What is going on with studies on banking efficiency?

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A R T I C L E   I N F O

A B S T R A C T

We analyse and present the current mainstream research on banking efficiency by assessing recent articles from major finance journals. We examine 87 papers that were published between January 2011 and July 2017. We classify these manuscripts based on study type, approach, objective, and method. We apply clusters and citation networks to identify the evolution of the studies, including research gaps and paradigms. We also analyse the origin of the studies through geographical coordinates to visualize the global connections among the articles. Our study contributes to a future research agenda, studies' integration at international level, and a dissemination of relevant findings on the topic. Moreover, using Lotka's Law, we find that the field of banking efficiency had low productivity, without a significant number of prolific specialized authors or institutions.

1. Introduction

Bank efficiency has been a major object of analytical and empirical literature in the last 20 years. Nowadays, this interest has been driven not only by the major financial crises of recent decades but also by major structural changes in the sector. Technological advances, new regulatory processes, and changes in market structures have substantially altered the factors and methods of evaluating the performance of financial institutions (FIs).

The efficiency of FIs depends on factors that (directly or indirectly) affect the absorption of costs and the delivery of services to clients. In this way, more than just explicit costs affect FIs' performance. On one hand, the range of issues that influence banks' ability to obtain information about the market and about the borrowers themselves can also affect FIs' productivity and efficiency. On the other hand, banks have improved the ability to conduct transactions in a secure and timely manner. Therefore, a variety of factors are essential for measuring and explaining efficiency, including the nature of accounting practices, the rules of governance, the existence of databases, and the level of market concentration.

The significant changes in the most diverse sectors have caused specialized research interests to change substantially. For example, nowadays the main research areas on the efficiency of financial institutions, as categorized by Berger et al. (1995) or Berger and Humphrey (1997) in the end of the 1990s, do not have the same status. Our study demonstrates that the efficiency of private and government financial institutions has not been a main area of research in the main journals anymore. In contrast, the implications that bank mergers have on efficiency remains an area of great interest, and the determinants of financial-institution efficiency have become such a complex category that it should be divided into several major sub-areas of interest.

Concurrently, the number of publications and sources of information about the topic has also grown exponentially. This fact makes extremely difficult for researchers, policymakers and other professionals follow the advances and challenges of the sector. Thus, knowing where are the major research centers, their specific interests, and their main researchers have a fundamental role for

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obtaining, propagating and generating knowledge on banking efficiency.

Additionally, due to the high degree of interconnection of the financial system with the whole economy, studies in bank efficiency provide important information not only for experts and academics in the area but also for those seeking to understand how changes in that industry can affect different areas of study and markets.

Therefore, proposals for advancing the research in banking efficiency presuppose that information has been obtained on its current state, as well as on how its development occurs and on which factors affect this development. Bibliometric and scientometric studies become increasingly relevant as it enables the analyses of the integration of research at an international level, the dissemination of results relevant to the sector, and the identification of the main centers of knowledge generation in the area. Thus, adapting the method employed by Jabbour (2013) and Silva et al. (2017), this study's objectives are as follows:

- Identify in the main finance journals the articles that are related to banking efficiency, aiming to build a sample of relevant works. Our research is singular because it uses a selection method that only admits articles that are characterized as "excellent" instead of using all articles from certain databases (Silva et al., 2017) or using selection by citation (Cintra et al., 2017).
- Classify the papers' characteristics, scope, and objectives and then perform a cluster analysis for comparability purposes.
- Formulate the studies' citation network; analyse the authors' productivity; and identify the most influential regions, journals, authors, and articles.
- Identify the main paths of the current mainstream research.
- Provide a framework to address the relevant gaps in the current discussion.

The paper is structured as follows. After this introduction, the second section presents the study's research method and describes the two first steps followed in the research; in the first step, we select papers using objective procedure and criteria; in the second step, we structure the classification system. The next section focuses on the third step, which builds a framework of the current discussion. The fourth section brings the fourth step, discussing the study's main results and the profile of the recent scientific production on banking efficiency. Finally, the fifth section outlines the fifth step, where the main conclusions of the research and listing the challenges and opportunities for future studies are presented.

2. Research method

We use a methodology based on the procedure used in Jabbour (2013) and Silva et al. (2017). Nevertheless, our selection process is innovative because we do not filter studies by convenience; rather, we use the selection criteria of an independent institution (ABS, 2015) to define the relevant journals to browse for papers. The steps of the method are as follows:

- First step: We conduct a survey of the relevant articles from the best journals, as identified in the *Academic Journal Guide of Association of Business Schools* (ABS, 2015), and tabulate the pertinent data;
- Second step: We develop a classification system using a logically structured code to identify factors such as research networks, main authors, major journals, and areas of study related to banking efficiency;
- Third step: We apply the classification system to provide a framework for the current discussion on banking efficiency, including its level of productivity and its main research networks;
- Fourth step: We provide a profile of the scientific production on the theme based on the papers gathered from influential journals;
- Fifth step: We conclude our study by stating the main opportunities and challenges for future studies.

Our main objective is to assess the current state of the art in banking efficiency studies. Therefore, our methodology involves only evaluating the articles from the top finance journals. To select the papers, as already discussed, we use the *Academic Journal Guide of Association of Business Schools* (ABS, 2015) as an initial criterion for classifying the scientific journals.

The ABS (2015) categorization criterion is interesting because it follows an objective systematic approach that uses statistical citation information to assess the judgments of authors, editors, and specialists regarding hundreds of publications. ABS (2015) classifies journals in several areas of focus, including finance. For each thematic area, ABS (2015) scores journals from 1 to 4; where higher scores are better, and a level of distinction is identified as 4*. These categories are described in Table 1.

The classification by period, theme, and quality allows us to use only articles published in journals that are classified as high level and that have had a recent impact on the scientific community. We evaluate only articles from journals classified as 4*, 4, or 3 in the ABS (2015) score, focusing on banking efficiency and targeted to the specialized finance community. Using the ABS classification from 2015, 37 journals met this criterion.

In addition to evaluating the journals' quality and the studies' impact on the scientific community, we use bibliometrics to determine which banking-efficiency topics the finance community has studied recently. We also restrict our search to articles published from the beginning of 2011 until the first seven months of 2017. The delimitation of our review period (2011–2017) is justified by two main reasons. First, we seek to evaluate how the recent research in the area is structured and thus compare the results with surveys from previous periods. The second reason is to reach the period after the financial crisis of 2008–2011 which has as its final mark the issuance of the Budget Control Act of 2011 (Hu and Zarazaga, 2016). Our procedure for selecting and analysing the articles is indicated in Table 2.

After collecting the data from the publishers' databases and electronic platforms, we read the abstract, introduction, and methodology sections of each paper in the pool of studies, which totals 87 papers. We also examined the articles' references. We then

Table 1
Description – ABS ratings. *Source:* Adapted from ABS (2015, p. 7).

Rating	ABS description of quality rating
4*	Journals of distinction. Within the business and management field including economics, there are a small number of grade 4 journals that are recognised world-wide as exemplars of excellence. Their high status is acknowledged by their inclusion in a number of well-regarded international journal quality lists. In addition, journals from core social sciences disciplines that do not appear in those listings may also be rated 4* on the grounds that they are clearly of the finest quality and of undisputed relevance to business and management.
4	All journals rated 4, whether included in the Journal of Distinction category or not, publish the most original and best-executed research. As top journals in their field, these journals typically have high submission and low acceptance rates. Papers are heavily refereed. Top journals generally have the highest citation impact factors within their field.
3	3 rated journals publish original and well-executed research papers and are highly regarded. These journals typically have good submission rates and are very selective in what they publish. Papers are heavily refereed. Highly regarded journals generally have good to excellent journal metrics relative to others in their field, although at present not all journals in this category carry a citation impact factor.
2	Journals in this category publish original research of an acceptable standard. A well-regarded journal in its field, papers are fully refereed according to accepted standards and conventions. Citation impact factors are somewhat more modest in certain cases. Many excellent practitioner-oriented articles are published in 2-rated journals.
1	These journals, in general, publish research of a recognised, but more modest standard in their field. Papers are in many instances refereed relatively lightly according to accepted conventions. Few journals in this category carry a citation impact factor.

Table 2
Procedures performed in bibliometrics.

Step	Description
1.	Definition of the *Academic Journal Guide* as a reference for the segregation of the main journals;
2.	Selection of 37 journals that met defined quality criteria (score > 2);
3.	Direct access to the databases of the respective publishers and electronic platforms of the selected journals;
4.	Search for articles from the following search filters:
(a)	Keywords: "banking efficiency" or "efficiency in banking" or "technical efficiency" and "bank".
(b)	Period: 2011 to 06/2017.
(c)	Search places: summaries, keywords, and titles.
(d)	Language: English.
5.	Correction of false positives. Reading of abstracts for elimination of undue filter selection, that is, articles that despite meeting the search criteria did not have as purpose the study of banking efficiency;
6.	Data tabulation, descriptive analysis, Lotka Productivity test, and network analysis.

recorded this information on worksheets using logical categories and analysed the data using descriptive statistics.

We tabulated the number of papers published in each year, the number of authors per paper, and the countries of origin of the authors. We then identified and catalogued the geographic coordinates of the authors' institutions. This procedure made it possible to build maps of the research networks and to visually demonstrate the origins of the studies.

To formulate the categories, we used a process similar to the one that Silva et al. (2017) and Jabbour (2013) used. However, we adapted the categories to our unique selection process and restricted them to the studies objectives. For the methodological framework, we used the following classification (depicted in Table 3): (1) study type, (2) objective, (3) method of measurement, (4) method of association, and (5) main subject.

For the study type, we used two categories: "theoretical" and "empirical-theoretical". Note that we did not include the usual classification of "empirical" because, after analysing the data, we did not find any purely empirical studies in our sample.

Regarding the objective, scientific studies often aim to describe, explain, predict, or evaluate an established phenomenon. We found two major objectives for the bank-efficiency studies: "association" and "measurement". The first objective is related to studies that are focused primarily on prediction or explanation of banking efficiency. This class is similar to the category that Berger et al. (1995) presented as "determinants of financial institution efficiency". The second category (measurement) refers to studies that are dedicated especially to determining a method or model for defining levels of efficiency in FIs.

Note that we chose not to distinguish among description, prediction, and explanation because of the old controversies regarding the distinctions between these concepts. Hanna (1969) presents a good discussion on the subject. Furthermore, description objective was not verified in our sample as the main goal of the studies, usually having a secondary role in the papers. This fact demonstrates the advance of the area since in previous studies the mere description of the average of the scores and its dispersion consisted of a specific field of analysis, as noticed in Berger and Humphrey (1997).

Therefore, in our analysis, the objective had four categories: "measurement", "association", "both", and "not applicable". Taking into account the previous discussion, studies categorized as "measurement" are mainly aimed at evaluating how banking efficiency should be measured. These studies classified as "association" are those that focus on understanding the components of banking technology and identifying what determines whether a bank operates efficiently. "Both" was the classification for those studies that lacked a clear and specific focus, mixing association and measurement.

We verified two main methods of measurement: stochastic frontier analysis (SFA) and data envelopment analysis (DEA). These two methods are quite traditional and have been used by the specialized literature in the last decades (Berger and Humphrey, 1997),

Table 3
Classification and coding used to analyze the articles.

Rating	Meaning	Encryption
1	Study type	A – Theoretical and empirical. B – Theoretical.
2	Objective	A – Measurement. B – Association. C – Both. D – Not applicable.
3	Methods used – measurement	A – SFA. B – DEA. C – Others. D – Not applicable.
4	Methods used – association	A – Statistical/parametrical. B – Statistical/non or semi parametrical. C – Mathematical modelling. D – Not applicable.
5	Main object of study	A – Competitiveness, concentration, and efficiency. B – Diversification, risk, and efficiency. C – Efficiency and governance. D – Islamic, conventional banks, and efficiency. E – Efficiency in small institutions. F – Mergers and acquisitions, TBTF, and efficiency. G – Proposed alternative models, simulation to evaluate efficiency. H – Supervision and regulation of banks and efficiency. I – Others.

but their variations have received substantial advances. We also used four methods of association: "statistical/parametric", "statistical/non- or semi-parametric", "mathematical modelling", and "not applicable". Finally, the fifth dimension (main subject) encompasses eight comprehensive subjects, which we defined based on the main theme addressed in each study.

Finally, it is important to highlight that our classification system (Table 3) does not comprise all the methods and research techniques used in banking and finance studies. Therefore, the methodological framework used in this analysis should be understood in the context of this paper's scope and its methodological restrictions.

3. Framework of the current discussion on banking efficiency

There are several ways of understanding and addressing the problem of how to evaluate FIs' efficiency (Paradi et al., 2011; Matousek et al., 2015). One of the most basic way is the separation of structural from non-structural approaches (Hughes and Mester, 2008). Another very common classification divides studies based on their use of parametric or non-parametric methods (Berger and Humphrey, 1997; Casu et al., 2004). These segmentations are interesting when researchers desire to theoretically understand the process of evaluating banking efficiency.

An underlying theoretical structure, together with an optimization concept, allows for a theoretical model to be compared with empirical results, thus establishing a metric for efficiency. In contrast, the non-structural approach, which is not used in this theoretical framework, mainly is used to compare FIs' efficiencies to enable evaluation (Hughes and Mester, 2008). In other words, the non-structural approach considers institutions based on a set of performance indicators. The main difference between the two approaches is in the necessity of a theoretical model in the structural approach, which presupposes that models exist and that the concept has been optimized.

We highlight that some authors understand the concept of efficiency only as linked to methods that involve a measurement of a frontier. For example, Berger and Humphrey (1997) analyze only efficient frontier studies, which are subdivided by the authors into five "approaches": DEA, FDH, SFA, DFA, TFA. However, we do not use this classification because we consider it very restricted.

It is important to separate studies that only evaluate the performance of some metrics from the studies that analyse a set of indicators that have the ability to indirectly evaluate efficiency or productivity. Our research is focused on studies that evaluate the efficiency or productivity of FIs; we have not considered any study that evaluates only performance variables, such as profitability or return.

In spite of the restriction of our study to the Finance field, the complexity of the factors involved in banking-efficiency analysis has fostered a multiplicity of approaches for their measurement, comparison, and understanding. These approaches, in turn, use a variety of techniques, tools, and theoretical or empirical studies. On the one hand, this leads to progress in knowledge, but, on the other hand, it complicates the monitoring of all existing advances and challenges in the area.

For these reasons, the dual segmentation of areas in banking efficiency is not enough to understand how the theory of finance is now being evaluated. Therefore, more specific examination is needed regarding the methodological approaches, research objectives, and techniques used in recent scientifically relevant studies.

Similarly, banking theory has gained new contours, which have in turn modified the studies on banking efficiency. The literature has shifted away from traditional microeconomic theory moving towards a modern theory of banking intermediation, combined with the microeconomics of banking production (Hughes and Mester, 2008; Bhattacharya and Thakor, 1993). The bibliographic survey allowed us to verify the major questions and objectives of current studies, described in the classification of Table 3.

One of the major current research areas has the aim of verifying the impact that competitiveness in the banking industry has on FIs' efficiency. This area is quite traditional and has already been discussed for more than two decades (Berger and Humphrey, 1997). Within the studies with this goal, we can also find the impact of concentration at the level of efficiency and productivity as an objective of interest.

Studies in this area have analysed, for example, the impact that cross-border banks have on cost efficiency and competition (Lozano-Vivas and Weill, 2012); the effect that financial liberalization has on banks' total-factor productivity (Tanna et al., 2017); the relationships among competition, bank risk, and measures of efficiency (Leroy and Lucotte, 2016); and the relative cost-effectiveness of banks in areas that enjoy greater economic freedom (Chortareas et al., 2016).

Especially since the economic crisis of 2008–2010, other areas that have been of great importance in studies on banking efficiency are the evaluation of diversification's impact and the absorption of efficiency risks in the banking sector. There is great interest in understanding the relationship between efficiency and group convergence during stable periods (Matousek et al., 2015; Tan and Floros, 2013) or economic crises (Besstremyannaya, 2017; du Toit and Cuba, 2018).

One traditional area in the theory of bank intermediation has gained more relevance; focusing on the dynamics between key regulatory and supervisory policies and on various aspects of banking efficiency. The importance of regulatory issues has been addressed in the governance area (Hughes and Mester, 2008). However, regulatory questions have gained specific contours, and prudential policies and regulatory reforms adopted after the economic crises at the beginning of the century have encouraged further studies in this area; examples include the observations of the new changes, principles, and rules of the Basel Committee (Ayadi et al., 2016; Bitar et al., 2018).

Usually, these studies seek to identify the relationships that regulatory and supervisory frameworks have with banks' productivity (Lozano-Vivas and Pasiouras, 2013; Delis et al., 2011; Triki et al., 2017). However, the studies also assess the effects of specific regulatory reforms, as Casu et al. (2016) analysed, or even the indirect aspects that depend on banking regulations, such as economic creditor rights and information sharing (Kalyvas and Mamatzakis, 2017).

In addition, several important studies have been concerned with the ways in which mechanisms or governance structures impact banks' efficiency. These studies look for evidence regarding corporate governance's impact on banks' performance (Mamatzakis and Bermpei, 2015) or focus on how the level of banking efficiency can impact equity capital markets' disciplinary power (Qian and Yeung, 2014).

Studies in the regulatory and governance areas are closely related to those that seek to evaluate the relations between efficiency and competitiveness in the banking sector. Our paper proposes a classification that seeks to determine the main objectives of the selected studies. In this context, we aim at to further segregate the streams of research to provide a better understanding of studies' advances and the questions they raise.

The analysis of efficiency is directed at several types of FIs. A comparison that is usually made is between Islamic and conventional banks (Abdul-Majid et al., 2017; Wanke et al., 2016a). The Islamic banks are those that operate within the rules of Shariah, also known as the "Islamic Rules in Transactions". Many analyses focus on this type of institution when investigating the factors that affect efficiency (Wanke et al., 2016c); other analyses compare the performance of traditional FIs with those of institutes (Wanke et al., 2016b).

Small FIs are also normally segregated into specific analyses. This group of studies usually seeks to evaluate how certain factors impact small institutions. The assumption is that efficiency depends on the size of the FIs; therefore, small FIs would need specific analysis.

In these studies several fields that normally are considered in terms of large banks are targeted only at small FIs. For example, some of these studies evaluate the effectiveness of certain governance mechanisms on the efficiency of small FIs (Hartarska and Mersland, 2012; Servin et al., 2012); others papers determine whether regulatory pressure impacts small FIs' performance (Glass et al., 2014).

One area of banking research is aimed at verifying the merger and acquisition (M&A) processes and the "too big to fail" theory on the efficiency of the financial sector as a whole and of FIs in particular. For some time, scholars have formed a general consensus that the integration of FIs is beneficial up to a certain (relatively small) size, and there is evidence that mergers yield economies of scope and gains in managerial efficiency (Amel et al., 2004). Although, some studies also found that the M&A effect is tenuous and that the distinction between target and acquiring banks must be analysed to obtain more reliable results (Du and Sim, 2016).

The M&A area continues to produce many studies in major financial journals. Current studies seek to assess whether M&As are better when the banks are efficient (Halkos and Tzeremes, 2013) and whether efficiency improvements drive bank megamergers (Devos et al., 2016).

The testing of theoretical hypotheses does not completely dominate banking-efficiency studies. There are also studies with the objective of creating new models or even indicators (using the non-structural approach) to evaluate or measure FIs' performance as in Ouenniche and Carrales (2018).

These studies include simulation techniques that are meant to evaluate the accuracy of the estimated inefficiency scores (Goddard et al., 2014), the application of innovative approaches with modifications (Fujii et al., 2014a; Tabak et al., 2013), and even model comparisons (Wanke et al., 2016c).

Some of the selected articles did not fit into any of the categories for the objectives. We categorized these articles as "others"
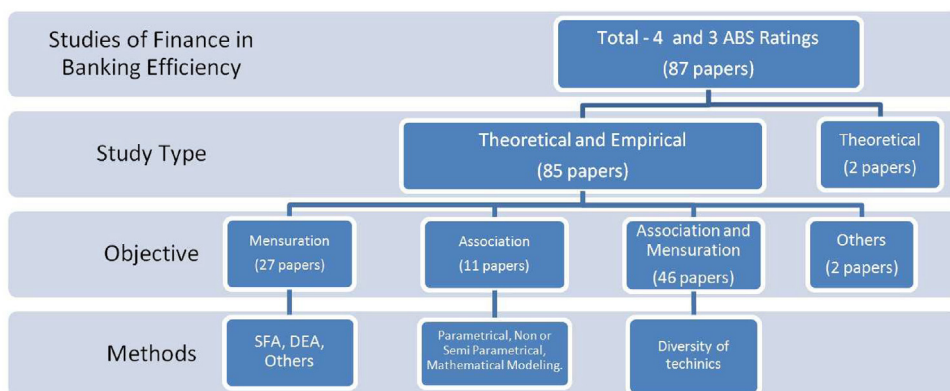
Fig. 1. Papers distribution.

because we understand that such new objectives are not yet clear lines of research in the banking literature.

We provide examples of the articles in the sample, but for a deeper analysis of the subjects discussed, we recommend reading the articles directly (see Table 14).

4. Main results

4.1. Productivity, citations networks, localization, and clusters

After data tabulation, we classified the articles into large groups based on research area. Fig. 1 shows the main research on banking efficiency and the bibliometric dimensions that we evaluated.

Fig. 1 facilitates the understanding of the articles' distribution among this study's main classification categories. Firstly, we selected the initial sample of articles, following the steps indicated in Table 2. The second line of this table indicates the distribution of the articles based on type of study; the preponderance of them are empirical studies. After this, the distribution of the works' main objectives is indicated. Finally, this table shows the link between studies' purposes and the techniques they employed.

Table 4 shows the distribution of the 87 articles that we identified from high-quality journals referenced in ABS (2015) from January 2011 through July 2017, based on the contents of their titles, abstracts, and keywords. It is noteworthy that, of the 37 high-quality journals, only 15 had at least one publication on banking efficiency in the period evaluated. This result shows that most of the analysed financial journals have not been interested or have been difficulties to receive studies in this area. In addition, most of the published articles came from the *Journal of Banking & Finance*, which makes sense due to this journal's focus on banking issues.

Table 4 also depicts the evolution of the number of publications per year. Only one journal had consistent publication in every year: the *Journal of Banking & Finance*. In the other journals' publications were scattered, which demonstrates that they have not targeted the area of banking efficiency and have only a circumstantial interest in the subject matter.

To detect and interpret patterns and ties among the researchers, geographic regions, and institutions that are producing state-of-

Table 4
Papers quantity per periodical and year of publication.

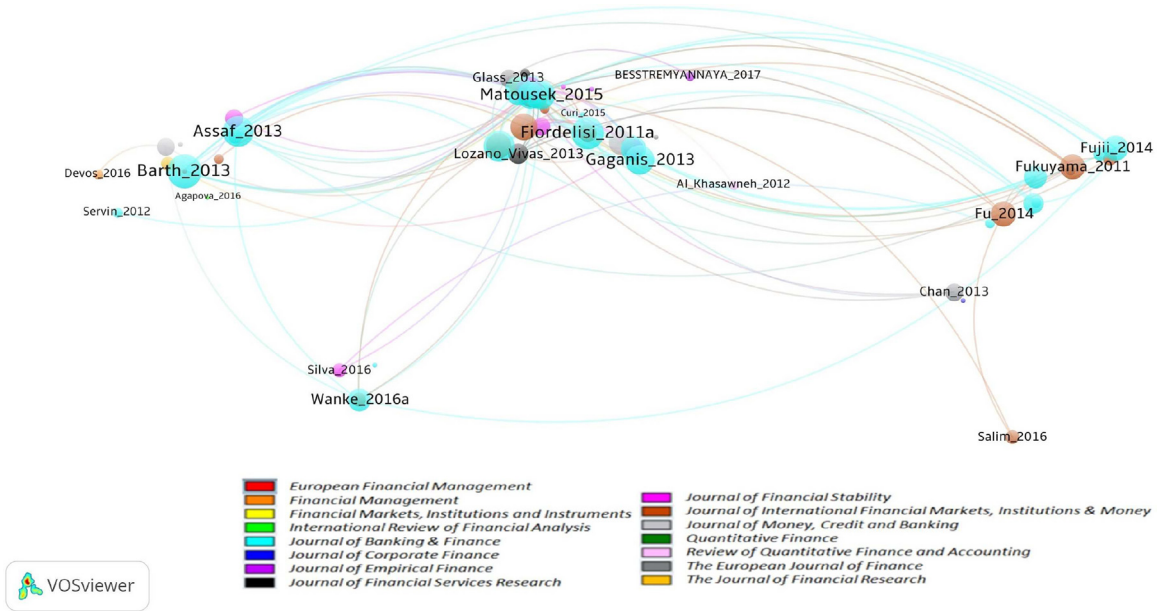| Journal	Year							
	2011	2012	2013	2014	2015	2016	2017/1	Total
Journal of Banking & Finance	5	4	9	3	2	3	2	28
Journal of International Financial Markets, Institutions &Money	1	0	4	5	0	4	1	15
Journal of Financial Stability	0	3	0	1	1	2	1	8
Journal of Money, Credit and Banking	2	1	0	1	1	1	0	6
Journal of Financial Services Research	2	1	1	0	0	0	0	4
European Financial Management	0	2	0	0	0	0	0	2
Review of Quantitative Finance and Accounting	1	0	1	1	0	0	0	3
Financial Management	0	0	1	0	0	1	0	2
Financial Markets, Institutions and Instruments	2	0	0	0	1	0	0	3
Journal of Empirical Finance	1	0	0	0	0	1	1	3
The European Journal of Finance	3	0	2	0	1	1	1	8
International Review of Financial Analysis	0	1	0	0	0	1	0	2
Journal of Corporate Finance	0	0	0	1	0	0	0	1
Quantitative Finance	0	1	0	0	0	0	0	1
The Journal of Financial Research	0	0	0	0	0	1	0	1
Total	17	13	18	12	6	15	6	87

Fig. 2. Network journals – distribution around the world.

the-art studies on banking efficiency, we conducted a set of network analyses. We set up a network-adjacency matrix to indicate which pairs of items in the network were linked by citations. More pairs of linked items indicate greater strength of their relations.

The distance between circles expresses the number of ties as closely as possible (see, for example, Fig. 3). In other words, closely connected papers are closer together than are unrelated papers.

We use this association-strength method to normalize the strength of the links between the items and to generate a network layout. This is also known as a probabilistic affinity index, a proximity index, or a pseudo-cosine. Eck and Waltman (2009) expressed this method's advantages; its equation is presented as Eq. (1), where c_{ij} is the observed number of co-occurrences and $s_i s_j$ is the expected number of co-occurrences for papers i and j.

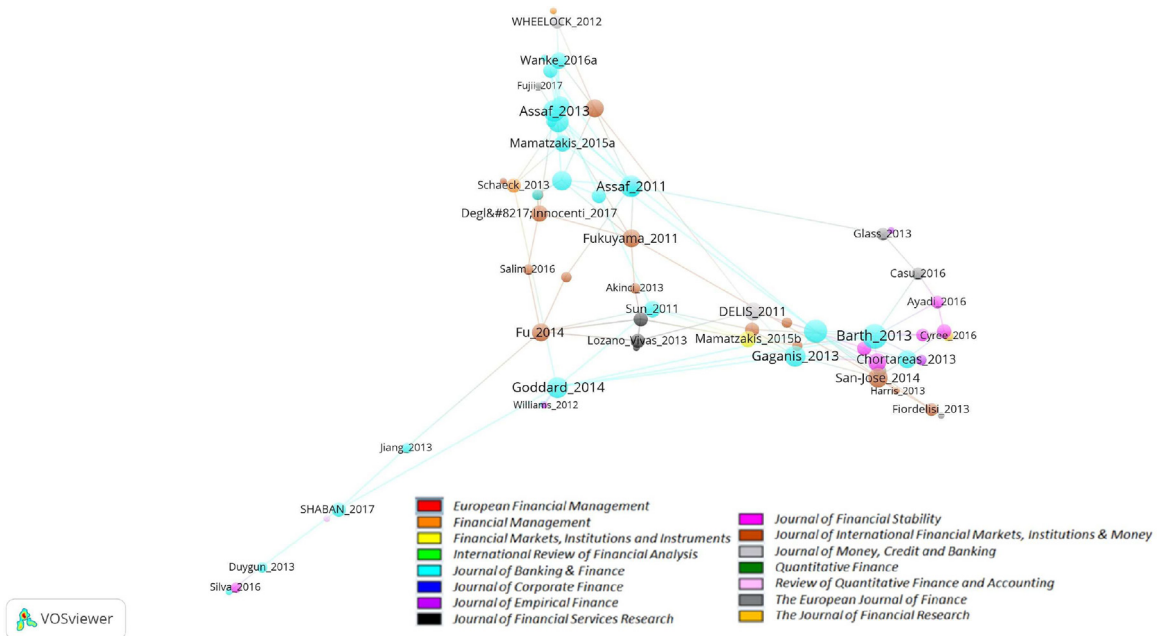$$S_A(c_{ij}, s_i, s_j) = \frac{c_{ij}}{s_i s_j},$$

(1)

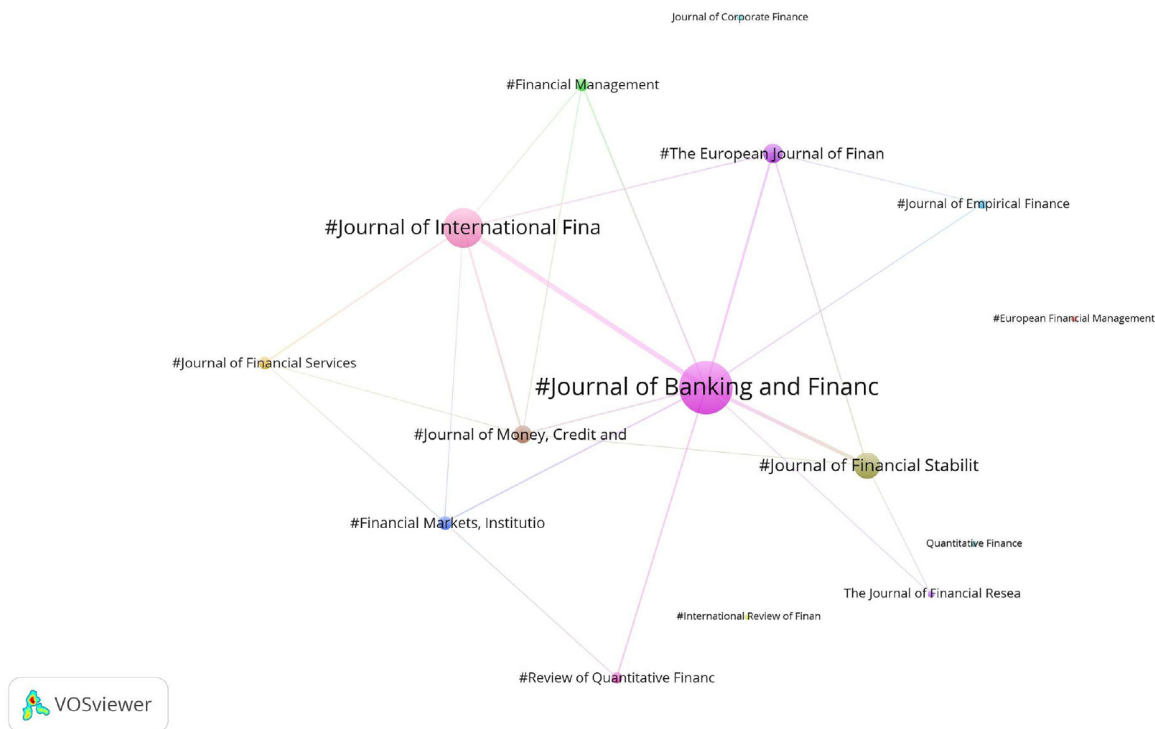**Fig. 3.** Network journals – strength relation and clusters.

Fig. 4. Network – centrality of main journals.

We use a unified approach to drawing and clustering bibliometric networks, as proposed by Waltman (2010). This approach has the advantage of starting from similar ideas and assumptions, unlike the many works that combine techniques with different principles (Waltman, 2010).

However, we drew our political maps using geographical coordinates that represent the institution location for each work's first author (for an example, see Fig. 2). The links between the studies are displayed, and the strength of the links are expressed by the sizes of the circles.

Fig. 2 shows how journals are distributed across the world and describes their relationships via the citation network. The two journals with the most publications, *Journal of Banking & Finance* and *Journal of International Financial Markets, Institutions & Money*, publish articles from institutions in many countries.

The visualization of the position and location on the drawing, as carried out using Waltman's et al. (2010) approach, makes it possible to verify that finance studies tend to be strongly influenced by the periodicals in which they are published. One point that deserves to be highlighted regarding network design is that the *Journal of International Markets, Institutions & Money* functions as an interconnection between the three large groups indicated in the network in Fig. 3.

We can verify that the relationships between the studies are related to their journals. Papers tend to be based more strongly on past studies that were published in the same journals that they are eventually published in. On the other hand, Fig. 4 is a visualization of the network in which each specific agent is a vertex of the network. This result shows that the *Journal of Banking & Finance* has great centrality and that it connects the main studies on banking efficiency.

The network shows that journals are connected, and information reaches the majority of journals. However, we should note that the network's structure is similar to that of a star-network. In other words, the *Journal of Banking & Finance* (central vertex) is connected to most all other journals, including an indirect link to the *Journal of International Markets, Institutions & Money*, but the other journals have weak connections among themselves.

Table 5 shows the number of articles according to their number of authors and journals of publication. We verified that the most common number of authors was three, followed immediately by two. It is important to note that articles with only one author are rare, which indicates that most works in the sample are constructed from collaboration or from the preparation of papers during academic courses.

In addition, Table 6 shows the authors' level of production in the area of banking efficiency and in the selected journals. The author who stood out most from the group, with ten publications in the sample, was Roman Matousek, who is a professor at Kent Business School in the United Kingdom. The second-most prominent author was Claudia Girardone, a professor at the University of Essex, also in the United Kingdom. Table 10 shows the research objectives of the four most productive authors.

Seeking a further indication of the low productivity of individual authors in banking efficiency, we carried out a test using the equation for the Lotka constant (Lotka, 1926), where a_n is the number of authors who have published n articles, a_1 is the number of authors who have published just one article, and c is the Lotka constant. For finance articles, this constant is estimated to be

Table 5
Number of papers by quantity of authors journals.

Journal	Number of authors					
	1	2	3	4	5	Total
Journal of Banking & Finance	0	6	17	4	1	28
Journal of International Financial Markets, Institutions &Money	0	7	5	3	0	15
Journal of Financial Stability	1	2	3	2	0	8
Journal of Money, Credit and Banking	1	3	2	0	0	6
Journal of Financial Services Research	0	1	3	0	0	4
European Financial Management	0	2	0	0	0	2
Review of Quantitative Finance and Accounting	1	0	1	0	1	3
Financial Management	0	1	1	0	0	2
Financial Markets, Institutions and Instruments	0	2	1	0	0	3
Journal of Empirical Finance	1	1	1	0	0	3
The European Journal of Finance	0	2	3	3	0	8
International Review of Financial Analysis	0	1	1	0	0	2
Journal of Corporate Finance	0	1	0	0	0	1
Quantitative Finance	1	0	0	0	0	1
The Journal of Financial Research	1	0	0	0	0	1
Total	6	29	38	12	2	87

Table 6
Number of published articles and number of authors.

Number of published articles	Number of authors
1	117
2	25
3	6
4	6
5	2
6	0
7	1
8	0
9	0
10	1
Total	158

approximately 2 (Chung and Cox, 1990), as shown in Table 7. This test confirms the low productivity of this research area relative to that of finance research as a whole (Chung and Cox, 1990).

$$\log\left(\frac{a_n}{a_1}\right) = -c.\log(n) + \varepsilon,$$

(2)

We emphasize that the concept of productivity used should not be interpreted in order to indicate the authors' general productivity. That is, the concept of productivity that we use expresses a quantity of articles produced in this specific subject matter, i.e. banking efficiency in the finance area. Thus, for example, many authors can be quite productive, but in consequence of the fact that they are working in different fields they end up not having all their studies evaluated in our research focused on efficiency of FIs.

Thus, the productivity concept of Lotka's Law is adequate mainly to indicate a low scientific autonomy of the area. In other words, the significant distance between the most productive authors and the others would be an evidence that the area is not yet a specific field of knowledge, and is still a field within other areas, such as Banking, Finance or Operational Research.

Regarding the countries of the authors' affiliations, the nation that contributed the most to the sample was the United Kingdom (29 papers), which had more than twice as many articles as the second-place United States (11 papers). This is particularly surprising given the U.S. tradition in the study of finance and the relatively large sizes of the U.S. economy and population compared to those of the United Kingdom.

Fig. 5 confirms the strong concentration of the research from the European continent. The density of relationships and quantity of

Table 7
Test of Lotka constant (productivity).

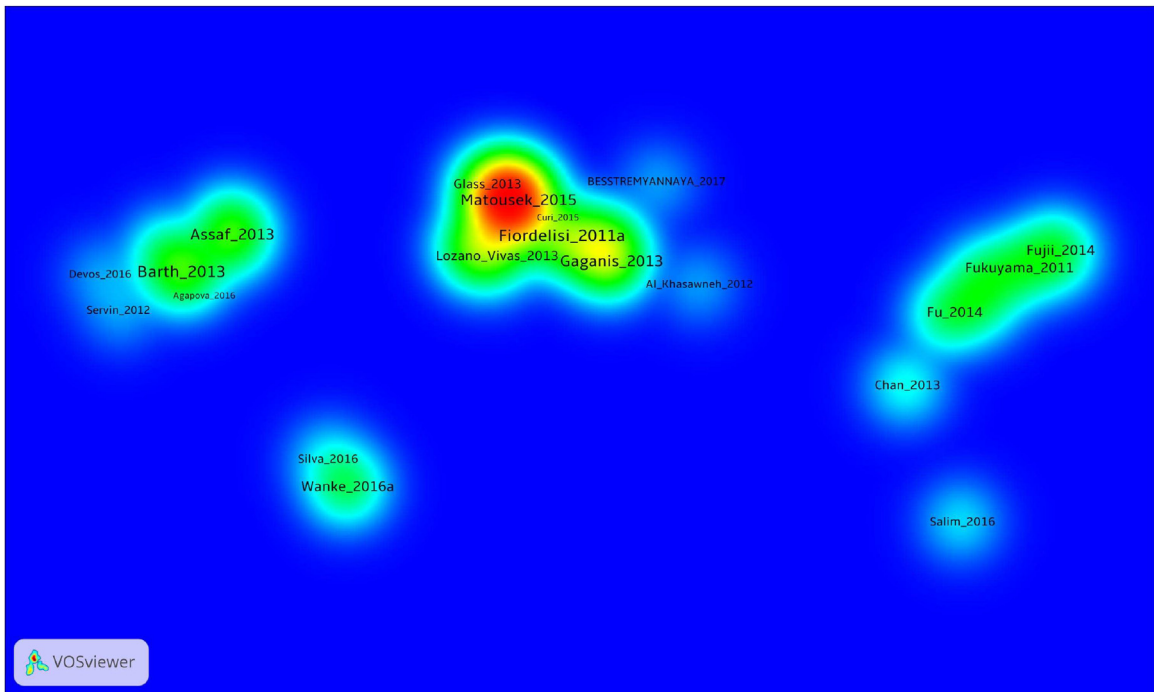| Coefficient	Coefficients	Standard error	Stat t	P-value
Intercept (forced 0)	0	–	–	–
Variable X, log(n)	4.846	1.013	4.781	0.0014

Fig. 5. Density and locality of research on banking and efficiency. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)
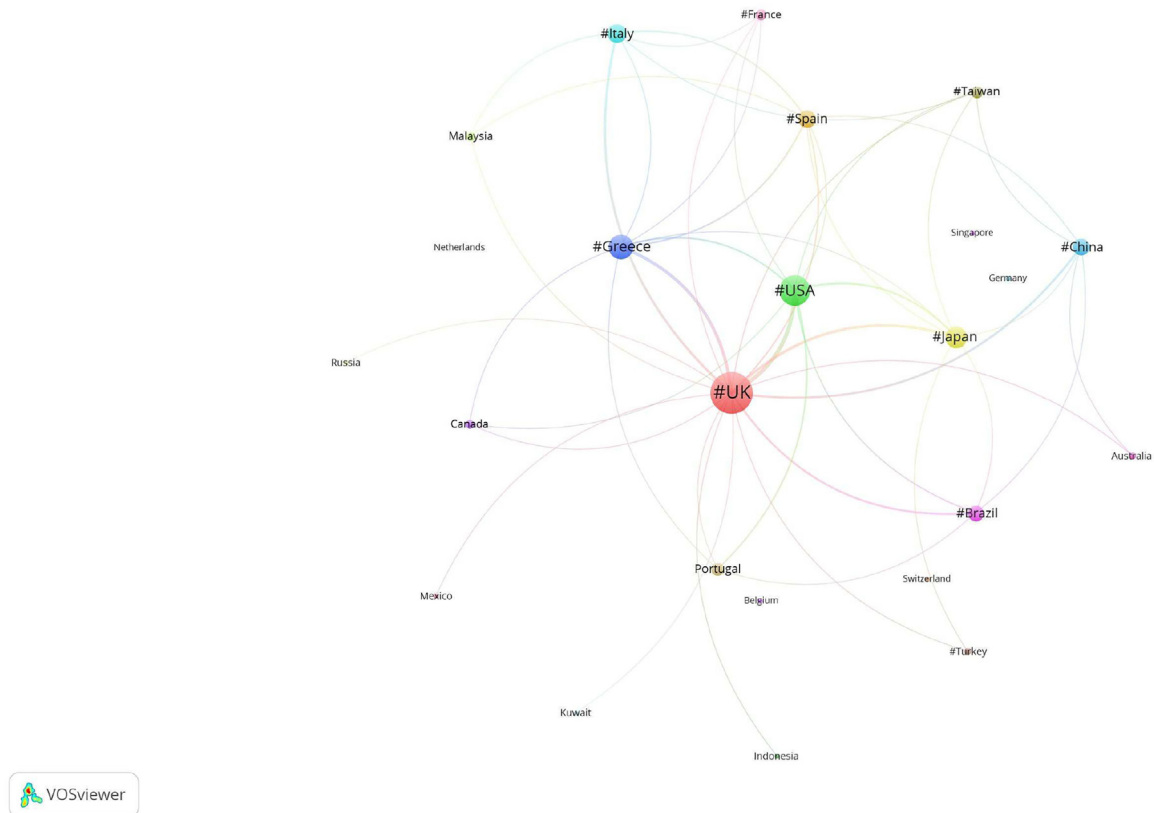

Fig. 6. Countries centrality of research on banking efficiency.

Table 8
Papers by year of publication according to main object of study.

Year	4A		4B		4C		4F		4G		4G		4D		4E		4H		Total
2011	4	17%	5	31%	0	0%	4	33%	1	14%	2	13%	0	0%	1	20%	0	0%	17
2012	6	26%	1	6%	0	0%	1	8%	2	29%	1	6%	0	0%	2	40%	0	0%	13
2013	3	13%	3	19%	3	50%	2	17%	2	29%	4	25%	0	0%	1	20%	0	0%	18
2014	1	4%	2	13%	1	17%	3	25%	1	14%	3	19%	0	0%	1	20%	0	0%	12
2015	1	4%	2	13%	1	17%	0	0%	0	0%	2	13%	0	0%	0	0%	0	0%	6
2016	5	22%	2	13%	1	17%	1	8%	1	14%	3	19%	1	100%	0	0%	1	100%	15
1/2017	3	13%	1	6%	0	0%	1	8%	0	0%	1	6%	0	0%	0	0%	0	0%	6
Total	23	100%	16	100%	6	100%	12	100%	7	100%	16	100%	1	100%	5	100%	1	100%	87

Note: Islamic and Conventional Banks (4D), Banking Supervision and Regulation (4H), Mergers and Acquisitions and TBTF (4F), Competitiveness, Concentration and Efficiency (4A), Efficiency in Small Institutions (4E), Governance (4C), Diversification and Risk (4B), and Mod Alter Proposal, Simulation (4G).

articles are indicated by the red colour.

We can visualize the papers structure and countries relationships according to the pattern of their citation (Fig. 6). For instance, the nations whose works either cite or are cited by almost all of the other countries are classified as core countries; they are in the centre of the circle. The world network has a great level of centrality, and the disposition of connections shows how information spreads easily and how the centre works to transmit information between the countries. In this case, we presuppose that authors exchange information in both directions when linked by a citation.

The direct and indirect links between the origins of the studies by country are better analysed in the circular network depicted in Fig. 6. The centrality of the United Kingdom is indicated in this figure, which also makes it possible to verify which countries have papers with direct and indirect links to other countries.

Table 8 shows the objectives that had the highest number of articles in the study's period. The links between diversification, risk, and banking efficiency (4B) were highlighted in 16 published articles (the largest number); the next most popular objectives were those that linked supervisory and regulatory factors (4H) and those that combined competitiveness and concentration (4A).

As we discussed, scholars in the diversification and risk area seek to create empirical models and studies to evaluate various financial risks so as to meet needs caused by business failures and economic crises. This area has had singular relevance in studies of banking efficiency, mainly those with structural approaches; it includes the risk variable in the measurement of FIs' efficiency, which the traditional studies that form the foundation of microeconomic theory did not do.

The banking literature in supervision and regulation considers the effects that banks' regulatory environment, including capital requirements and regulatory or supervisory policies, have on banking efficiency (Barth et al., 2013; Ayadi et al., 2016; Pessarossi and Weill, 2015). Another area of study is the evaluation of the differences between regulated and unregulated FIs, which is hypothesised to generate comparative inefficiencies within the financial market (Barros and Wanke, 2014). These issues appear to have been driven by recent financial crises and by the consequent imposition of additional prudential regulations such as the Basel Accords.

The competitiveness and concentration objective involves measuring the impact that competitiveness of different markets has on FIs' efficiencies. It is common to involve evaluations of possible associations between advances in economic freedom and indicators of market performance and efficiency. Although this area is quite traditional (Berger and Humphrey, 1997), new issues have been found, including the complementary roles that financial freedom and free political systems play in increasing banking efficiency (Chortareas et al., 2013).

Another commonly researched objective involves M&As, which accounted for 13.7% of the total studies. Research in this area seeks to understand the causes and effects of M&A processes, especially those that create gains in economic efficiency or in returns. Topics in this area range from the relation between banking efficiency and merger processes and the resulting efficiency when two efficient banks combine via M&A (Pasiouras et al., 2011; Halkos and Tzeremes, 2013), as shown in Table 8.

Table 9 shows some journals' specializations in terms of objectives and thematic areas. The *Journal of Banking & Finance* has concentrated more than 60% of its articles on the 4B and 4G approaches, indicating that this journal has a lot of interest in articles that provide innovative measurement models or evaluations of banking efficiency. For example, Caselli et al. (2016) found that banks' share-price losses following sovereign downgrades increased as their efficiency increased and as banks' systematic risk increased.

In contrast, as an example of a study with a newly proposed model (4G), Holod and Lewis (2011) showed that the effect that the amount of deposits has on banking efficiency depends on different stages of the bank-production process. The authors proposed an alternative DEA model in which deposits were an intermediate product. They argued that one weakness of current banking-efficiency models is a lack of consensus of the role that deposits play in the bank-production process.

In the *Journal of International Financial Markets, Institutions & Money*, 70% of the articles focused on the 4B and 4H areas. As expected due to its scope, most of the papers in the Journal of Financial Stability concentrated on banking efficiency in the supervisory and regulatory approaches, as these issues are directly linked to the need for financial-market stability. One case study with regulation as its main objective is Barth et al. (2013), which states that stronger official supervisory power is positively associated with greater banking efficiency only in countries that have independent supervisory authorities. The results are shown in Table 9.

Referring to the thematic approach adopted by the selected studies' authors, Table 10 presents some insights regarding the works

Table 9
Main object of study by journal.

Journal	Object of study																		
	4A		4B		4C		4F		4G		4G		4D		4E		4H		Total
European Financial Management	1	1.15%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1.15%	0	0.00%	2
Financial Management	1	1.15%	0	0.00%	0	0.00%	1	1.15%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	2
Fin. Mark. Inst. and Instruments	0	0.00%	1	1.15%	1	1.15%	1	1.15%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	3
J. of Banking &Finance	7	8.05%	6	6.90%	2	2.30%	2	2.30%	6	6.90%	2	2.30%	1	1.15%	2	2.30%	0	0.00%	28
J. of Corporate Finance	0	0.00%	0	0.00%	1	1.15%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1
J. of Empirical Finance	1	1.15%	1	1.15%	0	0.00%	1	1.15%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	3
J. of Financial Services Research	0	0.00%	0	0.00%	0	0.00%	2	2.30%	0	0.00%	1	1.15%	0	0.00%	0	0.00%	0	0.00%	4
J. of Financial Stability	3	3.45%	2	2.30%	0	0.00%	0	0.00%	0	0.00%	3	3.45%	0	0.00%	0	0.00%	0	0.00%	8
J. of Int. Fin. Mark. Inst. &Money	2	2.30%	4	4.60%	1	1.15%	1	1.15%	1	1.15%	4	4.60%	0	0.00%	1	1.15%	1	1.15%	15
J. of Money, Credit and Banking	1	1.15%	0	0.00%	0	0.00%	1	1.15%	0	0.00%	4	4.60%	0	0.00%	0	0.00%	0	0.00%	6
Rev. of Quant. Finance and Accounting	1	1.15%	0	0.00%	0	0.00%	2	2.30%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	3
Int. Review of Financial Analysis	2	2.30%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	2
The J. of Financial Research	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1.15%	0	0.00%	0	0.00%	0	0.00%	1
Quantitative Finance	0	0.00%	1	1.15%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1
The European J. of Finance	4	4.60%	0	0.00%	1	1.15%	1	1.15%	0	0.00%	1	1.15%	0	0.00%	1	1.15%	0	0.00%	8
Total	23	26%	16	18%	6	7%	12	14%	7	8%	16	18%	1	1%	5	6%	1	1%	87

Note: Islamic and Conventional Banks (4D), Banking Supervision and Regulation (4H), Mergers and Acquisitions and TBTF (4F), Competitiveness, Concentration and Efficiency (4A), Efficiency in Small Institutions (4E), Governance (4C), Diversification and Risk (4B), and Mod Alter Proposal, Simulation (4G).

Table 10
Authors and main object of study – at least five publications.

Author	4A	4B	4C	4F	4G	4H	4D	4E	Others	Total
Roman Matousek	2	2	0	1	2	1	0	1	1	10
Claudia Girardone	1	0	0	2	0	1	0	0	0	7
Georgios E. Chortareas	0	0	0	1	0	3	0	0	0	5
Emmanuel Mamatzakis	0	2	0	0	1	1	0	0	0	5

Note: Islamic and Conventional Banks (4D), Banking Supervision and Regulation (4H), Mergers and Acquisitions and TBTF (4F), Competitiveness, Concentration and Efficiency (4A), Efficiency in Small Institutions (4E), Governance (4C), Diversification and Risk (4B), and Mod Alter Proposal, Simulation (4G).

of the most prominent authors. The most productive author, Roman Matousek, published studies using three approaches, but the other authors focused on specific approaches; for instance, Franco Fiordelisi published three articles on the relationships that efficiency has with competitiveness and banking concentration.

It should be noted that the authors Georgios E. Chortareas, Alexia Ventouri, and Claudia Girardone shared the same research focus because these authors worked together on their articles. However, the most productive authors focused on the area that links efficiency to competitiveness and banking concentration.

From Table 11, it is possible to verify that the thematic approaches are widely distributed among the studies of banking efficiency. The search for measurements of efficiency or associations between various factors and efficiency is thus not linked to a particular thematic approach.

Table 11
Main object of study and objective.

Objective	Object of study																		
	4A		4B		4C		4F		4G		4G		4D		4E		4H		Total
Measurement	4	5%	6	7%	1	1%	2	2%	5	6%	1	1%	0	0%	2	2%	0	0%	21
Association.	5	6%	1	1%	1	1%	2	2%	0	0%	2	2%	0	0%	0	0%	0	0%	11
Measurement and association	14	16%	9	10%	4	5%	6	7%	2	2%	11	13%	1	1%	3	3%	1	1%	51
Not applicable	0	0%	0	0%	0	0%	2	2%	0	0%	2	2%	0	0%	0	0%	0	0%	4
Total	23	26%	16	18%	6	7%	12	14%	7	8%	16	18%	1	1%	5	6%	1	1%	87

Note: Islamic and Conventional Banks (4D), Banking Supervision and Regulation (4H), Mergers and Acquisitions and TBTF (4F), Competitiveness, Concentration and Efficiency (4A), Efficiency in Small Institutions (4E), Governance (4C), Diversification and Risk (4B), and Mod Alter Proposal, Simulation (4G).
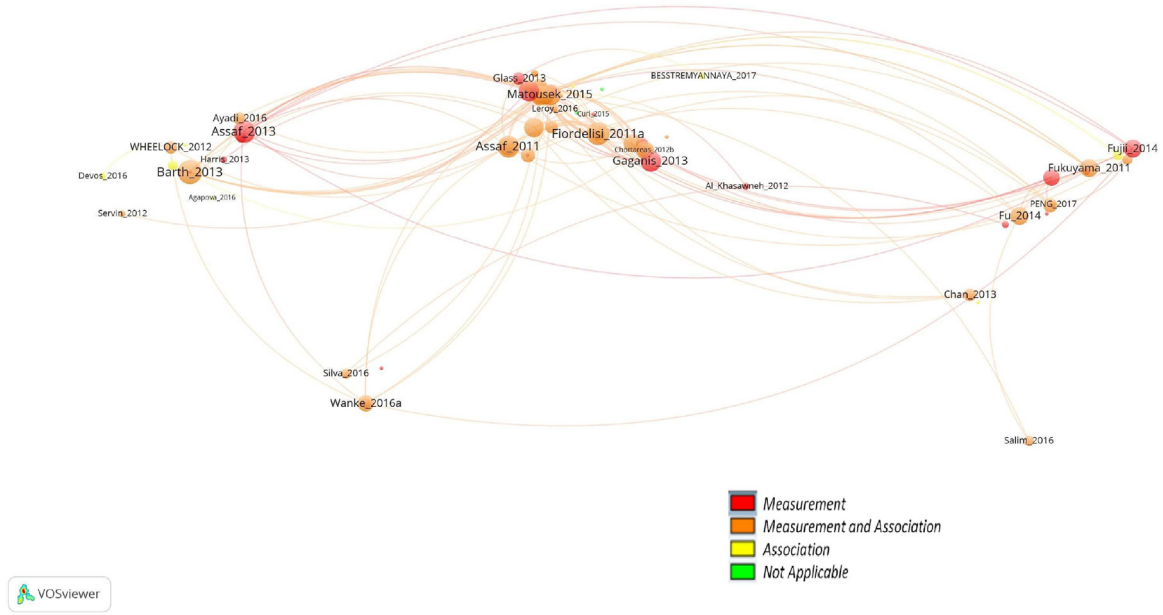
Fig. 7. Network objective of study – distribution around the world.

Still, in relation to the studies' objectives, the analysis of networks in Fig. 7 allows the visualization of how the approach that joins measurements and associations is the most prominent (this includes relationships based on citations). The approach that measures efficiency is the second-most common. However, there are few links among the articles that focus only on associations.

We verify that, currently, the main focuses of banking-efficiency studies are the measurement of efficiency and the association of other variables with efficiency. However, Fig. 7 indicates that studies with the main objective of measuring efficiency have stood out in several regions, including in Europe, which has the main concentration of papers.
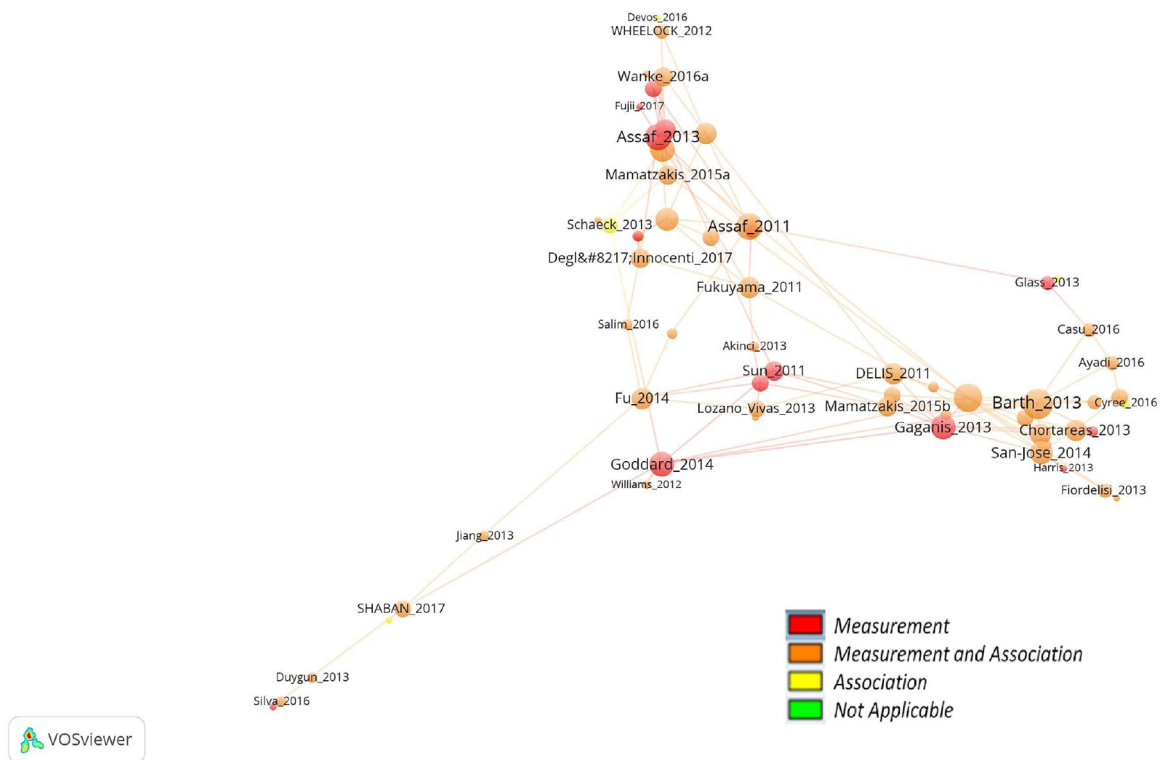

Fig. 8. Network objective of study – strength relation and clusters.

Table 12

Method used for measurement and main object of study.

Method used	Object of study																	
	4A		4B		4C		4F		4G		4G		4D		4E		4H		Total
DEA	12	14%	3	3%	2	2%	5	6%	2	2%	4	5%	1	1%	1	1%	0	0%	30
SFA	6	7%	10	11%	3	3%	3	3%	3	3%	8	9%	0	0%	3	3%	0	0%	36
Others	1	1%	2	2%	0	0%	1	1%	2	2%	0	0%	0	0%	1	1%	1	1%	8
Not applicable	4	5%	1	1%	1	1%	3	3%	0	0%	4	5%	0	0%	0	0%	0	0%	13
Total	23	26%	16	18%	6	7%	12	14%	7	8%	16	18%	1	1%	5	6%	1	1%	87

Note: Islamic and Conventional Banks (4D), Banking Supervision and Regulation (4H), Mergers and Acquisitions and TBTF (4F), Competitiveness, Concentration and Efficiency (4A), Efficiency in Small Institutions (4E), Governance (4C), Diversification and Risk (4B), and Mod Alter Proposal, Simulation (4G).

However, there does not seem to be any relationship between the clusters, according to the network of citations and the previous classifications related to the purpose of the studies. The visual network in Fig. 8 indicates that the articles with the objective of measurement are grouped in clusters, which suggests an interconnection between the studies. This result was expected, as the majority have two the main objectives (efficiency measurement and the association of variables).

Regarding the empirical technique used in the studies, we have verified the predominance of SFA and DEA in the measurement of efficiency for the various thematic approaches. Both methods are used to measure banking efficiency. Although studies' methods are advancing, the improvements lie within application and refinement; they are not altering the fundamentals of the methods. The main changes are been used by banking studies to solve constraints in the assumptions of the models (convexity, heteroscedasticity, etc.) and the increase of possibilities in their structures (network models, slack based measures, etc.). For example, network DEA models have been a workaround to the old discussion about the nature of bank deposits since they allow intermediate variables as in Wanke et al. (2017).

These tools both focus on association and measurement, and they tend to be used together, which allows researchers to evaluate the results obtained from the two methods. Here again, we can check the biases of the structural and non-structural approaches. Efficiency frontiers are usually addressed using an established theoretical framework and a linear optimization approach such as DEA. The results are given in Table 12.

We emphasize that works with different measurement techniques are related through their citation networks. In Fig. 9, many lines change colours, indicating that the related articles use different measurement techniques.

There is also a large geographic dispersion of methods for measuring efficiency, and the institutions' geographic origins indicate no preference for particular measurement methods. The classical methods of measurement (DEA and SFA) are dispersed across continents, as are other, less well-known methods of measurement. The design clusters (see Fig. 10) can be used to visually verify that
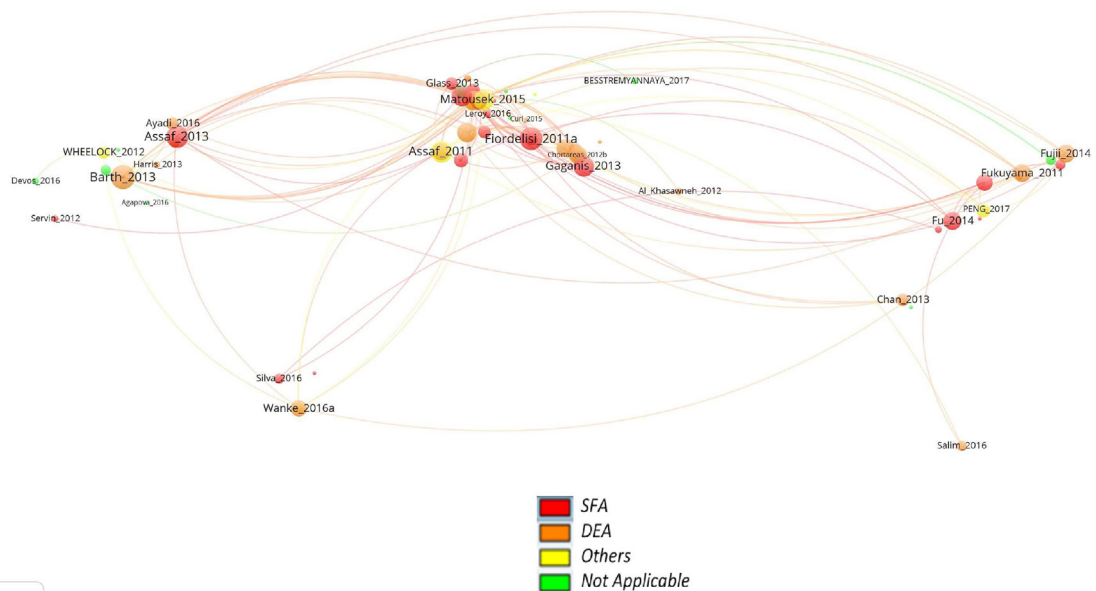

Fig. 9. Network – main measurement technique and space. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)
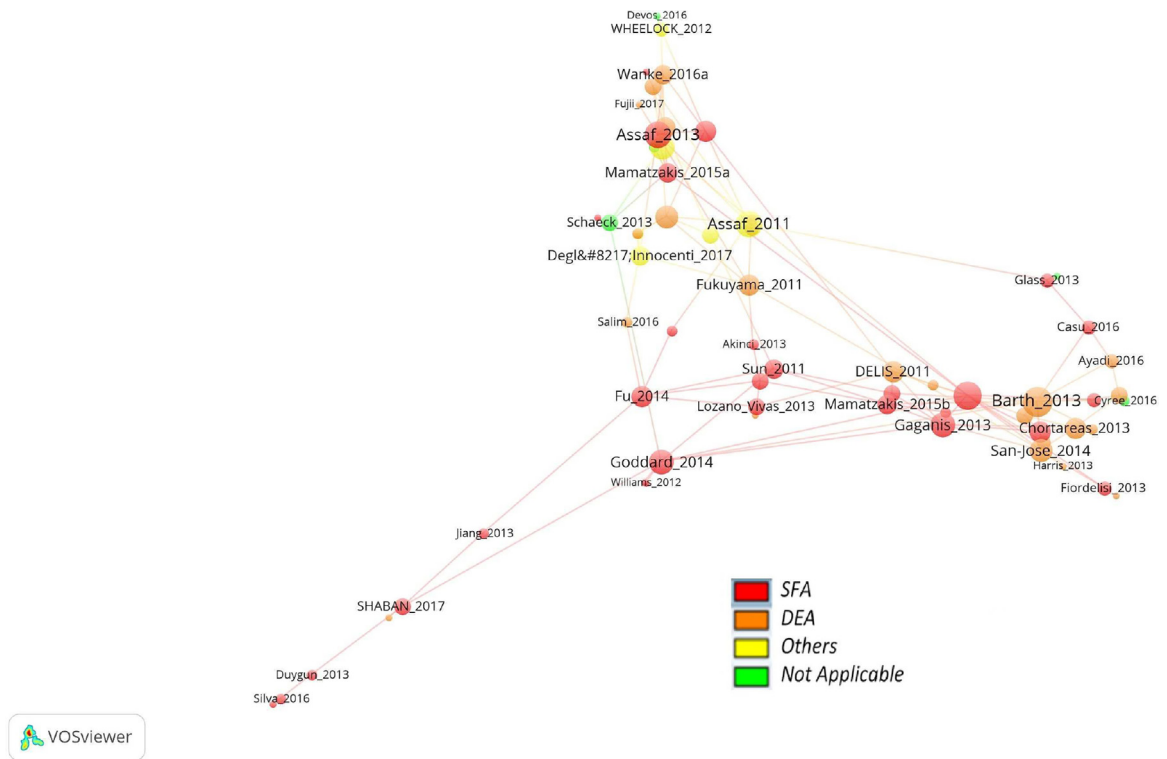
Fig. 10. Network – main measurement technique and clusters.

study's methods tend to influence the methods in its network of citations, which indicates either a difficulty in dissemination or an interaction between the articles that use different methodological approaches.

The result was not expected in view of the highly empirical nature of banking efficiency research. Thus, the surveys were expected to communicate with greater heterogeneity regardless of the method of measurement. The literature in the area does not discuss whether any measurement method would be more appropriate for specific research subjects or topics in banking efficiency. Thus, the reason for the cohesion of studies using the same method remains a question. A possible hypothesis would be the bias of the authors
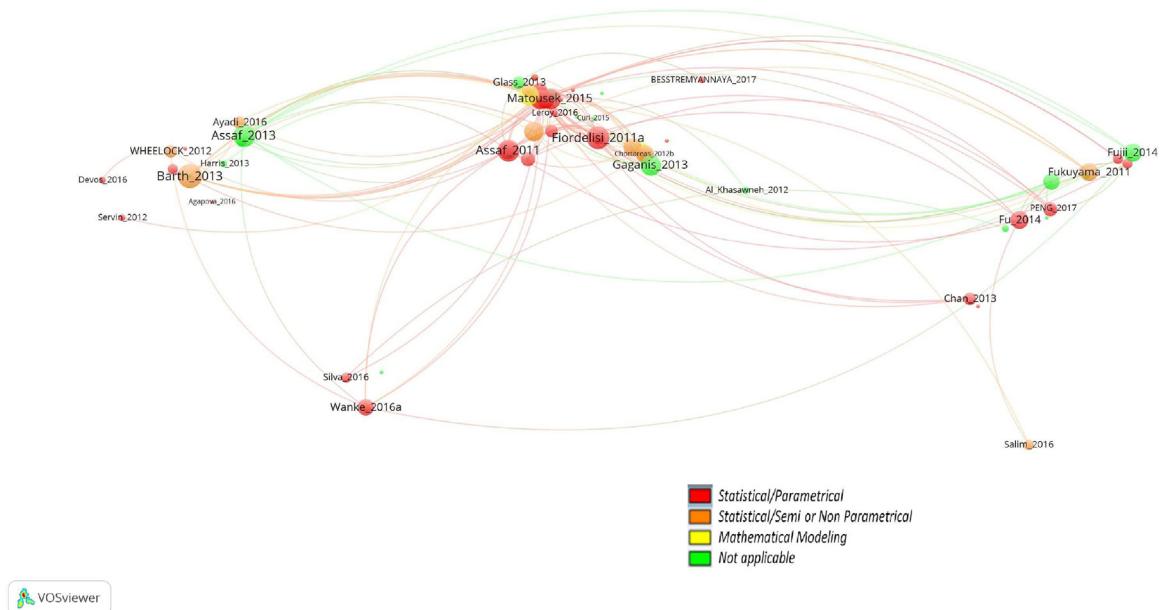

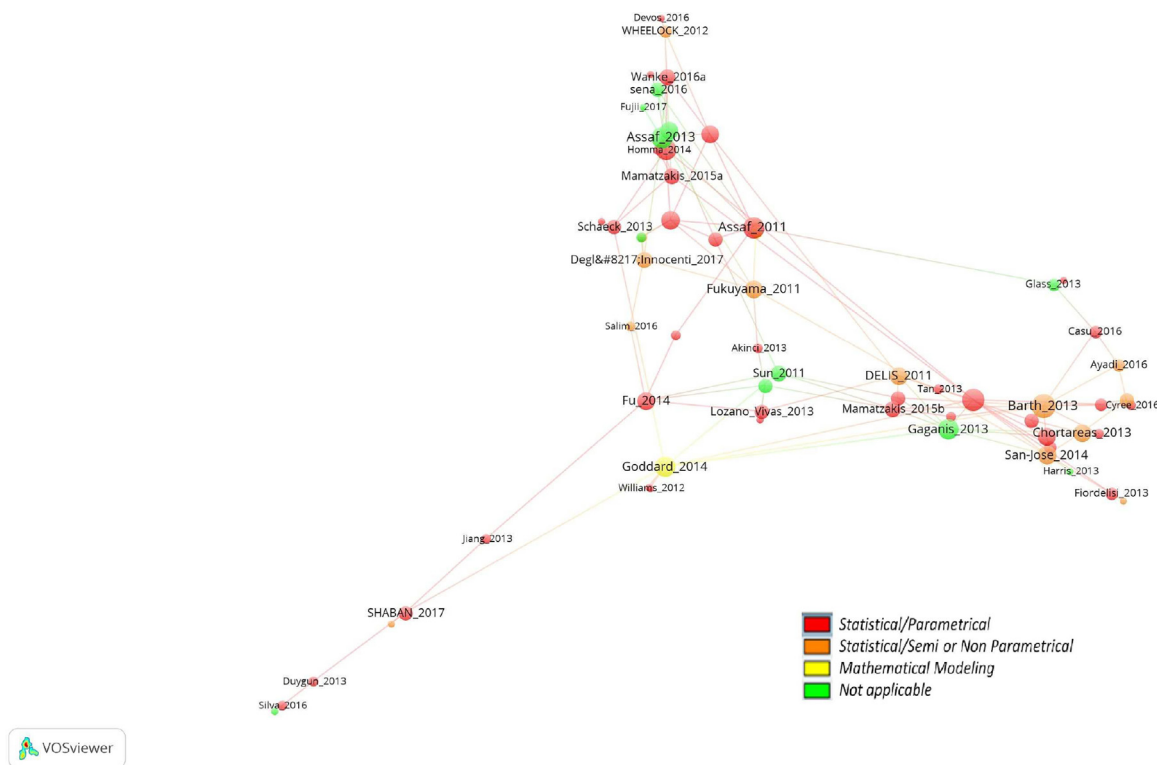Fig. 11. Focus of main association technique of research.

Fig. 12. Focus of main association technique of research.

regarding the method employed and, therefore, the easier and more likely citation of an article with a similar methodological process.

The results found for the association methods are also geographically dispersed, which is illustrated in Fig. 11. However, Fig. 12 indicates that the works that use totally parametric methodologies and those that adopt non- or semiparametric methods for the tests of association of variables to banking efficiency are not totally segregated between the quotes. This tends to demonstrate the greater acceptance of methods that deviate from the classic statistical methods based on the generally accepted parametric distributions (Table 13).

In contrast, studies focused on measurement, within the clusters, were also observed in the surveys with similar approaches in the method of association (see Fig. 12). At this point, however, the result was expected because the use of classic parametric methods depends heavily on the nature of the data used and, therefore, on the research topic.

Finally, both the geographic distribution and the network design formed by clustering are well distributed, as shown in Figs. 13 and 14. However, it is possible to visualize the proximity and clustering compliance between the Supervision (black), Competitiveness (red), and Alternative Models (Purple) groups. These areas demonstrated a larger network of citations between the studies, which theoretically indicates more mature areas of research objectives in the field of banking efficiency.

Table 13
Method used for association and mains object of study.

Method used	Object of study									
	4A	4B	4C	4F	4G	4G	4D	4E	4H	Total
Statistical/parametrical	16	18%	10	11%	4	5%	6	7%	1	1%	9	10%	1	1%	2	2%	0	0%	49
Statistical/semi or non parametrical	4	5%	0	0%	1	1%	2	2%	1	1%	4	5%	0	0%	1	1%	1	1%	14
Mathematical modelling	0	0%	0	0%	0	0%	1	1%	1	1%	0	0%	0	0%	0	0%	0	0%	2
Not applicable	3	3%	6	7%	1	1%	3	3%	4	5%	3	3%	0	0%	2	2%	0	0%	22
Total	23	26%	16	18%	6	7%	12	14%	7	8%	16	18%	1	1%	5	6%	1	1%	87

Note: Islamic and Conventional Banks (4D), Banking Supervision and Regulation (4H), Mergers and Acquisitions and TBTF (4F), Competitiveness, Concentration and Efficiency (4A), Efficiency in Small Institutions (4E), Governance (4C), Diversification and Risk (4B), and Mod Alter Proposal, Simulation (4G).
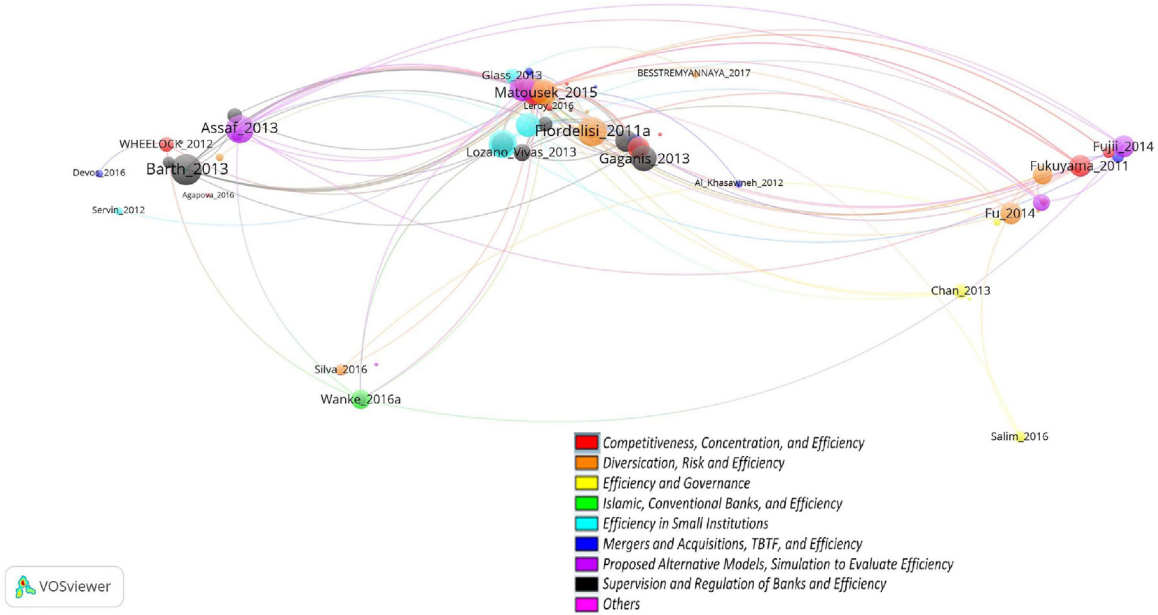
Fig. 13. Object of study – space. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)
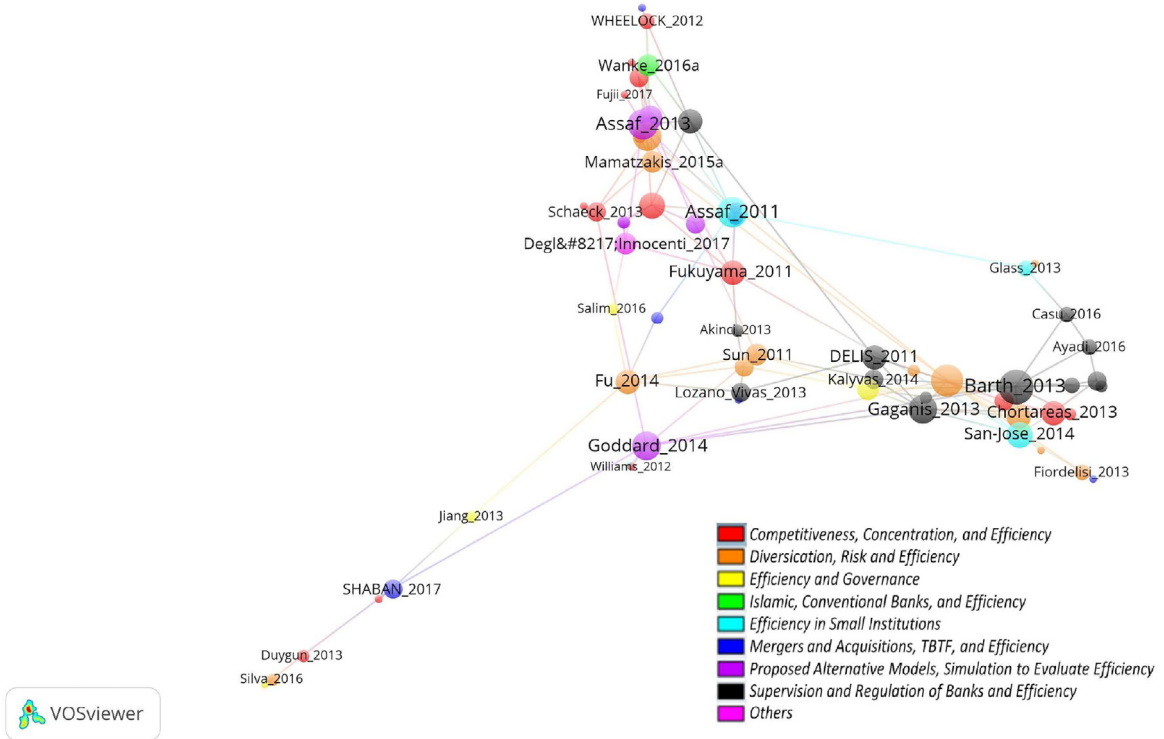

Fig. 14. Object of study – clusters. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

4.2. Analysis of the main research paths

We also looked for areas that had an incremental development of knowledge in the last years. We used a technique called main path analysis that was developed by Hummon and Dereian (1989). The presumption of the technique is that information flows
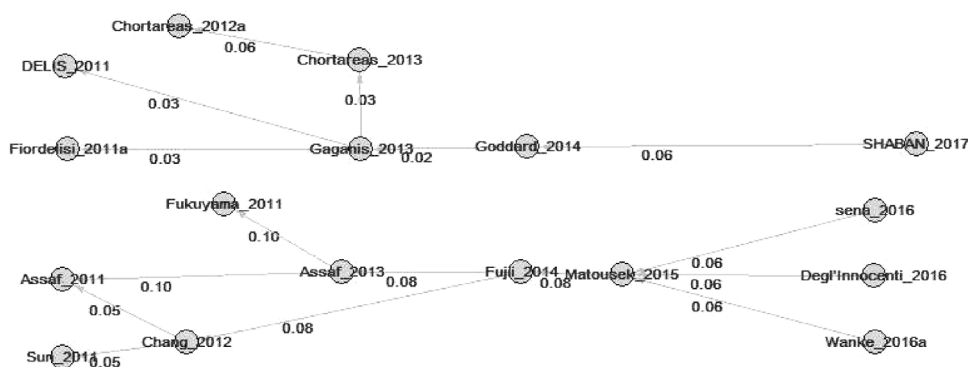
Fig. 15. Two main research paths.

through citations and, for that reason, the studies that are needed in many paths between several papers are treated as more crucial than those that are not necessary for connection between studies.

In our citation analyses, we found two main paths. Fig. 15 shows that the first path starts with Delis et al. (2011), Fiordelisi et al. (2011) and Chortareas et al. (2012b), and finally ends with Shaban and James (2017). The second and strongest path starts with Assaf et al. (2011) and Sun and Chang (2011) and ends with Sena et al. (2016), Degl'Innocenti et al. (2017a,b) and Wanke et al. (2016b).

The main paths demonstrate a lack of sub-specialization in the research areas related to the efficiency of FIs. The main paths include important studies with various research objectives. However, there are two points of integration. The first relates to the measurement method used. We found that many of the participants of the main paths used the study by Simar and Zelenyuk (2007) in their regression models after measurement using DEA models (Chortareas et al., 2013, 2012b; Delis et al., 2011). The second path refers to studies that assess the impact of banking regulation and supervision on the efficiency of FIs.

The bootstrapped truncated regression model of Simar and Zelenyuk (2007) appears as a paradoxical method in the area where it is necessary to perform regressions from DEA models to measure banking efficiency. The authors showed through simulation that the Tobit regression model used so far yielded inconsistent and biased estimates. Currently, few studies in the major financial journals use the Tobit regression when DEA is applied to measure efficiency. A rare example of a Tobit model study was found in an article by Wanke et al. (2016b).

Regarding the effect of banking regulation and supervision, the controversial issues continue to generate a large number of studies in the banking area and also in the specific issues of efficiency in FIs. The papers in these areas participated in the first path, with great integration between the works.

One of the groups of authors who started the first path was Delis et al. (2011). They followed the method of Simar and Zelenyuk (2007) and found that policies (incentives or regulations) that promote private monitoring and restrictions on activities have a positive impact on bank productivity. In addition, Delis et al. (2011) suggested that in moments of financial pressure, other factors such as stringent capital and supervisory standards would have positive effects on productivity as well.

The results of the study by Delis et al. (2011) were contradictory to those found by Chortareas et al. (2012b). This study analysed the association between banking efficiency and both regulatory and supervisory factors. However, the main results suggested a positive relationship between strengthening capital restrictions and official supervisory powers with operational banking efficiency. Nevertheless, interventionist policies could result in higher levels of banking inefficiency. Chortareas et al. (2012b) used DEA to measure efficiency and truncated regressions (Simar and Zelenyuk, 2007) and generalized linear models to evaluate the association of variables.

Following this line of research, Chortareas et al. (2013) analysed the relationship between financial freedom counterparts and banking efficiency levels. The authors measured banking efficiency using DEA and the truncated regression model of Simar and Zelenyuk (2007) to test the association between economic freedom and efficiency. The main results suggested that the degree of an economy's financial freedom is associated with better benefits for banking efficiency. These findings contradict results found in Berger and Humphrey (1997), indicating that studies with this subject still need to be deepened to establish why the different results occur.

The advantages and disadvantages associated with bank supervision were also investigated by Gaganis and Pasiouras (2013). The authors found that banking efficiency decreases as the number of financial sectors that are supervised increases. In addition, the results suggested a negative association between the efficiency and unification of supervisory authorities and central bank independence.

An issue indirectly linked to banking regulation is whether bank performance benefits from capital restrictions. In this direction, Fiordelisi et al. (2011) analysed the association of banking efficiency with capital and risk levels. Therefore, the study is indirectly important to bank supervision due to the associated financial stability with efficiency in FIs. Based on the main results, the authors suggested that lower banking efficiency increases banking risk, and that increases in bank capital precede cost efficiency improvements.

The development and application of new models have appeared in smaller number, but they are important within the line of research. Goddard et al. (2014) applied and evaluated random parameters models for SFA. The authors found that efficiencies

obtained from random parameters models tend to be better than fixed or random effects. They argue that the consequence is that random parameters do not confound parameter heterogeneity with inefficiency. Similarly, Goddard et al. (2014) used the models to evaluate cost efficiency for Latin American banks.

An issue that appeared in both research paths is directly related to the first major question proposed by Bhattacharya and Thakor (1993), which continues to generate various researches in financial intermediation. This issue involves the question of determinants of FI property structures. In the first main research path, Shaban and James (2017) evaluated whether ownership could change the performance of commercial banks. The main results were that state-owned banks tend to be less profitable and more exposed to risk than private and foreign banks. A controversial result is the suggestion that domestic acquisition is associated with a decrease in the efficiency of the acquired banks; however, acquisition by regional foreign investors was associated with performance gains.

In the second main path, Fujii et al. (2014a) applied a weighted Russell directional distance model to measure technical inefficiency and evaluate total factor productivity (TFP) change with non-performing loans (NPLs). The authors also showed evidence that inefficiency levels are significantly different among ownership structures of banks. In addition, the study analysed some specific issues related to FIs Indian banks.

As discussed by Fujii et al. (2014b), the treatment and use of NPLs in banking performance measurement models has been important in the current discussions. However, the characteristic of NPLs is controversial in literature; studies could use it as a measurement of risk, an input (expenses), an undesirable output, or even as a control variable. The current studies usually treated it as a bad output (Assaf et al., 2013; Matousek et al., 2015).

Assaf et al. (2013) offered an unusual method that serves an alternative for analysing banking efficiency and productivity, the Bayesian stochastic frontier approach (BSF). The authors used BSF to evaluate the productivity and efficiency of Turkish banks focused on accounting for NPLs. The authors employed NPLs as a bad output and found evidence of positive productivity growth due to improvements in technology. A singular methodological piece of evidence not accounting for NPLs in estimating the frontier model might seriously distort the efficiency and productivity results. Comparisons between domestic and foreign banks were evaluated.

In contrast, Matousek et al. (2015) applied a two-step approach that treats banks' NPLs as an undesirable output as well. The point of interest in the study was the possible convergence in banking efficiency. An overall decline in efficiency and a presence of club formation with typically weak convergence was found by Matousek et al. (2015). The line of research that analyses the process of banking integration in the EU countries and the Eurozone industry has been studied extensively.

Still, in relation to the second main research path, we found a concern of many papers to evaluate specific regional situations of banking efficiency. Examples are the studies by Fukuyama and Matousek (2011), Assaf et al. (2011) and Chang et al. (2012). Assaf et al. (2011) treated the productivity and efficiency of Shinkin banks and the various prefectures in Japan. They did not find efficiency and productivity growth, but they found a homogeneous efficiency across the banks that were analysed. The study also shows some evidence of productivity and efficiency growth.

As we can see, the concern of the studies is not only restricted to specific regions, but also concerns with the integration process. Following this direction, Degl'Innocenti et al. (2017a,b) explored the sources of growth in different stages of production using a two-stage approach. The results suggested opposite evidence: a productivity growth during the U.S. subprime crisis, but a decline during the global financial crisis. Furthermore, contrary to Matousek et al. (2015), they found a strong convergence pattern during the financial crisis.

The bank productivity growth in China was analysed by Chang et al. (2012). The main aspect investigated was the comparison of indexes and models. However, in addition, they proposed an advanced index that disaggregated total factor productivity growth into each input. With the analyses, the authors were able to show evidence that the their input slack-based productivity index provides more insight than traditional TFP indexes.

Fukuyama and Matousek (2011) analysed the cost, technical, and allocative efficiencies of the Turkish banks with a focus on changes promoted by financial crises. The authors used a network model DEA. In this kind of model, it is possible to evaluate intermediate outputs that become inputs. The study provided evidence that banking efficiency reflected the state of the economy before and after crises. Furthermore, there continues to be a gap between the best and worst performing banks.

A peculiar approach with predictive ability was applied by Wanke et al. (2016b). They used a dynamic slacks-based model (DSBM) as the first stage in a two-stage process to assess the relative efficiency of Malaysian Islamic and conventional banks by emulating the CAMEL rating systems. Monte Carlo Markov Chain was used in the second stage. The proposed models applied to generalized linear mixed models were combined with DSBM results to produce a mechanism for banking performance assessment. In addition, Wanke et al. (2016b) suggested that Islamic banks have higher inefficiency levels than conventional banks and that foreign Islamic banks have lower efficiency levels compared to their national counterparts.

Comparative analyses between different types of business and ownership structures also continue to be frequent subjects in the studies. In the main research path, Sena et al. (2016) trademarking banks. The known nonparametric metafrontier Malmquist index was used to decompose it into changes of efficiency for groups and sectors of banks. The main result found by the authors suggested that technical change works like a driver of TFP growth among non-trademarking banks; however, for trademarking efficiency, change explains most of the TFP variation.

Finally, another frequent question in the current studies is the relationship between risk and cost efficiency of banks. This stream of study has been extremely important in the modern application of efficiency analysis to banking because the standard literature does not allow bank production decisions to affect bank risk (Hughes and Mester, 2008; Mester, 1992). One of the studies that starts the second main path of research evaluates the influence of various types of risk on the efficiency of FIs. Sun and Chang (2011) analysed distinct risk aspects under a total of eight risk measures. The results suggested that risk measures have effects on both the level and variability of banking efficiency.

5. Conclusion

The literature on banking efficiency is very dynamic and complex and usually integrates several areas of finance and banking. In this study, we analysed the state-of-the-art in terms of the theme and some of the newer aspects addressed in the theoretical framework. We proposed and apply a method of classification in order to evaluate the recent paths of development, citation networks, coordination, and productivity of financial research in the main international financial journals.

We collected and interpreted publications from the period between 2011 and first semester of 2017 that were classified as high quality and having scientific impact by the international community through consultation with the *Academic Journal Guide 2015* of the Association of Business Schools.

Approaches that connect measurement and association had greater predominance. The results demonstrate the increased complexity of the issues addressed. Thus, studies seek to analyse factors that impact banking efficiency but at the same time use specific methods for the previous measurement of efficiency. This demonstrates a wide openness for studies that indicate integrated models of evaluation directed at FIs.

We specifically verified the predominance of the use of SFA and of the DEA for the measurement of efficiency in the various thematic approaches. The two methods currently function as paradigms for the measurement of banking efficiency. These tools in the studies that approach the subject with association and measurement tend to sometimes be used together, which allows one to evaluate the results obtained by the two different methods. This result emphasizes a research gap in the area.

The major of participants of the main paths used the method of Simar and Zelenyuk (2007) in their regression models after measurement using DEA. The bootstrapped truncated regression model appears as a paradoxical method in the area when it is necessary to perform regressions from DEA models. Studies aim to demonstrate the adequacy of other methods to explore regression using nonparametric estimates of efficiency in two-stage procedures are a gap of research in banking efficiency.

Limitations in the methods' characteristic are still the origin of several studies in the field and provide margin for their application in banking efficiency studies. In the case of SFA, unilateral distributions of inefficiencies, that use a half-normal assumption, still dominated the studies, but models using bi-lateral distribution and more adequate types of distribution are still research gaps for the area. In the same way for DEA applications, the construction of negative borders with less restricted properties for the models still are the object of discussion and application in the banking area. Examining if the estimator's statistical properties are adequate to the banking process is as well a prominent area.

It was verified that the main objective of current research is the theme that links the efficiency of FIs with diversification and risk, which was followed by studies focused on the impacts of supervisory and regulatory actions on the efficiency of banks. These issues have probably been driven by recent financial crises and the consequent imposition of prudential regulations.

Studies with the main theme of supervision, competitiveness, or alternative models demonstrated a larger citation network, which was fitted in the clusters. This result suggests more mature areas of research objectives in the field of banking efficiency. The formulation of specific models for banking efficiency has been integrated with models with direct application in certain research topics. The evaluation of specific models for certain objectives appears as a growing theme.

The supervision and the effect of banking regulation are controversial issues and continue to be focus of a large number of studies in the banking area, as well as in the specific issues of efficiency in FIs. The new rules of Basel and new forms of control of banks have potential to generate broad areas of research.

Another important point is related to the great geographical concentration. Currently, the research on the efficiency of FIs is concentrated in Europe. The majority of institutions that contributed to the theme originated in the United Kingdom, with more than twice the number of articles of the United States. However, the networks are connected, and information reaches all the major journals, even indirectly. The citation network structure is similar to a star network, with the *Journal of Banking & Finance* holding great centrality and with a role of connection between the main studies in banking efficiency. In turn, the *Journal of International Markets, Institutions & Money* functions as an interconnection between the three network clusters observed.

We also verify that the relationships between the studies are strongly related to the origin of the journal, and the unique journal that had consistent publication over the years was the *Journal of Banking & Finance*. This result is consistent with the fact that journals have specific themes of interest.

Another important issue is concerned with the lack of information on what the determinants of efficiency are according to the approach used. Thus, although studies show that changes in the configuration of inputs and outputs generate significant changes in efficiency estimates, no robust theoretical explanations have yet been proposed.

Finally, we found low productivity in the research of banking efficiency, which was confirmed by the analyses of Lotka's Law and by the descriptive statistics. We also found a high degree of dispersion of the studies. That is, there are a relatively limited number of authors and institutions that dedicate themselves to this specific subject. This fact indicates that, despite the tradition of the area, banking efficiency is not yet be a well-defined area of knowledge. Most of its studies come from areas such as finance, banking or operational research.

Appendix A

See Table 14

Table 14
Articles that compose the sample.

Study	Study type	Objective	Methods used – measurement	Methods used – association	Main Object of study	Latitude	Longitude
Hartarska and Mersland (2012)	Theoretical and empirical	Measurement	SFA	Not applicable	EPI	32.59	−85.49
Lozano-Vivas and Weill (2012)	Theoretical and empirical	Measurement	SFA	Not applicable	C&E	36.71	−4.41
Devos et al. (2016)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	F&A	31.77	−106.50
Schaeck and Cihák (2013)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	C&E	53.22	−4.12
Mallick and Yang (2011)	Theoretical and empirical	Measurement	Others	Not applicable	D&R	51.52	−0.13
Pasiouras et al. (2011)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	F&A	50.79	−1.09
Barth et al. (2013)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	SRB	32.59	−85.49
Holod and Lewis (2011)	Theoretical and empirical	Measurement	DEA	Not applicable	PMA	40.91	−73.12
Chortareas et al. (2013)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	C&E	37.96	23.77
Mamatzakis and Bermpei (2015)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	D&R	50.86	−0.08
Gaganis and Pasiouras (2013)	Theoretical and empirical	Measurement	SFA	Not applicable	SRB	35.30	25.08
Curi et al. (2015)	Theoretical and empirical	Measurement	DEA	Not applicable	D&R	46.49	11.35
Sun et al. (2013)	Theoretical and empirical	Measurement	SFA	Not applicable	E&G	20.05	110.33
Matousek et al. (2015)	Theoretical and empirical	Measurement and association	Others	Statistical/parametrical	D&R	51.29	1.07
Sun and Chang (2011)	Theoretical and empirical	Measurement	SFA	Not applicable	D&R	31.22	121.40
Fiordelisi et al. (2011)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	D&R	41.86	12.47
Goddard et al. (2014)	Theoretical and empirical	Measurement	SFA	Mathematical Modeling	PMA	52.22	−4.12
Homma et al. (2014)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	C&E	36.69	137.18
Tabak et al. (2013)	Theoretical and empirical	Measurement	SFA	Not applicable	PMA	−14.45	−39.40
Wanke et al. (2016b)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	E&Is	−22.95	−43.17
Assaf et al. (2013)	Theoretical and empirical	Measurement	SFA	Not applicable	PMA	42.39	−72.52
Chen and Kao (2011)	Theoretical and empirical	Measurement	SFA	Not applicable	D&R	22.62	120.26
Fujii et al. (2014a)	Theoretical and empirical	Measurement	DEA	Not applicable	PMA	38.25	140.87
Halkos and Tzeremes (2013)	Theoretical and empirical	Measurement	DEA	Mathematical Modeling	F&A	39.35	22.95
Qian and Yeung (2014)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	E&G	1.29	103.77
Chortareas et al. (2016)	Theoretical and empirical	Measurement	DEA	Statistical/parametrical	C&E	51.51	−0.11
Behr and Heid (2011)	Theoretical and empirical	Not applicable	Others	Not applicable	F&A	52.51	13.38
Radić et al. (2011)	Theoretical and empirical	Measurement	SFA	Not applicable	D&R	51.51	−0.06
Silva et al. (2016)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	D&R	−15.80	−47.88
Ayadi et al. (2016)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	SRB	45.50	−73.62
Luo et al. (2016)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	D&R	52.40	−1.50
Williams (2012)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	C&E	53.22	−4.12
Chortareas et al. (2012b)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	SRB	37.96	23.77
Pessarossi and Weill (2015)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	SRB	43.46	1.25
Harris et al. (2013)	Theoretical and empirical	Measurement	DEA	Not applicable	D&R	35.60	−77.35
Salim et al. (2016)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	E&G	−32.00	115.89
Fu et al. (2014)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	D&R	22.12	113.54
Kalyvas and Mamatzakis (2014)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	SRB	50.86	−0.08
Barros and Wanke (2014)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	SRB	38.75	−9.15
Fukuyama and Matousek (2011)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	C&E	33.54	130.36
Fiordelisi and Mare (2013)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	D&R	41.86	12.47
Tan and Floros (2013)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	D&R	53.64	−1.77
Montgomery et al. (2014)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	F&A	35.68	139.52
Mamatzakis and Bermpei (2015)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	SRB	50.86	−0.08
Monnet and Sanches (2015)	Theoretical	Not applicable	Not applicable	Not applicable	SRB	46.95	7.43
Carow et al. (2011)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	SRB	39.17	−86.51
Walther (2016)	Theoretical	Not applicable	Not applicable	Not applicable	SRB	51.75	−1.25
Hadad et al. (2011)	Theoretical and empirical	Association	DEA	Statistical/semi or non parametrical	C&E	52.76	−1.22

Table 14 (*continued*)

Study	Study type	Objective	Methods used – measurement	Methods used – association	Main Object of study	Latitude	Longitude
Agapova and McNulty (2016)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	C&E	26.37	−80.10
Al-Khasawneh (2012)	Theoretical and empirical	Measurement	DEA	Not applicable	F&A	29.27	48.05
Chronopoulos et al. (2012)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	F&A	56.34	−2.79
Cyree (2016)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	SRB	34.36	−89.53
Jonghe et al. (2011)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	F&A	51.04	3.72
Halkos et al. (2014)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	F&A	39.35	22.95
Leroy and Lucotte (2016)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	C&E	47.84	1.93
Lozano-Vivas and Pasiouras (2013)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	SRB	36.71	−4.41
Mamatzakis (2012)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	D&R	50.86	−0.08
Sena et al. (2016)	Theoretical and empirical	Measurement	DEA	Not applicable	C&E	51.87	0.94
Wanke et al. (2016c)	Theoretical and empirical	Measurement and association	Others	Statistical/semi or non parametrical	PMA	−22.95	−43.17
Assaf et al. (2011)	Theoretical and empirical	Measurement and association	Others	Statistical/parametrical	EPI	38.75	−9.15
Wheelock and Wilson (2012)	Theoretical and empirical	Measurement and association	Others	Statistical/semi or non parametrical	C&E	38.62	−90.18
Chang et al. (2012)	Theoretical and empirical	Measurement and association	Others	Statistical/parametrical	PMA	24.78	120.99
Delis et al. (2011)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	SRB	39.61	20.84
Servin et al. (2012)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	EPI	22.63	−101.71
Duygun et al. (2014)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	C&E	52.62	−1.12
Chan et al. (2013)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	E&G	3.12	101.65
Duygun et al. (2013)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	C&E	52.62	−1.12
Chronopoulos et al. (2011)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	F&A	56.34	−2.79
Jiang et al. (2013)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	E&G	51.58	−0.22
Degl'Innocenti et al. (2017a,b)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	C&E	50.93	−1.39
Chortareas et al. (2012a)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	C&E	37.96	23.77
Mamatzakis and Bermpei (2015)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	E&G	50.86	−0.09
Shaban and James (2017)	Theoretical and empirical	Measurement and Association	SFA	Statistical/parametrical	F&A	53.38	−1.49
Peng et al. (2017)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	C&E	24.99	121.58
Besstremyannaya (2017)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	D&R	55.70	37.39
Koetter and Noth (2013)	Theoretical and empirical	Association	Not applicable	Statistical/parametrical	C&E	53.22	6.56
Tanna et al. (2017)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	C&E	52.41	−1.50
San-Jose et al. (2014)	Theoretical and empirical	Measurement and association	DEA	Statistical/semi or non parametrical	EPI	43.33	−2.97
Degl'Innocenti et al. (2017a,b)	Theoretical and empirical	Measurement and association	Others	Statistical/semi or non parametrical	Others	50.94	−1.40
Kalyvas and Mamatzakis (2017)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	SRB	51.98	−0.01
Davies and Tracey (2014)	Theoretical and empirical	Not applicable	Not applicable	Not applicable	F&A	51.51	−0.01
Chortareas et al. (2011)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	C&E	37.96	23.77
Glass et al. (2014)	Theoretical and empirical	Measurement	SFA	Not applicable	EPI	55.15	−6.67
Davutyan and Yildirim (2017)	Theoretical and empirical	Measurement and association	DEA	Statistical/parametrical	C&E	41.02	28.96
Casu et al. (2016)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	SRB	51.53	−0.10
Fujii et al. (2017)	Theoretical and empirical	Measurement	DEA	Not applicable	C&E	32.78	129.86
Fiordelisi and Ricci (2011)	Theoretical and empirical	Measurement and association	SFA	Statistical/parametrical	C&E	41.86	12.47

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