

Quantitative techniques in bank efficiency measurement: A literature review

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Abstract

The performance of financial institutions has major effects on the economic growth of a country. Financial efficiency of banking sector is important, as it increases financial stability. In recent years, there has been an increasing amount of literature on bank efficiency and performance using different type of methods. The aim of this study is to analyze and compare the quantitative techniques used in measuring, evaluating and comparing the performance of the banks in the literature. For this purpose, 80 articles on bank efficiency measurement were analyzed for the period of 2008-2017. The articles including comparative studies of more than 7000 banks, were analyzed and classified according to the techniques used, country of origin, type and ownership of the banks.

Keywords: Bank efficiency, Bank performance, Quantitative methods.

JEL Codes: G21, L25, B23

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1. Introduction

Banks have an important role in the economy. They have intermediation function since they keep public's savings and finance the improvement of business and trade. Therefore, the performance evaluation of banks has been an issue of major interest for stakeholders such as investors, customers, market regulators and the public. The measurements of performance and efficiency of banks may provide valuable information to bank managers and market regulators for their decision making.

Since the better bank system enables the country to be more competitive, each country must try to build the most advanced banking system. It is necessary to work as efficient as possible and do not have unnecessary extra costs in current strong competitive financial environment. Measuring the level of efficiency of the banks can help to identify the performance of measured units. Inefficient banks have the tendency to make risky steps in the market and this can be dangerous for the entire financial system of a country. In addition, the banks reaching the high productivity, generally operate with lower costs and do not tend to do hazardous market operations.

Performance of banks can be expressed in terms of efficiency, productivity, profitability competition, concentration. Thus, a wide range of methods and underlying ratios can be used to evaluate it, depending on research purposes. Banks must be evaluated and analyzed using the most accurate and modern evaluation techniques in order to ensure a healthy financial system together with efficient economy and compared between each other. Essentially, the performance of financial institutions has major implications on the economic growth of a country. Financial efficiency is important, as it enhances financial stability. Banks and policy makers need to investigate the efficiency of the banking industry in order to enhance the economic growth of their country.

One of the most comprehensive surveys on bank efficiency is the study of Berger and Humphrey (1997). They analyzed 130 studies mainly from US and European countries and found that the most common methods were SFA (Stochastic Frontier Analysis) and DEA (Data Envelopment Analysis). A more recent survey by Berger (2007) includes the comparisons of domestic and foreign banks in the same nation using a nation-specific frontier. Brown and Skully (2003) analyzed the methodology and results of international comparative banking studies including bank efficiency and performance studies most of which used regression analysis. Fethi and Pasiouras (2010) determined and listed the operational research and artificial intelligence techniques in bank efficiency and performance. The early surveys discussed the effect of ownership on bank efficiency and performance. However the usage of multi criteria decision making (MCDM) tools such as AHP (analytic hierarchy process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) in bank performance measurement becomes popular in the last decade. In addition, the performance of Islamic banking (or participation banking) takes much attention in literature in recent years.

There are more than 100 comparative studies on performance and efficiency of banking sector for the last 10 years and total of 80 studies were reviewed for this study. These studies were published in 53 journals where the distribution of studies was homogenous. The main difference of this survey is that, it includes MCDM techniques in addition to traditional ones and that it encompasses 13 articles which compared Islamic and conventional banks for the last five years.

This study has three sections. First section is introduction. In the second section, the distribution of papers according to years, ownerships and country of origins are summarized. In the third section, the studies are grouped according to the quantitative method used and the most preferred methods are introduced. The determinants and criteria which were used in bank efficiency and performance measurement are analyzed and the results are summarized in the last section.

2. Classifications and Observations

This study includes 80 research or conference papers published in the period from 2008 to 2017, the 22 of which are the cross-country comparisons of bank efficiency and performance. Cross-country researches include banks from European Union, Golf Cooperation Council, Southeast Asia, OECD and BRICS countries. The rest of 58 studies are originated from different countries all over the world. The distribution of studies according to publication year and country of origin is listed in table 1. Turkey has the largest number of published articles (12), followed by Malaysia (6), China (6), Taiwan (5), India (4) and Iran (4). The top five journals that published the largest number of articles during the period from 2008 to 2017 are; Expert Systems with Applications (5), Procedia Social and Behavioral Sciences (5), European Journal of Operational Research (4), Procedia Economics and Finance (4), Economic Modelling (4).

Table 1. Classification of studies by country and publication year

No	Country	Years										Total
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
1	Turkey		1			1	5		3	1	1	12
2	Malaysia						3	1		2		6
3	China		2		1	1		1			1	6
4	Taiwan		3				1		1			5
5	India		1			1		1			1	4
6	Iran				1	1	2					4
7	Japan					1	1				1	3
8	Pakistan								1	1		2
9	Czech Republic	1						1				2
10	Lithuania					1						1
11	Greece	1		1								2
12	Bahrain										1	1
13	Germany			1								1
14	Saudi Arabia				1							1
15	Spain			1								1
16	Serbia							1				1
17	Brasilia			1								1
18	Ukraine									1		1
19	Korea						1					1
20	Canada				1							1
21	Indonesia								1			1
22	Dubai						1					1
Total		2	7	4	4	6	14	5	6	5	5	58
Cross-country		3	1	1	4	1	1	3	3	3	2	22
Grand Total		5	8	5	8	7	15	8	9	8	7	80

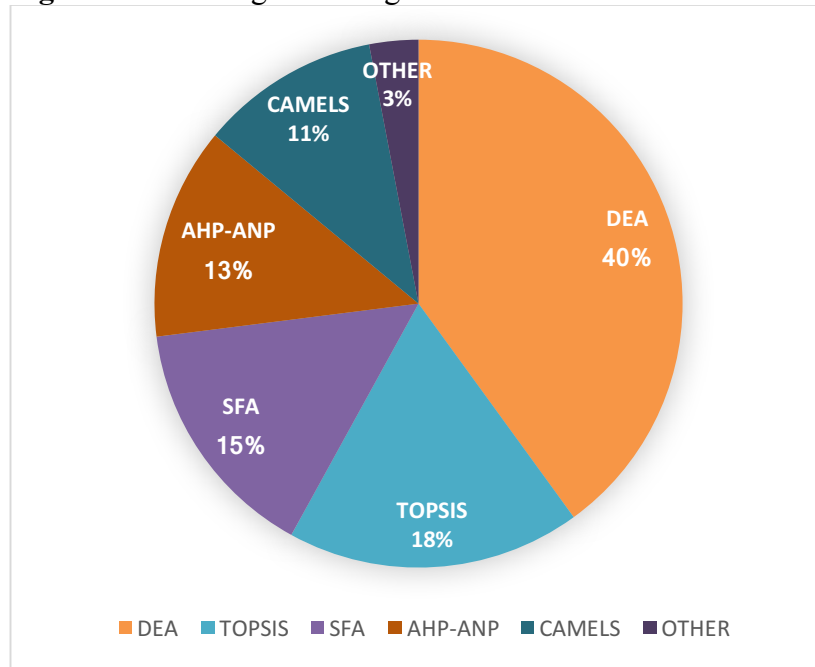
Source: Own elaborations

The majority of articles (39) analyzed the efficiency of commercial banks. The number of 24 studies searched the relationship between the ownership and efficiency of banks by comparing several type of banks: foreign, state, private cooperative, investment, family,

domestic, regional or partially private banks. There are also 13 studies comparing performance and efficiency of Islamic banking vs conventional banking.

Figure 1 shows the distribution of articles based on the mathematical model used in the analysis of bank performance and efficiency. The most common used technique is identified as DEA with the ratio of 40%. The second preferred method is TOPSIS (18%) and it is followed by SFA (15%), AHP-ANP (13%) and CAMELS (11%) respectively. The other methods include PROMETHEE, VIKOR, Goal Programming, Bayesian Estimation, Malmquist Index and other Regression methods.

Figure 1. Percentages of integrated methods



Source: Own elaborations

3. Methodologies of bank performance and efficiency

a. Ratios and CAMELS

There exists different methodologies in literature on measuring and comparing the performance and efficiency of banks and other financial institutions. Early research on this topic applied ratio analysis. The two measures return on assets (ROA) and return on equity (ROE) are the most frequently used ones. Lin and Zhang (2009) used these two ratios to determine the effects of bank ownership on the bank performance in China. Traditional method of applying financial ratios to evaluate bank's performance has been long practiced, with experts using CAMELS rating. CAMELS bank rating is used for the purpose of evaluating the financial efficiency and performance. CAMELS stands for capital adequacy (C), asset quality (A), management efficiency (M), earnings (E), liquidity (L) and sensitivity (S) to market risk (Wanke et al, 2016). Each of these components are calculated on a 1 to 5 scale, being accumulated into a composite evaluation. Dash (2017), Rashid and Jabeen (2016), Wanke et al. (2016b & 2017a), Doumpos & Zopounidis (2010), Rozzani and Rahman (2013), Derviz and Podpiera (2008), Girginer and Uçkun (2012), Hadriche (2015) used CAMELS rating to evaluate the performance of banks.

b. SFA Method

Berger and Humphrey (1997) categorized the bank performance measurement techniques into two main groups: parametric and non-parametric. While the Stochastic Frontier Approach (SFA) is the most popular parametric test in the literature, among the non-parametric tests, Data Envelopment Analysis (DEA) is the most popular (Paradi et al, 2011).

The stochastic frontier analysis (SFA) has been suggested by Aigner, Meeusen and Van den Broek in 1977. The basic idea is the introduction of an additive error term consisting of a noise and an inefficiency term. For the error as well as the inefficiency term distributional assumptions are made, most often the normal and half-normal assumption. Therefore, actual logarithmic output (cost) is assumed to result from the addition of a deterministic functional term, an inefficiency term and a term representing noise (Behr, 2010).

The studies of Perera and Skully (2012), Rozzani and Rahman (2013), Işık et al (2016), Jilan et al(2009), Andries, Sun and Chang (2011), Lensink et al (2008), Mamatzakis (2008), Staikouras (2008), Koutsomanoli-Filipaki et al. (2009), Zuhroh et al (2015) and Ivan (2015) introduced bank efficiency analysis with the method of SFA.

c. DEA Method

DEA is the most popular technique in measuring bank efficiency and performance. Among the 80 papers included in this survey, 32 of them used this non-parametric measurement method. Table 2 shows the articles that have used DEA methodology.

Developed by Cooper, Charnes and Rhodes in 1978 DEA is a non-parametric method that does not require the specification of the functional from relating inputs to outputs or setting of weight for various factors (Ulaş and Keskin, 2015). The strength of DEA has become increasingly popular in applications where multiple inputs and outputs. The aim of DEA is to maximize the efficiency of each decision making unit (DMU). The main reasons of popularity of DEA are that, it does not require the pre-specification of production function, it is linear based technique and it can be used for small samples (Gardener et al, 2011). The method can be output oriented (maximizing outputs) or input oriented (minimizing costs).

Table 2. Articles that used DEA method

No	Author	Methods	Year
1	Batir et al.	DEA-Tobit Regression	2017
2	Fukuyama & Matousek	DEA	2017
3	Belanes et al.	DEA	2015
4	Johnes et al.	DEA	2014
5	Fujii et al.	DEA	2014
6	Wang et al.	DEA	2014
7	Ismail et al.	DEA-Tobit Regression	2013
8	Perera & Skully	DEA-SFA	2012
9	Titko & Jureviciene	DEA	2013
10	Chao et al.	NDEA (Network DEA)	2015
11	Sufian et al.	DEA-Regression analysis	2016
12	Bayyurt	DEA-TOPSIS-ELECTRE	2013
13	Daly & Frikha	DEA	2015
14	Chotareas et al.	DEA-Truncated Regression	2012

15	Barros et al.	DEA-Inverse B-convexity	2011
16	Assaf et al.	DEA-Truncated Regression	2011
17	Svitalkova	DEA	2014
18	Zimkova	DEA	2014
19	Staub et al.	DEA	2010
20	Ulas&Keskin	DEA	2015
21	Hemmati et al.	DEA-TOPSIS	2013
22	Isik et al.	DEA-SFA	2016
23	Gardener et al.	DEA-Tobit Regression	2011
24	Kumar & Gulati	DEA	2009
25	Andries	DEA-SFA-Malmquist Index	2011
26	Paradi et al.	DEA- Slacks based measure	2011
27	Chen et al.	Fuzzy DEA	2013
28	Yılmaz & Güneş	DEA	2015
29	Ivan	DEA-SFA	2015
30	Repkova	DEA	2014
31	Marie et al.	DEA	2013
32	Sufian and Kamarudin	DEA-Malmquist Index	2014

Source: Own elaborations

d. AHP-ANP Method

In the literature, in order to evaluate the financial performance of the banking sector, many authors have used multi-criteria decision making techniques. One of the most preferred MCDM tools in measuring bank performance is AHP (analytic hierarchy process) which was first introduced by Saaty in 1980. Stankeviciė (2012), Önder et al.(2013), Dinçer and Hacıođlu (2013), Wu et al.(2009), Mandic et al.(2014), Seçme et al.(2009), Amile et al.(2012), Akkoç and Vatansever (2013), Özbek (2015) and Shaverdi et al. (2011) used AHP method generally with TOPSIS in their studies. A special form of AHP, analytic network process (ANP) was applied by Dinçer et al. in 2016 as a combined method with BSC (balanced scorecard approach).

e. TOPSIS Method

Another MCDM method in bank performance is TOPSIS method which assumes that the chosen alternative should have the farthest from the negative ideal solution and the shortest distance from the positive ideal solution. The ideal solution is the one that maximizes the benefit and also minimizes the total cost. Wanke et al.(2016a, 2016b, 2016c, 2017a & 2017b), Önder et al. (2013), Bayyurt (2013), Wu et al. (2009), Mandic et al. (2014), Seçme et al. (2009), Hemmati et al.(2013), Amile et al. (2012), Akkoç and Vatansever (2013), Hemmati (2013) and Shaverdi et al. (2011) were the authors who analyzed the performance through TOPSIS technique.

There are also other methods in literature. Such as one of the MCDM tools for ranking banks according to their performance is the PROMETHEE (Doumpos & Zopounidis (2010), Kosmidou and Zopounidis (2008) and Dash (2017). VIKOR was another technique used by Dinçer & Hacıođlu (2013), Wu et al. (2009 & 2017) and Shaverdi et al. (2011).

Although the information in performance analysis should be precise, certain and exhaustive, in real life, it is sometimes necessary to use information which does not have those characteristics and hence there is a need to face the uncertainty of a stochastic and/or fuzzy nature. A fuzzy assessment in the decision making process is very useful for the purpose of

compensating these shortcomings. Dinçer and Hacıoğlu (2013), Wanke et al. (2017b), Mandić et al. (2014), Seçme et al. (2009), Chen et al. (2013), Amile et al. (2012), Akkoç and Vatansever (2013) and Shaverdi et al. (2011) used fuzzy methods for the reasons mentioned above.

4. Results and Conclusion

It is determined that there are 24 study including the ownership nature of banks. The comparisons are generally between foreign, domestic, private and state banks. As a result, 8 of 24 articles concluded that foreign banks are more efficient compared to domestic ones. The findings of 5 articles conflicted with these results, stated that domestic banks are more efficient. The other 5 studies either determined no significance difference based on ownership or detected conditional differences. Among domestic banks, private banks are chosen as the banks with the higher performance levels comparing to state banks in the 7 studies. The 6 studies found that private and state banks were equal in performance. There was only one article finding state banks more efficient than private banks within the domestic sector.

Comparing to Islamic banks with conditional ones, 5 of 13 studies stated that Islamic banks are more efficient while 2 of them argued the opposite. One study comparing foreign and Islamic banking found the foreign banks more efficient which is coincident with the ownership results above.

It can be understood that evaluation techniques in bank performance and efficiency has significantly changed in the last decade and usage of MCDM methods in this area have been increasing. It is hoped that this survey can be used by managers and academics as a foundation of further studies and help practitioners to make better decisions with the help of these techniques.

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