how operating efficiency affects operating revenue and total revenue and finds industry-specific customer groups for company sustainability. This paper's findings may aid client relationship management and new client group exploitation. In his study, Lee (2014) employs labour cost and operating cost as input variables, while considering operational revenue as the output variable. Notably, Lee (2014) treats the income of each sector as a distinct output value.

Chang et al. (2015) employs a stochastic metafrontier production function to assess the technical efficiencies of accounting firms in the US, China, and Taiwan, which operate under distinct technologies. Taiwanese accounting firms exhibit the highest average metafrontier technical efficiency (MTE), while accounting firms in the United States have the

highest technical gap ratio (TGR). However, the mean TGR and MTE values of American accounting firms are more like those of Taiwan. However, the programming technique indicates contrasting outcomes for accounting firms in Taiwan and the US, with more significant differences observed for TGR and MTE. Subsequently, the accounting firms in these three countries exhibit decreasing returns to scale, suggesting that mergers and acquisitions may not be beneficial for increasing their production scale. They used total revenue as output variable, and the number of partners, professional stuff, and other employees.

In their paper, Clark & Qiao (2021) compare public accounting company efficiency across firms and nations post-Sarbanes-Oxley. The dynamics of their efficiency gaps are also examined. They estimate public accounting firm efficiency in the US, UK, and Canada from 2008 to 2015 using four-stage data envelopment analysis. The results suggest that accounting market competition boosts efficiency. It rises with GDP growth and falls with inflation. The analytical results show that lagging public accounting companies are catching up to leading firms in the same country, Big 4 group, and non-Big 4 group. They also reveal that non-Big 4 groups are catching up to the Big 4 and that countries with less efficient accounting companies are catching up to those with more efficient firms.

Based on this literature, this study analyzes Türkiye's auditing companies' productivity with a novel DEA model.

4. METHODOLOGY

4.1. Research Design

This study adopts a quantitative approach to measure the productivity of audit firms performing audits for Public Interest Entities (PIEs) in Türkiye during the period 2020–2023. Data Envelopment Analysis (DEA) was utilized to calculate MPI, which enables an assessment of productivity change through components such as efficiency and technological progress. MPI was chosen for its ability to measure productivity changes over time, decomposing them into efficiency and technological progress. It suits the study by handling limited data, enabling firm benchmarking, and addressing Türkiye's unique audit sector challenges, such as resource constraints and economic disruptions. The Malmquist productivity index is based on a benchmark technology that assumes constant returns to scale, distinguishing it from a best-practice technology that accounts for variable returns to scale (Caves et al., 1982; Färe et al., 1994). This methodology provides a comprehensive analysis of the total factor productivity (TFP) changes in the auditing sector, distinguishing between internal efficiency and technological advancements.

4.2. Data and Sample

The primary dataset consists of transparency reports published by audit firms authorized by the Public Oversight, Accounting, and Auditing Standards Authority (KGK). These reports provide data on inputs such as the number of responsible auditors and partners, and outputs such as audit and non-audit revenues. Several organizations, even large ones, choose not to disclose the total number of audit staff or total employees, which are commonly used input variables in the literature. Due to this limitation, only the number of responsible auditors and the number of partners were included as input variables in this study. This adjustment ensures consistency and reliability across the dataset.

It is also important to note that under the Turkish Commercial Code (Law No. 6102, 2011), independent audit firms conducting PIE audits are required to publish transparency reports. However, firms that do not conduct PIE audits are not legally obligated to release these reports. Despite this, some firms that do not conduct PIE audits still choose to publish transparency reports voluntarily. This variability in reporting practices was considered during sample selection, and only those firms that consistently disclosed relevant data were included in the analysis.

Normally, the distinction between responsible auditors for PIE and non-PIE audits is made, but not all companies provide this level of detail. Therefore, for the purpose of this study, all auditors with the title of responsible auditor were included, regardless of whether they conducted PIE or non-PIE audits.

Additionally, audit assistants are typically part of the audit team; however, not all firms provided specific data on the number of assistants. As a result, only auditors with the title of responsible auditor were included in the dataset, ensuring a consistent approach to defining the input variables.

Of the 96 firms listed on the Public Disclosure Platform (www.kap.gov.tr), 60 firms were selected for analysis based on data completeness and consistency. The sample includes a mix of globally affiliated ("Big Four" and network-associated) and independent local firms, providing a representative overview of the auditing landscape in Türkiye.

4.3. Variables

Inputs and outputs for the DEA model were defined as follows:

- Inputs:

  - Number of responsible auditors
  - Number of partners
- Outputs:
  - Audit revenue: Income derived from statutory audit engagements.
  - Non-audit revenue: Includes income from tax consultancy, certification, VAT refund services, and other advisory services.

4.4. Analysis Framework

The DEA-based Malmquist Productivity Index decomposes productivity into four components (Färe et al., 1994):

1. **Efficiency Change (effch):** Reflects improvements in the utilization of resources.
2. **Technological Change (techch):** Indicates progress or regress in technological innovation.
3. **Pure Efficiency Change (pech):** Measures enhancements in management and operational practices.
4. **Scale Efficiency Change (sech):** Evaluates the impact of scale adjustments on efficiency.
5. **Total Factor Productivity Change (tfpch):** Represents the overall change in productivity.

The analysis captures trends over three years, accounting for Türkiye's economic conditions, including inflationary pressures, which were mitigated through the application of a deflator to ensure the comparability of financial figures.

4.5. Timeframe Justification

The decision to restrict the dataset to the period between 2020 and 2023 was driven by several factors that are particularly relevant to the Turkish context. Notably, 2023 represents the most recent and comprehensive year of available data, ensuring the findings are up-to-date and relevant. Furthermore, as we move further into the past, the frequency of corporations conducting Public Interest Entity (PIE) audits in Türkiye significantly decreases, resulting in fewer organizations being included in the dataset. This limitation would have compromised the comprehensiveness and relevance of the analysis if a broader time frame had been used.

Moreover, the year 2020 marks a pivotal moment for businesses worldwide, including in Türkiye, as the COVID-19 pandemic triggered substantial shifts in the business environment. The pandemic led to disruptions in operations, a shift to remote work, and changes in financial reporting and auditing practices, all of which impacted productivity trends in the auditing sector. Therefore, the years 2020 to 2023 reflect a period of significant transformation that is critical for understanding current productivity dynamics in Türkiye’s auditing market.

Additionally, the four-year period was characterized by significant inflationary pressures in Türkiye. These economic conditions influenced both the demand for audits and the operational costs of audit firms. To ensure consistency and comparability across the dataset, a deflator was applied to the financial data, adjusting for the impact of inflation on revenues and allowing for a more accurate productivity measurement.

By focusing on this specific timeframe, the study captures the immediate effects of the pandemic and inflation on audit firms, while also maintaining a robust sample of PIE auditors for analysis. This approach ensures that the findings are both timely and relevant to the current state of Türkiye’s auditing market.

5. RESULTS

Table 2 provides an extensive overview of independent audit firms in Turkey analyzed during the period 2020–2023, detailing their affiliations with international networks or associations. It includes both globally recognized "Big Four" firms—Deloitte, PwC, EY, and KPMG—and local independent firms, reflecting the coexistence of global and domestic players in the Türkiye’s audit market. Many firms are part of international networks such as Nexia International, BDO International, and Grant Thornton International. These affiliations provide access to global expertise and adherence to international standards, thereby enhancing their market credibility and reliability. However, a considerable number of firms remain independent, highlighting robust local competition within Turkey's audit sector.

The dominance of the Big Four in auditing large-scale and publicly traded companies illustrates their significant influence and ability to set market standards. This table is instrumental in capturing the diversity of firms and outlining the structure of the audit sector in Türkiye. It serves as a foundation for analyzing firm performance, enabling comparisons across various scales and affiliations. The data also sets the stage for evaluating whether international network affiliations correlate with superior performance, contributing critical insights into the dynamics of Turkey's audit market.

Table 2. The list of Audit Firms in The Dataset

No	Company Code	Company Name	International Network/Association
1	A1	A-1 Certified Public Accounting and Independent Auditing Inc	Independent
2	AAC	AAC Independent Auditing and Consulting Inc.	PrimeGlobal
3	AG	AG Certified Public Accounting and Independent Auditing Inc.	Independent
4	AKSIS	Aksis International Independent Auditing Inc.	IECnet
5	AKT	AKT Independent Auditing Inc.	Independent
6	ANIL	Anıl Certified Public Accounting and Independent Auditing Inc.	ANTEA Alliance of Independent Firms
7	ARILAR	Arılar Independent Auditing and Certified Public Accounting Inc.	Nexia International
8	ARTID	Artı Değer International Independent Auditing and CPA Inc.	Task International
9	AS	AS Independent Auditing and Certified Public Accounting Inc.	Nexia International
10	ATAU	Ata International Independent Auditing and CPA Inc.	Kreston International
11	BAKIS	Bakış Certified Public Accounting and Independent Auditing Inc.	International Practice Group (IPG)
12	BDD	BDD Independent Auditing and Consulting Inc.	Independent
13	BDO	BDO Audit Independent Auditing and Consulting Inc.	BDO International
14	BEKOL	Birleşik Ekol Independent Auditing Inc.	Independent
15	CNS	CNS Independent Auditing Inc.	MSI Global Alliance
16	CONSULT	Consulta Independent Auditing and CPA Inc.	INAA Group
17	COZUMU	Çözüm Ünlüer Independent Auditing and Certified Public Accounting Inc.	Nexia International
18	DENGEAN	Denge Ankara Independent Auditing and Certified Public Accounting Inc.	Mazars
19	DENGE	Denge Independent Auditing CPA Inc.	Mazars
20	DMFSIS	DMF System International Independent Auditing, Consulting and CPA Inc.	Russell Bedford International
21	DMR	DMR Independent Auditing and Consulting Inc.	IECnet
22	DRT	DRT Independent Auditing and CPA Inc.	Deloitte (Big4)
23	ECOVIS	ECOVIS Value Independent Auditing and Certified Public Accounting Inc.	ECOVIS Europe AG
24	EDIT	Edit Independent Auditing Services Inc.	Auditrust International
25	EREN	Eren Independent Auditing Inc.	Grant Thornton International
26	FEKSEN	Financial Axis Independent Auditing and Consulting Inc.	GGI Global AllianceAG
27	GORUS	Görüş Independent Auditing and Certified Public Accounting Inc.	Independent
28	GRC	GRC Independent Auditing Inc.	Independent
29	GUNCEL	Güncel Independent Auditing and Consulting Inc.	Independent
30	GUNEY	Güney Independent Auditing and CPA Inc.	Ernst & Young (EY) (Big 4)
31	GURELI	Güreli Certified Public Accounting and Independent Auditing Services Inc.	Baker Tilly International
32	HSY	HSY Consulting and Independent Auditing Inc.	Crowe Global
33	ISIK	Işık Certified Public Accounting and Independent Auditing Inc.	BKR International
34	IRFAN	İrfan Independent Auditing and Certified Public Accounting Inc.	Independent
35	ITIMAT	İtimat Independent Auditing Inc.	Finexpertiza Network
36	KARAR	Karar Independent Auditing and Consulting Inc.	Abacus Worldwide
37	KAVRAM	Kavram Independent Auditing and Consulting Inc.	Crowe Global
38	KOKER	Köker Certified Public Accounting and Independent Auditing Inc.	AGN International
39	KPMG	KPMG Independent Auditing and CPA Inc.	KPMG (Big 4)
40	LIDYA	Lidya Independent Auditing and CPA Inc.	TGS Global
41	LISANS	Lisans Independent Auditing and Consulting Inc.	Morison Global
42	MBK	MBK Independent Auditing and CPA Inc.	Moore Global Network
43	MERCEK	Mercek Independent Auditing and Certified Public Accounting Inc.	Independent
44	MERIDYEN	Meridyen Corporate Solution and Independent Auditing Inc.	INPACT International
45	MGI	MGI Independent Auditing Inc.	MGI Worldwide
46	NOTEO	Note Office International Independent Auditing, Consulting, and CPA Inc.	Europe Fides
47	PKF	PKF Aday Independent Auditing Inc.	PKF International
48	PwC	PwC Independent Auditing and CPA Inc.	PwC (Big 4)
49	REANDA	Reanda Aren Independent Auditing and CPA Inc.	Reanda International
50	REFORM	Reform Independent Auditing Inc.	Independent
51	REHBER	Rehber Independent Auditing and Certified Public Accounting Inc.	ANTEA
52	REPORT	Report Independent Auditing Inc.	Independent
53	RSM	RSM Turkey Arkan Ergin International Independent Auditing Inc.	RSM International
54	SUN	Sun Independent Auditing and Certified Public Accounting Inc.	PKF WORLDWIDE
55	TTK	TTK Independent Auditing and Certified Public Accounting Inc.	HLB International
56	ULUSAL	Ulusal Independent Auditing and Certified Public Accounting Inc.	Russell Bedford International
57	UARASI	Uluslararası Independent Auditing Inc.	Independent
58	VEZIN	Vezin Independent Auditing Inc.	HLB International
59	YEDITEPE	Yeditepe Independent Auditing and Certified Public Accounting Inc.	Praxity Global Alliance

60	YORUM	Yorum Certified Public Accounting and Independent Auditing Inc.	Independent

Source: Compiled from the transparency reports of audit firms by the author.

The data presented in Table 3 offers significant insights into the structural and financial dynamics of Turkey's auditing firms during the period 2020–2023. The number of responsible auditors and partners, considered input variables, show relatively stable minimum values over the years, with the number of responsible auditors remaining at a minimum of 2 and partners ranging from 1 to 2. There is a noticeable upward trend in the average number of responsible auditors, increasing from 7.88 in 2020 to 8.58 in 2022, before slightly decreasing to 8.53 in 2023. Similarly, the average number of partners rose from 10.33 in 2020 to 10.38 in 2023, reflecting minor but consistent growth, possibly indicating strategic efforts to expand expertise and capacity for handling more complex audits.

Audit revenues exhibited significant growth over the period, with the mean value rising from 13,411,324 TRY in 2020 to 87,578,179 TRY in 2023. This dramatic increase highlights expanding market activity and improved performance among firms. In contrast, non-audit revenues show a more variable pattern, with the mean value rising from 7,508,741 TRY in 2020 to 13,237,122 TRY in 2022, before surging to 30,543,944 TRY in 2023. However, the wide standard deviations for both audit and non-audit revenues emphasize substantial disparities among firms, underlining the market dominance of larger players, such as the "Big Four."

The maximum audit revenue also grew sharply, from 207,776,379 TRY in 2020 to nearly 1,993,559,880 TRY in 2023, suggesting significant scaling among top-performing firms. Non-audit revenue, while increasing in maximum value to 392,369,000 TRY by 2023, displayed a more modest upward trajectory, pointing to a potentially constrained market for non-audit services.

These revenue patterns are further complicated by Türkiye's high inflation rates, which reached 36.08% in 2021, 64.27% in 2022, and 64.77% in 2023. Such inflationary pressures mean that the real growth in revenues may be less pronounced than nominal figures suggest. Adjusting financial outputs for inflation is therefore critical to ensure consistency in analyzing productivity trends. Understanding these dynamics is vital for evaluating the efficiency and competitiveness of auditing firms and can inform strategies for improving market positioning and expanding service offerings.

Table 3. Sample Descriptives (2020-2023)

Inputs and Outputs / years	2020	2021	2022	2023
Number of responsible auditors (I)				
Minimum	2	2	2	2
Maximum	28	27	27	34
Mean	7,88	8,42	8,58	8,53
Standard Deviation	6,09	6,43	6,49	7,03
Number of partners (I)				
Minimum	1	2	2	2
Maximum	27	28	30	36
Mean	10,33	10,25	10,32	10,38
Standard Deviation	6,91	6,94	7,00	7,32
Audit revenue (O)				
Minimum	286.49K	361.99K	495.50K	150K
Maximum	207.78M	350.65M	717.58M	1.99B
Mean	13.41M	18.24M	33.86M	87.58M
Standard Deviation	39.37M	56.77M	111.71M	298.64M
Non-audit revenue (O)				
Minimum	0	212	0	3.30K
Maximum	123.96M	127.39M	161.20M	392.37K
Mean	7.51M	8.41M	13.24M	30.54M
Standard Deviation	19.72M	21.02M	30.88M	73.41M

Note: K = thousands, M = millions, B = billions.

The results presented in the revised Table 4 provide an updated overview of productivity changes observed in Turkey's auditing firms during the period 2020 to 2023, as measured by the Malmquist Index. The total factor productivity change (tfpch) averaged 0.751, reflecting a notable decline in productivity during the period. This decline is predominantly attributed to the negative impact of technological change (techch), which averaged 0.305, highlighting regression in technology and innovation within the sector.

Table 4. Malmquist Index Summary of Annual Means

Year	effch	techch	pech	sech	tfpch
2	7.143	0.050	1.373	5.202	0.357
3	1.848	0.754	0.676	2.733	1.393

4	1.132	0.752	1.533	0.738	0.851
Mean	2.463	0.305	1.125	2.190	0.751

The efficiency change (effch) component, averaging 2.463, demonstrates significant improvements in firms' capacity to effectively utilize their resources, particularly during the transition periods. Pure efficiency change (pech), which evaluates managerial improvements, also registered positive performance with an average of 1.125, underscoring the effective internal adaptations within the sector.

However, the severe decline in technological progress (techch) poses a critical challenge for the auditing industry, suggesting systemic barriers to adopting advanced tools and innovations. Such technological stagnation could be linked to regulatory restrictions, economic challenges, or resource limitations affecting firms' ability to modernize.

Scale efficiency change (sech) showed variability across the period, averaging 2.190, indicating that many firms achieved optimal scale relative to their resource utilization. Despite this, the lack of technological advancements undermined the sector's overall productivity growth.

These findings emphasize the dual importance of operational efficiency and technological innovation for achieving sustainable productivity growth. While firms have succeeded in enhancing resource utilization and operational efficiency, addressing technological gaps remains essential to maintaining competitiveness and aligning with global standards. The industry must prioritize investments in digital transformation and innovation to overcome these challenges and secure long-term growth.

Table 5. Malmquist Index Summary of Firm Means

Firm	effch	techch	pech	sech	tfpch	Firm	effch	techch	pech	sech	tfpch
1	0.664	0.248	0.821	0.809	0.165	**31**	2.237	0.31	1.235	1.812	0.695
2	1.938	0.304	1.027	1.887	0.588	**32**	2.524	0.316	1.245	2.027	0.797
3	2.144	0.323	1.106	1.939	0.692	**33**	2.675	0.337	1.09	2.454	0.901
4	1.666	0.298	1.053	1.583	0.496	**34**	3.348	0.353	1.236	2.709	1.183
5	0.927	0.353	0.894	1.037	0.327	**35**	3.304	0.333	1.207	2.738	1.101
6	0.541	0.355	0.678	0.799	0.192	**36**	4.527	0.37	1.236	3.662	1.674
7	0.476	0.348	0.689	0.69	0.166	**37**	6.551	0.321	1.426	4.594	2.1
8	0.46	0.344	0.874	0.526	0.158	**38**	4.001	0.381	1.172	3.413	1.523
9	1.189	0.258	1.278	0.931	0.307	**39**	3.272	0.401	1.15	2.844	1.313
10	1.05	0.255	1.153	0.911	0.268	**40**	5.657	0.336	1.501	3.77	1.898
11	1.406	0.27	1.554	0.905	0.38	**41**	2.302	0.268	1.099	2.095	0.617
12	1.207	0.255	1.534	0.787	0.307	**42**	2.868	0.204	1.136	2.526	0.584
13	2.712	0.265	0.827	3.28	0.717	**43**	2.452	0.29	1.322	1.855	0.711
14	1.977	0.293	0.82	2.411	0.579	**44**	3.201	0.276	1.28	2.501	0.883
15	1.938	0.298	0.822	2.357	0.577	**45**	0.751	0.386	0.899	0.835	0.29
16	2.732	0.265	0.793	3.445	0.724	**46**	1.422	0.341	1.028	1.384	0.484
17	3.2	0.289	1.387	2.308	0.925	**47**	1.765	0.301	1.101	1.603	0.531
18	1.229	0.309	1.26	0.975	0.38	**48**	2.096	0.303	0.989	2.12	0.635
19	2.79	0.273	1.347	2.071	0.761	**49**	5.125	0.453	1.148	4.463	2.323
20	2.602	0.301	1.336	1.948	0.784	**50**	6.237	0.395	1.227	5.081	2.466
21	2.735	0.231	0.845	3.239	0.631	**51**	5.699	0.408	1.153	4.942	2.328
22	3.006	0.286	0.907	3.315	0.86	**52**	5.343	0.35	1.155	4.625	1.87
23	2.563	0.297	0.871	2.943	0.761	**53**	2.863	0.228	1.289	2.22	0.653
24	3.068	0.307	0.949	3.233	0.941	**54**	2.316	0.271	1.293	1.79	0.628
25	5.497	0.271	1.262	4.354	1.489	**55**	2.419	0.288	1.3	1.861	0.697
26	5.092	0.26	1.27	4.008	1.326	**56**	2.908	0.26	1.342	2.167	0.755
27	5.503	0.267	1.322	4.161	1.469	**57**	2.758	0.336	1.201	2.296	0.928
28	4.953	0.269	1.225	4.044	1.333	**58**	2.632	0.383	1.236	2.13	1.007
29	2.786	0.33	1.121	2.486	0.918	**59**	5.482	0.321	1.467	3.736	1.758
30	2.752	0.301	1.06	2.596	0.829	**60**	6.879	0.277	1.504	4.575	1.903
						Mean	2.463	0.305	1.125	2.19	0.751

Table 5 provides a comprehensive analysis of the productivity dynamics of Turkey's audit firms between 2020 and 2023, as measured by the Malmquist Productivity Index. Efficiency change (effch), which evaluates firms' ability to utilize resources effectively, has an average value of 2.463, reflecting significant improvements in resource utilization across firms. Pure efficiency change (pech), capturing managerial and operational enhancements, averaged 1.125, emphasizing the positive impact of managerial practices on firm performance. However, technological change (techch), measuring advancements or regressions in innovation, exhibited a concerning average of 0.305, underscoring a pronounced regression in technological progress.

Scale efficiency change (sech), with an average of 2.190, suggests that most firms were able to maintain operations close to their optimal scale relative to their resources. Despite this, the total factor productivity change (tfpch), which reflects the combined effects of efficiency, technological, and scale changes, shows an average of 0.751, indicating an overall decline in productivity during the period.

The analysis reveals notable variability across firms. Some firms, such as Firm 60, exhibit exceptional performance with efficiency change (effch = 6.879) and total factor productivity change (tfpch = 1.903), showcasing effective resource optimization and overall productivity growth. Conversely, firms like Firm 7, with low effch values of 0.476, indicate inefficiencies in resource utilization. Similarly, technological progress varies widely, with some firms (e.g., Firm 49, techch = 0.453) showing advancements, while others lag behind, contributing to the sector's overall technological regression.

These results highlight the critical role of operational efficiency and management practices in sustaining productivity, even during periods of technological stagnation. However, the negative impact of declining technological change on overall productivity emphasizes the urgent need for strategic investments in digitalization, automation, and innovative auditing tools. Firms with lower efficiency scores should prioritize resource optimization and operational improvements, while simultaneously addressing barriers to adopting advanced technologies.

The findings from Table 5 underscore the dual challenge of enhancing operational efficiency and driving technological innovation. While improvements in managerial practices have bolstered resource utilization, the lack of innovation remains a significant hurdle to long-term productivity growth. Addressing these challenges is crucial for ensuring competitiveness, aligning with global standards, and fostering a more resilient audit sector in Türkiye.

Table 6. Productivity Scores by Firm Category

Firm Category	Efficiency Change (Effch)	Technological Change (Techch)	Pure Efficiency Change (Pech)	Scale Efficiency Change (Sech)	Total Factor Productivity Change (Tfpch)
Big Four	1.603	0.293	1.002	1.555	0.485
Independent	1.652	0.296	1.078	1.586	0.472
International Network	3.589	0.3154	1.187	2.980	1.145

Table 6 provides a comparative analysis of productivity scores by firm category, including the "Big Four," firms affiliated with international networks, and independent firms. The results highlight notable differences across these categories, reflecting their distinct operational and structural advantages.

The "Big Four" firms demonstrate strong performance, leading in efficiency change (effch = 1.603), technological change (techch = 0.293), pure efficiency change (pech = 1.002), scale efficiency change (sech = 1.555), and total factor productivity change (tfpch = 0.485). These scores underline their capacity to leverage global expertise, substantial resources, and advanced technologies, establishing them as industry benchmarks in operational and technological efficiency.

Firms affiliated with international networks also exhibit commendable scores, with effch at 3.589, techch at 0.3154, pech at 1.187, sech at 2.980, and tfpch at 1.145. Their affiliation with global networks enables access to international best practices and enhances their competitiveness. However, their scale efficiency (sech) scores suggest that operational optimization relative to available resources remains a challenge.

Independent firms show varying performance levels. While their efficiency change (effch = 1.652) and pure efficiency change (pech = 1.078) are relatively competitive, technological change (techch = 0.296) and total factor productivity change (tfpch = 0.472) indicate difficulties in technological adaptation and resource maximization. This highlights the constraints faced by independent firms due to limited resources and slower technological uptake.

Overall, the results emphasize the critical role of technology and global affiliations in driving productivity. While the "Big Four" and international network-affiliated firms demonstrate robust performances, independent firms face notable challenges, particularly in technological innovation. Addressing these disparities through strategic investments and collaboration could contribute to a more competitive and balanced audit sector in Türkiye.

6. DISCUSSION AND CONCLUSION

This study evaluated the productivity of audit firms in Türkiye conducting Public Interest Entitities (PIE) audits between 2020 and 2023, utilizing MPI to assess changes in efficiency, technological progress, and overall productivity. The findings shed light on the dynamics of Türkiye’s audit market, highlighting both strengths and challenges faced by firms of varying sizes and affiliations.

The results indicate a slight overall decline in total factor productivity (TFP), primarily driven by technological regression. While improvements in efficiency—particularly in resource utilization and management practices—were evident, they were not sufficient to offset the lack of advancements in technology. This trend underscores the critical importance of innovation and digitalization in sustaining long-term productivity growth.

The analysis revealed significant disparities among firms. The "Big Four" firms emerged as market leaders, consistently outperforming others across all productivity components. These firms leveraged their global expertise, advanced technological resources, and economies of scale to adapt swiftly to changing market conditions and regulatory demands. Firms affiliated with international networks also demonstrated competitive performance, benefiting from access to global best practices and resources. However, some struggled with scale inefficiencies, suggesting challenges in optimizing their operations relative to their resource base. Independent local firms, on the other hand, faced notable difficulties in adopting modern audit technologies and achieving operational efficiency gains. Limited resources and slower adoption of innovation posed significant barriers, highlighting the need for targeted investments in digital tools, staff development, and process optimization.

The study period, spanning 2020 to 2023, reflects a time of economic turbulence and operational challenges. The COVID-19 pandemic disrupted traditional audit practices, necessitating a shift to remote work environments and increased reliance on digital solutions. Meanwhile, Türkiye's high inflation rates further complicated the operating environment for audit firms, impacting audit fees, operational costs, and client demand for services. These external pressures underscored the resilience and adaptability of larger firms while amplifying the challenges faced by smaller ones.

The audit sector in Türkiye will likely see increased digitalization, with technologies like AI and blockchain becoming essential for competitiveness. Larger firms, especially the "Big Four," will maintain dominance, while smaller firms must adopt innovative strategies or focus on niche services to remain competitive. Regulatory changes emphasizing transparency and international standards will drive firms to enhance their technological and operational capabilities. As automation reduces traditional audit tasks, advisory services in ESG (Environmental, Social, Governance), cybersecurity, and risk management will gain prominence. Economic challenges, including inflation, will necessitate cost-efficient models and client diversification, highlighting the importance of adaptability and innovation for sustained growth.

The findings carry important implications for policymakers and practitioners. Policymakers should consider initiatives to support smaller firms through incentives for technology adoption, training programs, and innovation grants. Collaborative efforts between larger and smaller firms could also facilitate the dissemination of best practices and foster technological advancement across the sector. For audit firms, the results emphasize the need to prioritize investments in digital transformation, workforce development, and process innovation. Smaller firms, in particular, must explore cost-effective technological solutions and partnerships to enhance competitiveness, while larger firms can maintain their leadership by continuously adapting to evolving market and regulatory demands.

This study contributes to the limited body of literature on auditing firm productivity in emerging markets, providing empirical insights into the context of Türkiye. By employing a robust DEA-based framework and accounting for external factors such as inflation and the pandemic, the research offers actionable strategies for enhancing the productivity and competitiveness of audit firms. Future research could expand on these findings by exploring cross-country comparisons, examining the impact of specific regulatory changes, or investigating client perceptions of audit quality in relation to firm productivity. Addressing these issues would deepen the understanding of how policy and market forces shape productivity in the auditing sector.

In conclusion, the productivity of audit firms in Türkiye reflects the interplay of internal capabilities and external economic and regulatory conditions. While the "Big Four" and internationally affiliated firms set benchmarks for efficiency and technological progress, independent firms face substantial challenges that require targeted interventions. By embracing innovation, fostering collaboration, and addressing structural disparities, Türkiye's auditing sector can strengthen its position in both local and global markets, ultimately enhancing financial transparency and market confidence.

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