

MEASURING EFFICIENCY IN AUDITING: A COMPREHENSIVE LITERATURE REVIEW

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Resumen

Determinants of audit firm performance and audit effectiveness and efficiency are of great interest to a broad audience. In this paper, we try to shed light on the evolution of recent literature on efficiency in auditing. To this end, we gather and review an extensive list of academic papers in order to outline its chronology, the methods used for measuring firm's efficiency, the research methods designed to test hypothesis on audit efficiency and the main variables involved. Two main streams of research are pointed out: (i) auditing firm's efficiency; and (ii) efficiency of audit production and auditor's performance.

1 Introduction

Considering the very competitive character of the auditing market (Kleinman et al. [1998]) and within a growingly competitive scenario, auditing firms are more and more concerned on serving production in an efficient way in order to survive and grow. Thus, this scenario lends greater importance to audit efficiency (McDaniel [1990]; McNair [1991]; Mock and Wright [1993]) and get authors interested in analyzing efficiency in auditing.

This literature review is built around the concepts of “audit” and “efficiency”. Thus, these two terms are the basis for our search undertaken from July to December 2018 through Web of Science and Google Scholar. Notice that, although this search terms are not biasing the results to external audit, results on internal audit efficiency (see, e.g. Savčuk [2007]) have a testimonial character.

Leaving aside the various classifications of audit, the core of the present work is efficiency in auditing, understanding this as financial auditing, external auditing, independent auditing or financial statements auditing.

It is important to bear in mind, however, that the reviewed papers were selected for inclusion in this work if they were totally or partially written in English. In this respect, we found the Buchner et al. [1997] paper. In light of its title, it would have been included in the sample selection, had it not been for being written completely in German.

Works by Ashton et al. [1987], Ashton et al. [1989], Newton and Ashton [1989], Bamber et al. [1993], Knechel and Payne [2001], Payne and Jensen [2002], Tanyi et al. [2010] and Knechel et al. [2012] rely upon audit report lag as a proxy for audit production or efficiency. In the Newton and Ashton [1989] paper, audit delay is presented as the only publicly observable measure of audit efficiency. Regarding Gaeremynck et al. [2010], the fact that audit lag can be used as a publicly available proxy for audit efficiency is empirically demonstrated. With respect to determinants of audit lag, Knechel and Sharma [2012] examines the effect of variables such as level of non-audit service fees, total assets or tenure of the auditor on audit lag.

The accounting profession has strongly supported that the joint provision of audit and nonaudit services yields to a better performance of the audit. The (Knechel and Sharma [2012]) results suggest that there is some merit to this argument. In the Simunic [1984] work, the synergies that public accounting firms may reach from providing nonaudit services are examined. Regarding the debate about whether nonaudit services compromise the effectiveness of the audit or not, the Sarbanes-Oxley Act of 2002 (SOX) must be mentioned.

This paper pursues reviewing recent literature on efficiency in auditing. Literature on this issue can be classified into two main groups: (i) auditing firm’s efficiency; and (ii) efficiency of audit production and auditor’s performance.

On one hand, this paper primarily aims to provide and analyze an exhaustive list of publications dealing with the problem of examining how efficiently an auditing firm uses its inputs to obtain outputs. The list displayed collects information on 18 papers published during the period 1996-2017.

Regarding the second stream of literature, this paper aims to provide and analyze a list of 16 papers published between years 1981 and 2018.

Potential users of this paper are: (i) policy makers; (ii) audit supervisory authorities; (iii) accounting bodies; (iv) auditing firms; (v) auditing firms’ professional staff; (vi) auditing firms’ clients; (vii) shareholders of firms under audit; (viii) academics; and (ix) society at large.

The remainder of this paper is divided into three sections. In Section 2, the auditing firm’s efficiency related articles lists (Stream 1) are displayed, as well as summary statistics on these papers. Section 3 is devoted to the efficiency of audit production and auditor’s performance related papers (Stream 2). Finally, Section 4 offers concluding remarks.

2 Bibliography on auditing firm's efficiency. Stream 1

2.1 Auditing firm's efficiency

Table 1 provides information regarding 17 chronologically ordered papers about efficiency on auditing firms. This summary contains basic work data such as authors and publication year (Column 2), methods employed, variables involved, opportunity set and data source (Columns 3-6).

These 17 works share the common factor of assessing the efficiency of resources within firms providing auditing services. To this end, authors employ a variety of mathematical models, being Data Envelopment Analysis (DEA) prevalent. These works concentrate on a more or less broad set of firms. While Lee [2009] evaluates the operational efficiency of 173 medium-sized audit firms, Lee [2015] investigates how non-audit services affect accounting firm productivity by using a panel of data for 25 Korean accounting firms. The remaining 15 papers look at a number of firms between 25 and 173. Such a reflection is made because authors of this paper have been aware of the existence of a work not focusing on firms, but focusing on offices of a firm. More precisely, it focuses on five offices of an international public accounting firm. To maintain mutual consistency in comparing papers dealing with efficiency of resources within firms, Banker et al. [2002] is not included in the 17-works list. In Banker et al. [2002] interesting conclusions regarding the Information Technology impact on the firm's productivity improvement are reached (see Table 2). However, authors notice limitations on the use of single firm data: "Although the single firm data limits broad generalizations to other contexts...".

Paper number	Authors	Model	Inputs	Outputs	Opportunity set and data source
1	Jerris and Pearson [1996]	Ratios	Total revenues; Number of: partners, professionals, employees and offices.		92 CPA firms in 1994. U.S.; Accounting Today ¹ .
2	Cheng et al. [2000]	DEA; Tobit censored regression model.	Number of employees; Net Fixed Assets. All items of revenues and Net Fixed Assets are measured in New Taiwan Dollars.	Revenues from: Auditing services; Tax services; and Management Advisory Services (MAS) services. All items of revenues and Net Fixed Assets are measured in New Taiwan Dollars.	150 CPA firms ² in 1994. Taiwan; Department of Statistics, Ministry of Finance, Taiwan, ROC.
3	Banker et al. [2003]	Translog revenue function.	Number of partners; Number of other professionals; and Number of other employees.	Accounting and auditing (A&A) services; Tax services; and MAS. Unit: millions of dollars. All monetary values are inflation adjusted to 1995 dollars.	64 CPA firms ³ from 1995 to 1999, both years included. U.S.; Accounting Today.
4	Banker et al. [2005]	DEA; OLS regression model; Malmquist index	Number of partners; Number of other professionals; and Number of other employees.	A&A services; Tax services; and MAS. Unit: millions of dollars. All monetary values are inflation adjusted to 1995 dollars.	64 CPA firms ⁴ from 1995 to 1999, both years included. U.S.; Accounting Today.
5	Franz and Jerris [2005]	Ratios	Total revenues; Number of: partners, professionals, employees and offices.		92 CPA firms in 1994. 93 CPA firms in 2004. U.S.; Accounting Today.
6	Banker et al. [2007]	DEA	Number of partners; Number of other professionals; and Number of other employees.	Revenues from: A&A services; Tax services; and MAS. Unit: millions of dollars.	93 CPA firms in 1995. 92 CPA firms in 1996. 93 CPA firms in 1997. 94 CPA firms in 1998. U.S.; Accounting Today.
7	Chang et al. [2008]	DEA; Regression models.	Number of partners; Number of other professionals; and Number of other employees.	Total service revenues generated. Unit: millions of dollars. The total revenues are inflation adjusted to 2000 dollars.	58 CPA firms ⁵ from 2000 to 2004 (excluding 2002). U.S.; Data on the output: Accounting Today; Data on the input: Hand collected from the annual reports of accounting firms that were filed with the American Institute of Certified Public Accountants (AICPA) for each of the pertinent years.
8	Chang et al. [2009a]	DEA; Malmquist index.	Number of partners; Number of other professionals; and Number of other employees.	A&A services; Tax services; and MAS. Unit: millions of dollars of revenues.	56 CPA firms ⁶ for 1996-1999 and 2003-2006. U.S.; Accounting Today.
9	Chang et al. [2009b]	DEA; Malmquist index.	Number of partners; Number of other professionals; and Number of other employees.	A&A services; Tax services; and MAS. Unit: millions of dollars of revenues. The total revenues are inflation adjusted to 2000 dollars.	62 CPA firms from 2000 to 2004 (excluding 2002). U.S.; Data on the output: Accounting Today; Data on the input: Hand collected from the annual reports of accounting firms that were filed with the American Institute of Certified Public Accountants (AICPA) for each of the pertinent years.
10	Chang et al. [2009c]	DEA	Number of partners; Number of other professionals; Number of other employees; and Number of branch offices.	A&A services; Tax Services; and MAS. Unit: millions of dollars of revenue.	87 CPA firms from 2003 to 2004. U.S.; Accounting Today.

Paper number	Authors	Model	Inputs	Outputs	Opportunity set and data source
11	Lee [2009]	DEA	Number of branches; Number of total employees; Number of partners; and Total expenditures of audit firm (unit: dollars).	Attestation revenues; Tax business revenues; Management consultancy revenues; and Corporate registration and other business services. Unit: dollars.	173 medium-sized audit firms in 2005. Taiwan; Survey Report of Public Audit Firms in Taiwan, published by the Financial Supervisory Commission, Executive Yuan, Taiwan, ROC.
12	Chang et al. [2011]	DEA; Adaptation of the quadripartite decomposition method proposed by Henderson and Russell [2005]; OLS regression model.	Total number of employees; IT capital (unit: New Taiwan Dollar. IT capital expenditures are inflation-adjusted using 1993 as the base year); and human capital (unit: human capital index estimated on the basis of returns to education and experience).	Total revenue. Unit: New Taiwan Dollar. Inflation-adjusted using 1993 as the base year.	51 public accounting firms ⁷ for 1993 and 2003. Taiwan; Annual Survey of Accounting Firms in Taiwan, published by the Department of Statistics of Taiwan's Ministry of Finance.
13	Barros et al. [2014]	DEA; Malmquist index.	Number of partners and shareholders; Number of professional staff; and Number of offices.	A&A services; Tax services; and Other revenues (ROTS).	35 auditing firms from 2005 to 2012. UK; Accountancy Age Top 50 and Accountancy Magazine Top 60.
14	Lee [2014]	DEA; Independent sample t test; Multiple regression analysis.	Labor cost; and Operating assets cost. Unit: New Taiwan Dollar.	Operating revenue from: Manufacturing industry; Wholesale and retail industry; Lodging, food and beverages industry; Transport and storage industry; Information and communications industry; Professional and technical services industry. Unit: New Taiwan Dollar.	49 CPA firms in 2010. Taiwan; The 2010 Public Accounting Firms Service Investigation Report issued by the Financial Supervisory Commission of Taiwan.
15	Chang et al. [2015]	Stochastic metafrontier production function.	Number of partners; Number of professionals; and Number of other employees.	Total revenues. Unit: Millions of US dollars before tax. To maintain mutual consistency in comparing the annual data of the three countries, first: use the 2005 base year consumer price index of each country to deflate the data and convert it into real variables; and second: convert RMB and TWD into USD (in millions of dollars) based on annual average exchange rate.	109 accounting firms. U.S.; 50 accounting firms ⁸ . Taiwan; 142 accounting firms. China; Period: 2007-2009 ⁹ ; U.S. data comes from Accounting Today; Taiwan data comes from the Annual Survey of Accounting Firms in Taiwan, published by the Financial Supervisory Commission ROC; China data comes from the Chinese Institute of Certified Public Accountants (CICPA).
16	Lee [2015]	DEA; Regression model.	Number of partners; Number of certified public accountants who are not partners (CPA); and Number of all other employees.	Annual total firm revenues. In deflated millions (M) of Korean won (KRW).	25 accounting firms ¹⁰ from 1997 to 2012. Korea; Annual business reports of the firms.
17	Wanke et al. [2017]	DEA; Bootstrapped procedure followed by neural networks.	Number of offices; Number of partners; and Number of professional staff.	A&A revenue; Tax revenue; Consultancy revenue; and Other revenue. Unit: £1,000/year.	35 auditing firms from 2005 to 2012. UK; Accountancy Age Top 50 and Accountancy Magazine Top 60.

Source: Own elaboration

¹ Each year Accounting Today conducts a survey of the 100 largest accounting firms. Only domestic US operations are included in the survey and data from foreign holdings are excluded.

² All of these companies provide all of the following three services: auditing, tax and MAS services. Firms that did not run their businesses for a whole year are not included in the sample to ensure the homogeneity of the observations.

³ These firms appeared in Accounting Today's list consistently for each of the 5 years from 1995 to 1999.

⁴ The condition that data be available for a firm for all five years between 1995 and 1999 is imposed.

⁵ For these 58 firms data are available for the four-year period beginning 2000 and ending 2004 (excluding 2002).

⁶ These 56 firms appear consistently in Accounting Today over the 8-year period 1996-2006 (excluding 2000-2002).

⁷ Four Big 4 firms and 47 non-Big 4 firms, that appear consistently over the period 1993-2003.

⁸ Firms with 0 professional staff are eliminated.

⁹ Input and output data is collected for the top 100 accounting firms in each country (ranked on the basis of total revenues). The same accounting firm may not always be ranked in the top 100 each year.

¹⁰ These 25 firms have existed during the whole sample period.

Concerning Jerris and Pearson [1996], it is worth noting the work's update published in the same journal one year later (Jerris and Pearson [1997]). The 1997 publication provides a ratios-based evaluation of accounting firm production and efficiency for 1995 compared to the previous year. In both cases, the analysis concentrates on CPA firms providing A&A, taxes and MAS services. After excluding non-CPA firms, firms non generating revenues from the three aforementioned services and firms with incorrect data, ninety-two and ninety firms of the top 100 were analyzed in 1994 and 1995, respectively. Data comes from Accounting Today.

Table 2: A review on the Banker et al. [2002] paper

Paper number	Authors	Model	Inputs	Outputs	Opportunity set and data source
18	Banker et al. [2002]	DEA; Regression analysis.	Professional labor costs; Operating costs. Inflationary adjustment by the monthly Consumer Price Index (CPI).	Monthly revenue. Inflationary adjustment by the monthly CPI.	5 offices of an international public accounting firm from 1997 to 1999; Quantitative and qualitative data from 5 offices of the firm.

Source: Own elaboration

With the purpose of assessing the impact of audit software and knowledge-sharing applications in public accounting firms, Banker et al. [2002] employ parametric (regression analysis) and nonparametric (DEA) estimation methods. This is consistent with other papers assessing firm's productivity (see Table 1). Regarding inputs and outputs, although costs are not widely used, revenues are the most used option as output when assessing firm's productivity.

With respect to last column of Table 2, authors select 1997 to 1999 as 1998 was the key period when the Information Technology transition took place. Notice that unlike the papers in Table 1, Banker et al. [2002] does not refer to the firm's geographical area. In this sense, it states: "The confidentiality agreement with the firm that provided the data for this study precludes revealing its identity and disseminating detailed data without its written consent".

2.2 Summary statistics on Stream 1

This section undertakes a thoroughly revision of the papers just displayed but from a different perspective. In this section the idea is bringing the reader with summary statistics on key aspects of the papers.

2.2.1 On the methodological approaches

Related to methods, DEA takes center stage as is used in 13 out of the 17 papers. While no method is linked to DEA application in 3 cases, DEA is combined with other methods in 10 out of the 17 papers. Four of the times DEA is combined with Malmquist index (Malmquist [1953]). Chang et al. [2009a] and Chang et al. [2009b] follow Banker et al. [2005] in applying the Malmquist productivity index to estimate changes in productivity and efficiency of CPA firms under selected circumstances. While the three cases focuses on US accounting firms, works by Chang et al. investigate changes in the playing field of accounting firms prior to and following the Sarbanes-Oxley Act enacted into law in year 2002.

Regarding the more recent paper using a Malmquist index, Barros et al. [2014] concentrates on the productivity change in the UK of auditing firms over 2005-2012.

On the other hand, recourse to ratios is made in Jerris and Pearson [1996] and Franz and Jerris [2005]. While Jerris and Pearson [1996] focuses on 92 CPA firms' production and efficiency in 1994, Franz and Jerris [2005] extends this behavioral analysis to year 2004, thus, including 93 CPA firms to the case. All of these firms obtain revenues in all of the following three components: accounting and auditing, tax and MAS services. Ratios employed are in both papers as follows: revenue per firm; revenue per partner; revenue per professional; revenue per employee and revenue per office.

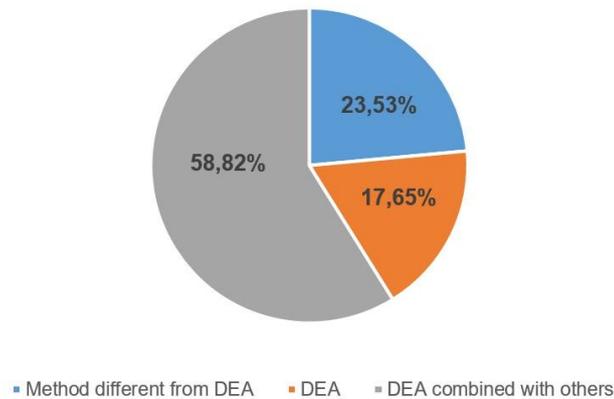


Figure 1: Methodologies
Source: Own elaboration.

2.2.2 On the variables involved: Inputs

When analyzing the inputs, special mention must be made to human resources variables. Authors consider only this kind of input variables in eight of the papers. The three different categories of human resources more employed are displayed in Table 3. Both Chang et al. [2009a] and Lee [2015] justifies the non-inclusion of capital inputs by quoting O’Keefe et al. [1994]. While Chang et al. [2009a] refers to the “only second-order importance” of capital inputs, Lee [2015] refers to them as “not considered to be of primary importance”. Furthermore, Chang et al. [2008] cites Texas Society of Certified Public Accountants [2005] when referring to the significant fraction of total costs for public accounting firms that personnel costs constitute.

2.2.3 On the variables involved: Outputs

As shown in Table 3, a common practice consists of measuring the outputs of each firm as the income of the auditing activity considering three sources of income, this is, Accounting and Auditing (A&A) services, Tax services and Management Advisory Services (MAS). On the other hand, total firm revenues as a measure of output is less common used (see Chang et al. [2008], Chang et al. [2011], Chang et al. [2015] and Lee [2015]).

When examining the variety of output measures, the description of outputs made by Lee [2014] draws attention. In this case, the source of revenues distinguishes between six industry sets.

Table 3: Top 3 more used inputs-outputs.

Top 3 inputs	Top 3 outputs
Number of partners	Revenues from Accounting and Auditing Services
Number of other professionals	Revenues from Tax services
Number of other employees	Revenues from Management Advisory Services

Source: Own elaboration

Principal Component Analysis (PCA) is used to reduce variables in Wanke et al. [2017], this leading to the following results. From the inputs side: First factor (total staff); Second factor (number of offices). Regarding the outputs: First factor (revenues from core services); Second factor (other revenues).

Chang et al. [2009a] strengthen the convenience of choosing three different categories of professional staff (inputs) and three sources of income (output). As this paper states, accounting firms “employ three different categories of professional staff, partners, professionals, and other employees, to generate three types of outputs, accounting and auditing, taxation and consulting

services”.

2.2.4 On the data: Opportunity set and data source

If the target of the analysis focuses on the geographical areas receiving more attention from the auditing firm's efficiency point of view, a remarkable fact underlies. United States grabs the attention in nine of the reviewed papers. Chang et al. [2015] highlights this appreciation as follows “The literature on efficiency and productivity in accounting industry has barely been analyzed outside the US.” Thus, nine of the cases are dedicated exclusively to the United States scenario. Besides, data on this country is also relevant in the above-mentioned Chang et al. [2015], as it involves a comparison of the technical efficiency of accounting firms in three countries, being the United States one of them. This paper stands out in this sense, as is the only one dealing with the efficiency of accounting firms topic in more than one country (U.S., China and Taiwan). Mention to this point is made in Chang et al. [2015] by stating “...many of the existing studies deal only with the accounting firm in a single country”.

In Chang et al. [2015], the output variable is defined as total revenue received from the provision of services with no distinction between forms of service. This is because the classification systems used for these services differ among the U.S., China and Taiwan.

Figure 2 allows the reader to conclude that most of the works concentrate on the American continent. However, no country apart from U.S. is analyzed in America. Asia has also a special place in this literature review, as data from Taiwanese, Chinese and Korean firms plays a key role in six out of the seventeen cases. Finally, no country apart from UK is analyzed in the European context. Two papers out of the seventeen deal with UK firms.

On the other hand, sample periods consists of more than one year in most of the cases. The broad-based period taken in Lee [2015] (1997-2012) stands out of the other papers sample periods. Regarding the years under analysis, some other aspects emerge. Take, for example, Papers 7 to 9, in which year 2002 is excluded from the analysis. As the Sarbanes-Oxley Act (SOX) was enacted into law in year 2002, these papers try to ascertain the performance effects of SOX. Besides, it is worth mentioning the “a decade comparison”, 1994 versus 2004, undertaken by Franz and Jerris [2005]. In the case of Chang et al. [2011], data for the years 1993 and 2003 is analyzed.

This section concludes with some reference to the data source. When dealing with U.S.-based cases, Accounting Today is the main source of data. As stated by Chang et al. [2008] “This annual survey of the profession's largest firms has become one of the most often cited sources in the field”. Notice that an alternative data source on the 100 largest public accounting firms in the U.S. is the Public Accounting Report, published by Strafford Publications, Inc. On the other hand, paper by Chang et al. [2011] carefully describes three advantages of Annual Survey of Accounting Firms in Taiwan in comparison to Accounting Today.

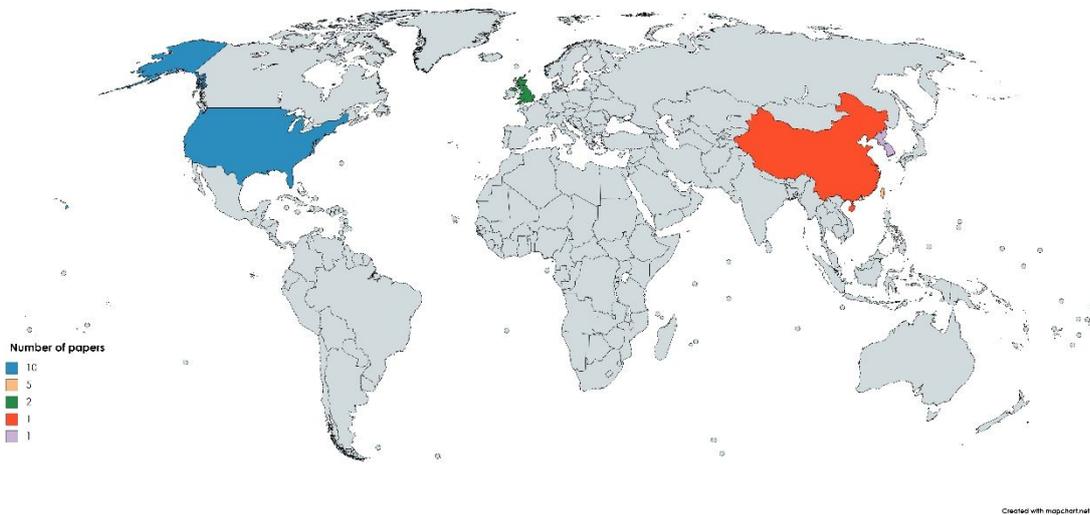


Figure 2: Geographical areas
Source: Own elaboration from mapchart.net

3 Bibliography on efficiency of audit production and auditor's performance. Stream 2

As stated before, this section regards to a review on papers not specifically dealing with auditing firms but dealing with efficiency of audit production or auditor's performance. Tables 4-8 compile information on 16 chronologically ordered papers.

The efficiency with which a firm completes an audit is the main focus of Williams and Dirsmith [1988]. It pursues to examine the differential impact of audit firm technology on the client earnings announcement dates. Regarding "who is participating" in this study, despite the prevalence of auditors in the other works, in the Williams and Dirsmith [1988] article, companies from manufacturing (Standard Industrial Classification Code (SIC) 10-39) and from service (SIC codes 40-89) are included in the sample.

McDaniel [1990] analyzes whether and how the joint imposition of time pressure and program structure affects auditors' performance. The fact that only one public accounting firm participated in the study is seen by the authors as a limitation.

In Myers [1997], the relation between audit structure and audit effectiveness is tested by using auditors from 2 Big Six accounting firms, a structured firm and an unstructured firm. As in McDaniel [1990], the number of firms involved in the study (2 firms in this case) is seen by the authors as a limitation.

Dopuch et al. [2003] employ both stochastic frontier estimation (SFE) and DEA in the task of examining the relative efficiency of audits of US companies. Also in the US context, Knechel et al. [2009] evaluate the relative efficiency of audit engagements by using DEA. This paper highlights a key advantage of using cross-sectional data from a single audit firm. More precisely, by quoting O'Keefe et al. [1994], the authors underline that the use of cross-sectional data from a single audit firm reduces the confounding effects of pricing policies and differences in production technologies.

Paper by Bamber and Ramsay [2000] focuses on the working paper review process. It pursues to analyze the effects of specializing review at different levels on reviewers' efficiency and confidence. As in other cases discussed above, Bamber and Ramsay [2000] considers that recruiting staff from one accounting firm requires caution in interpreting the experiment results.

In Moroney [2007] an experiment is conducted to determine whether industry specialists (manufacturing and superannuation industry specialist auditors) are more efficient at each stage of the decision-making process when working in specialization.

Kang et al. [2015] concentrates on the benefits of comparability between financial statements. Authors use audit hours as a proxy for audit efficiency and evaluate the effect of financial statement comparability on audit hours. Chang et al. [2018] deal with the technical and allocative inefficiencies of audit firm staffing. Authors also concentrate on the billing realization rates of audit engagements issue. In the Chang et al. [2018] paper, some advantages of using data from a single office are underlined. O'Keefe et al. [1994] analyze: (a) the empirical relation between varying client circumstances and the nature and mix of labor resources to obtain a desired level of assurance; (b) the degree of auditor reliance on clients' internal control systems; (c) the existence of a learning curve in auditing; (d) the existence of knowledge spillovers from nonaudit to audit services. In the O'Keefe et al. [1994] paper, authors underline the use of data from a single firm as a limitation to the generalizability of the results. By using evidence from fees paid for nonaudit services and lags in audit reports, Knechel and Sharma [2012] examine the effect of nonaudit services on the effectiveness and efficiency of the audit. For the purposes of the Knechel and Sharma [2012] paper, effectiveness refers to the quality of the auditor's conduct of the engagement and decisions about detected errors and efficiency refers to the timeliness and cost of the audit process. In the Gaeremynck et al. [2010] paper, the fact that audit lag can serve as a publicly available proxy for audit efficiency is empirically demonstrated.

Considering that the workpapers preparation task can represent the most time-consuming of an audit engagement, paper by Ricchiute [1981] is devoted to reflect about the use of automated workpapers. In this paper, a link between audit efficiency improvement and the use of time-sharing terminals transferring information from client to auditor and among auditors is established.

In the Yoo Jin and Joon Hwa [2015] work, the authors analyze if audit efficiency for industry specialist auditors is higher than for non such auditors. Unlike the other papers in which the opportunity set focuses on an auditing firm, in the Yoo Jin and Joon Hwa [2015] paper, a sample of 8384 firms involved in a wide variety of industries are considered. On the other hand, it is worth noting that the Yoo Jin and Joon Hwa [2015] paper is mainly written in Korean.

Yoo Jin and Jeong Ok [2016] examines if hiring the auditor of mother firm as the auditor of subsidiary firm influences on audit efficiency. As in Yoo Jin and Joon Hwa [2015], a sample of (643) firms, involved in a variety of industries such as “publishing activities” are considered. Furthermore, special mention must be made to the fact that the Yoo Jin and Jeong Ok [2016] paper that we were able to consult is mainly written in Korean.

Paper by Wurst et al. [1989] turns around the concept of sampling accounts by auditors. More precisely, it relates to dollar-unit sampling. In this paper, two methods of obtaining dollar-unit samples (simple random sampling and sieve sampling) are analyzed and compared.

With regard to Lawrence and Kleinman [2001], it proposes a Goal Programming model that contributes to the achievement of an efficient sample selection process.

Table 4: A review on audit production and auditor’s performance (I)

Paper number	Authors	Research method	Independent variables	Dependent variables	Who is participating
19	Williams and Dirsmith [1988]	t-tests; Regression analysis; Analysis of Variance (ANOVA).	Relative degree of structure vs judgment of a CPA firm’s audit technology.	The timeliness with which the audit is completed.	679 companies ¹ .
20	McDaniel [1990]	ANOVA; Tukey-Kramer; One-sided F-test.	Time pressure; Audit program structure.	Overall audit effectiveness; Auditor efficiency; Auditor consistency.	179 staff auditors from a national public accounting firm ² .
21	Myers [1997]	Mann-Whitney-Wilcoxon (MWW) procedure; Approximate randomization procedures.	Audit firm experience ³ ; Audit situations ⁴ ; Experience levels ⁵ .	Auditor effectiveness in performing the audit task.	Auditors from 2 Big Six accounting firms ⁶ .
22	Bamber and Ramsay [2000]	Two phases experiment: 1) subjects complete review notes; 2) subjects answer a question-naire; Efficiency metric; ANOVA.	Subjects’ level: senior or manager; Type of review: all-encompassing (complete) review or specialized (focused) review.	Subjects’ efficiency and confidence in review.	35 managers and 39 seniors from one accounting firm.
23	Moroney [2007]	Each participant completed 2 cases, one set in the manufacturing industry and the other set in the superannuation industry; MANOVA (Multivariate analysis of variance); ANOVA; Factor analysis; Regression analysis.	Auditor industry specialization (manufacturing or superannuation); Client (case) industry setting.	Overall efficiency at each stage of the decision-making process.	86 participants ⁷ from each of the Big 4 accounting firms.
24	Knechel and Sharma [2012]	Performance-adjusted cross-sectional modified-Jones model (Kothari et al. [2005]); Regression analysis.	Level of non-audit service fees ⁸ .	Audit report lag ⁹ .	5004 firm ¹⁰ -year observations over 2000 to 2003 inclusive.
25	Kang et al. [2015]	Metric DKV ¹¹ ; Pearson and Spearman correlations; Multivariate analysis.	Comparability of financial statements.	Natural logarithm of audit hours.	Hours worked by auditors in Korean firms ¹² in completing 2322 audits.

Source: Own elaboration

¹ Companies were audited by the same Big Eight firm for the period 1980-84. Classification of Big Eight firms comes from Kinney Jr [1986]. Information on company auditors was obtained from Who Audits America. Database: Compustat; Value Line Investment Services; Wall Street Journal Index; Compact Disclosure.

² These staff auditors were attending a regional in-charge staff training school and averaged two years of public accounting experience.

³ Structured and unstructured.

⁴ Typical and atypical.

⁵ Inexperienced and experienced.

⁶ Each firm provided subjects from 6 offices. Each office sent 10 cases. 82 of the 120 cases were useable.

⁷ Specialists in the manufacturing industry: 48; Specialists in the superannuation industry: 38. Participants have 2 or more years of industry audit experience.

⁸ Non-audit service fees are measured by the authors based on Securities and Exchange Commission (SEC) disclosures for the following categories: (1) financial information systems design and implementation, (2) tax services, and (3) other non-audit services.

⁹ Audit lag is the number of days between the fiscal year-end date and the initial audit report date. The audit report date is hand-collected by the authors from proxy filings with the SEC.

¹⁰ The sample is restricted to Big 5/Big 4 audit firms. Database: Compustat.

¹¹ Metric developed by De Franco et al. [2011].

¹² Firms listed in the Korea Stock Exchange for the period 2006-2010.

Table 5: A review on audit production and auditors performance (II)

Paper number	Authors	Main focus
26	Ricchiute [1981]	Time-sharing applications in auditing.

Table 6: A review on audit production and auditor's performance (III)

Paper number	Authors	Model	Inputs	Outputs	Opportunity set and data source
27	O'Keefe et al. [1994]	OLS regression models; White's heteroscedastic-consistent covariance matrix estimation method.	Disaggregated labor hours by rank within the firm: partner, manager, senior, and staff.	Level of assurance achieved.	1 Big 6 international CPA firm in 1989 ¹ ; Data was obtained via questionnaires sent to the partners.
28	Dopuch et al. [2003]	Stochastic Frontier Estimation (SFE); DEA.	Labor hours utilized: Hours of partner, manager, senior, and staff time on an engagement.	Client characteristics: the log of assets; percentage foreign assets; client complexity; number of audit reports prepared for the client; financial leverage; the fact that shares are publicly traded; and the assessed inherent risk.	1 Big 6 Public Accounting Firm in 1989 ² ; Data base developed through a questionnaire survey of audit partners of the Big 6 firm.
29	Knechel et al. [2009]	DEA.	Labor ³ cost.	Hours spent on evidence-gathering activities ⁴ that determine the level of assurance.	An international account- was obtained by means of a survey developed and administered by the firm.
30	Yoo Jin and Joon Hwa [2015]	DEA; Regression analysis.	Audit hours; audit cost.	Audit quality.	8384 firms.
31	Yoo Jin and Jeong Ok [2016]	DEA; Heckman two stage method.	Audit fee; audit hour.	Discretionary accruals; Accrual quality.	643 firms.
32	Chang et al. [2018]	DEA; OLS regression models.	Staff hours of: partners, managers and other audit professionals.	Client characteristics: client size; ownership structure of clients; client complexity; proportion of foreign assets; leverage; receivables; inventory; client's bankruptcy risk; securities litigation risk; loss; profit-to-revenue ratio.	1 Big 4 international CPA firm branch office during a recent fiscal year ⁶ ; Data is collected by the authors.

Source: Own elaboration

¹ 249 U.S. audits are examined.

² A sample of 247 audits of U.S. companies is examined.

³ 4 levels of labor are considered: partner, manager, supervisor, and staff.

⁴ Audit planning; internal control evaluation; substantive testing-critical objectives; substantive testing-non-critical objectives; review-critical; review-non-critical; financial statement preparation; and client interaction.

⁵ A sample of 450 U.S.-based engagements is examined.

⁶ 165 audit engagements performed for its largest clients are examined.

Table 7: A review on audit production and auditor's performance (IV)

Paper number	Authors	Methods employed	Procedure description
33	Wurst et al. [1989]	Point estimator.	The variances of an unbiased point estimator of the total overstatement error amount in the population for the two methods of sampling are compared. Some actual accounting populations that were modified to contain different overstatement error amounts, error rates, and error distribution characteristics are examined.

Source: Own elaboration

Table 8: A review on audit production and auditor's performance (V)

Paper number	Authors	Methods employed	Goals description
34	Lawrence and Kleinman [2001]	Goal Programming model.	<ol style="list-style-type: none"> 1. Attain the closest level to the goal level of the estimate of variance of the error rate. 2. Attain the closest level to the goal level of the estimate of variance of the dollar value of records in error. 3. Attain the closest level to the goal level of the expected number of errors remaining in the population. 4. Attain the closest level to the goal level to the dollar value remaining unchecked in the population. 5. Attain the closest level to the goal level expected value of unsampled items that remain in error in the population.

Source: Own elaboration

4 Concluding remarks

The literature review undertaken by this paper enable us to corroborate that efficiency in auditing has consolidated itself as an area of interest for the scientific community. This is apparent from the fact that papers on this issue have been periodically published during decades.

If the analysis on firm's efficiency is considered and, from a more accurate perspective focused on the geographical areas receiving more attention, we find that: (i) the interest on the United States case prevails; (ii) in the European context, the analysis is exclusively carried out in the UK.

Conclusions achieved from the reviewed papers may have implications for audit markets similar to those under analysis. However, limitation of the generalizability of the findings to other countries, suggests that future research could be focused on unexplored research settings or areas that have received limited academic attention.

Regarding the number of firms under review, the opportunity set is generally characterized by a limited number of firms when the efficiency of audit production and the auditor's performance are analyzed. However, in the firm's efficiency papers, a much wider opportunity set prevail. With respect to single data source, there is no unanimity on its (or no) suitability.

When considering the analysis on audit production or auditor's performance, the experiments try to connect these dependent measures with variables such as audit structure or time pressure. To know the degree to which these variables affect efficiency, effectiveness or consistency is key for the managers of the firms, not only responsible for the firm results, but also in charge of ensuring proper training of auditors.

Concerning performance evaluation techniques, this literature review supports DEA as the most commonly employed method in the audit industry efficiency analysis.

Finally, there may be articles that, although been related to efficiency in auditing, have not been included in the present literature review. While acknowledging this limitation, authors consider that the publication of this paper puts in a clear light the efficiency in auditing literature scenario. This is achieved by reviewing a set of 34 papers based on a wide range of research methods and highlights the contribution of this paper to the literature review in auditing.

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