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BANK TECHNICAL EFFICIENCY OF COUNTRY GROUPS: A META-REGRESSION ANALYSIS

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ABSTRACT

Purpose- This study endeavors to examine studies using Data Envelopment Analysis in calculating the banking sector efficiency across country groups and to determine the factors affecting their technical efficiency through meta-regression analysis.
Methodology- As of November 22, 2023, relevant works were systematically reviewed using Web of Science, Scopus, and Google Scholar. The literature review employed a comprehensive search encompassing all files with the keywords such as ‘’technical efficiency (All Field) AND bank (All Field)’’. The research process adhered to the PRISMA guidelines. This study reviewed all studies published between 1932 and 2023 identifying 64599 studies in the initial scan by the author. The author independently scrutinized the titles, abstracts, keywords, text, and references of all manuscripts to mitigate selection bias and reveal whether eligibility criteria were met. Exclusions from the scope encompassed duplicate downloads, papers, books and book chapters, together with studies having low quality scores, no full-text versions, and those that are irrelevant to the subject.
Findings- The results of meta-regression analysis revealed that the data collection year of the studies and the income groups of the countries did not have an impact on the mean technical efficiency. The number of banks, number of observations, publication year, and number of countries were statistically significant on the mean technical efficiency estimate.
Conclusion- The study further standardized variables and methodological assumptions used in bank sector efficiency studies within country groups through meta-regression analysis. Empirical findings in the literature were combined. This study enhances accessibility to the existing body of knowledge for researchers in the field

Keywords: Banks, technical efficiency, Data Envelopment Analysis, Tobit Analysis, Meta-Regression Analysis
JEL Codes: C01, D24, M10

1. INTRODUCTION

The banking system fosters economic growth by allocating savings to competitive firms, entrepreneurs, individuals and states, and thereby enhancing capital accumulation and profitability (Bumann et al. 2013; Pagano 1993; Rajan and Zingales 1998; Ho et al., 2021). The evaluation of efficiency measurement in the banking sector has become a focal point of research, given to its significant effects on both microeconomic and macroeconomic development within the economy (Aiello and Bonanno 2016; Iršová and Havránek 2010; Ho et al., 2021).

Efficiency was first defined in a study by Farrell (1957). According to Farrell (1957), efficiency is a measure of the ratio of weighted outputs to inputs. Decision-making units use similar inputs to produce similar outputs. Thanassoulis (2001) aimed at transforming inputs into outputs for each decision unit. A technically efficient business can produce more output than others with similar inputs (Cherchye and Abeele, 2005; Attah-Kyei et al., 2023). A technically efficient insurance company operates above the efficient production frontier (Farrell, 1957).

Bank efficiency studies commonly employ two methods. These are DEA, a non-parametric method (Horvat et al., 2023; Milenković et al., 2022; Cvetkoska et al., 2021) and SSA, a parametric method (Ben Mohamed et al., 2021; Sharma et al., 2020; Nguyen & Vo, 2020; Koutsomanoli-Filippaki et al., 2009). Meta-regression analysis (MRA) serves as a statistical tool that investigates the relationship between the key findings of studies and notable characteristics such as sample and year of data collection (Glass 1976; Glass et al. 1981; Stanley and Jarrell 1989). MRA synthesizes different studies into a unified model. It evaluates the impact of certain aspects of the studies on the results. MRA finds application in economics (Chaffai, 2022; Aiello and Bonanno, 2019; Fall et al., 2018), education (Villano and Tran, 2021; Mikušová, 2020), agriculture (Paz et al., 2023, Nguyen-Anh et al., 2022; Trong Ho et al., 2022), environment (Hübner et al., 2021; Zangeneh et al., 2021; Nyathikala & Kulshrestha, 2020).

This study aims at examining studies using the DEA method in measuring the efficiency of banks within country groups and determining the factors affecting bank sector efficiency scores in country groups through meta-regression analysis. The study also strives to enhance accessibility to the literature to researchers who will use the DEA method in measuring the efficiency of banking sector and to determine the variables affecting efficiency. The risk of bias and limitation inherent in a single study calculating bank sector efficiency with DEA were eliminated through a meta-regression analysis. This study is expected to contribute to the literature by providing an effective overview with effective, valid and reliable parameter estimates for future studies utilizing DEA for efficiency assessment in bank sectors (Moher et al., 2009; Kaya & Algın, 2022).

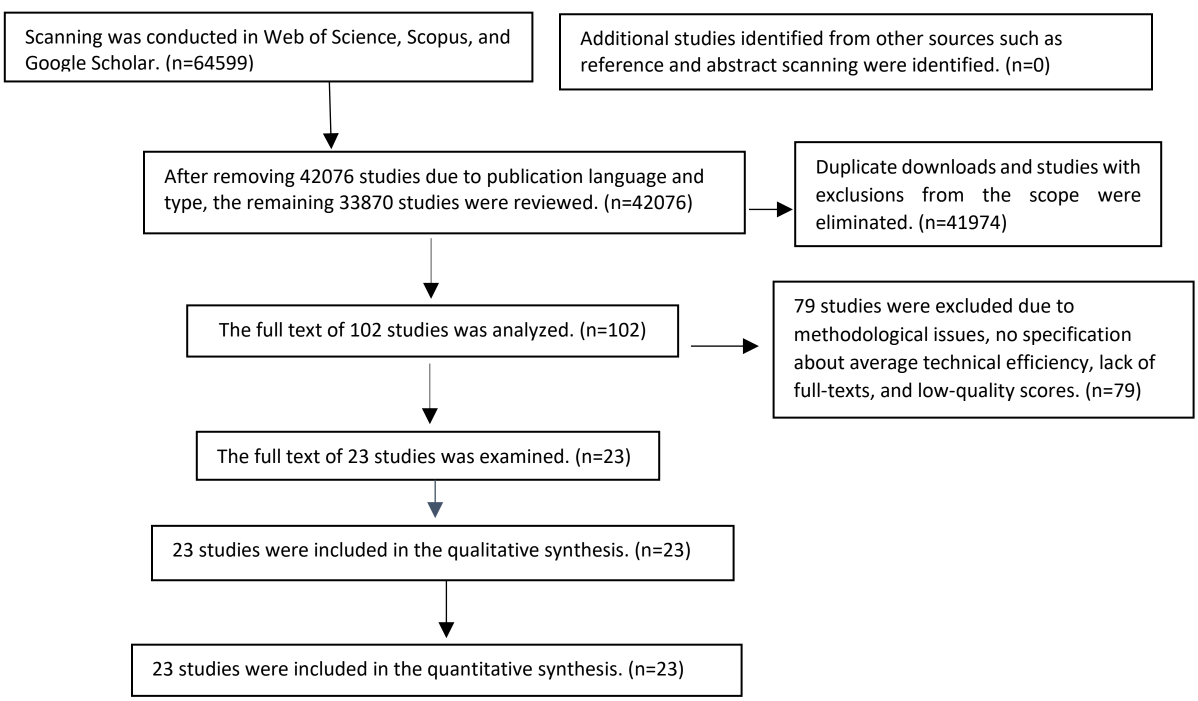
2. DATA AND METHODOLOGY

On November 22, 2023, relevant works were systematically reviewed using Web of Science, Scopus, and Google Scholar. The literature review employed a comprehensive search encompassing all files with the keywords such as ‘‘technical efficiency (All Field) AND bank (All Field)’’. The research process adhered to the PRISMA guidelines (Moher et al., 2009).

2.1. Selection of Studies

This study reviewed all studies published between 1932 and 2023 identifying 64599 studies in the initial scan by the author. The author independently scrutinized the titles, abstracts, keywords, text, and references of all manuscripts to mitigate selection bias and reveal whether eligibility criteria were met. Exclusions from the scope encompassed duplicate downloads, papers, books and book chapters, together with studies having low quality scores, no full-text versions, and those that are irrelevant to the subject. Figure 1 displays the selection process of studies.

Figure 1: Flow Diagram of the Study



Source: Moher et al., 2009; Kaya & Algın, 2022.

The author carried out a thorough review of all studies. After eliminating duplicate and irrelevant studies, 102 studies were chosen for full-text review. Studies with methodological issues and those possessing low quality scores and no specified mean technical efficiency were excluded during the full text review.

A 14-question quality checklist covering reporting, external validity, bias and power dimensions was deployed for calculating the quality score of the studies (Downs & Black, 1998; Varabyova & Müller, 2016). Each question in the checklist received a quality score (Table 1), with 1 point for meeting the criteria and 0 point for not meeting it(Table 2).

Table 1: Quality Checklist of Studies

Item	**Scoring** **yes (1)** **no/unclear (0)** **Not Applicable (N/A)**
Reporting	
1. Is the hypothesis/objective of the study clearly described?	23/23
2. Is the underlying economic theory of production/cost properly described? (e.g., is the economic justification for selecting input- vs. output orientation given?)	23/23
3. Are the input and output variables clearly defined and their inclusion justified?	23/23
4. Are the main findings of the study clearly presented with reference to study objectives?	23/23
5. Are the study limitations discussed (e.g., omitted variables)?	7/23
External validity	
6. Is the sample inclusive enough (appropriate benchmark)?	23/23
7. Is the assumption of a common technology addressed/tested (e.g., developing and developed countries analyzed together)?	23/23
Bias	
8. Are the data accurate enough to answer the questions, particularly the output data (only quantity or also quality output measures)?	23/23
9. Are the techniques (parametric, nonparametric or both) used to assess the main outcomes appropriate?	23/23
10. Has the dataset been examined for the presence of outliers?	1/23
11. Is the problem of convergence due to dimensionality properly addressed?	1/23
12. If the second-stage analysis is undertaken,are any statistical problems accounted for?	0/8 15 N/A
Power	
13. Have the sensitivity analyses been conducted?	2/23
14. Are the confidence intervals for efficiency estimates generated?	3/23

An overall quality score for the study was calculated by adding up the scores of all questions. 23 studies with a total quality score of 8 and above were selected for analysis (Table2).

Table 2: Quality Assessment Results

No	Author(s)	Reporting					External Validity		Bias					Power		Total Score
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	
1	(Horvat et al., 2023)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	9/14 =0.64
2	(Ul Hassan Shah, 2022)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	9/14 =0.64
3	(Milenković et al., 2022)	1	1	1	1	1	1	1	1	1	0	0	1	0	1	11/14=0.79
4	(Cvetkoska et al., 2021)	1	1	1	1	0	1	1	1	1	1	0	0	0	0	9/14 =0.64
5	(Christopoulos et al., 2020)	1	1	1	1	0	1	1	1	1	0	0	1	0	1	10/16=0.71
6	(Banna et al., 2019)	1	1	1	1	1	1	1	1	1	0	0	1	0	1	11/14=0.79
7	(Fujii et al., 2018)	1	1	1	1	0	1	1	1	1	0	1	0	0	0	9/14 =0.64
8	(Loong et al., 2017)	1	1	1	1	0	1	1	1	1	0	0	1	1	1	11/14=0.79
9	(Kamarudin et al., 2017)	1	1	1	1	1	1	1	1	1	0	0	0	0	1	10/16=0.71
10	(Doumpos et al., 2017)	1	1	1	1	1	1	1	1	1	0	0	0	0	1	10/16=0.71
11	(Balcerzak et al., 2017)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	9/14 =0.64
12	(Wong & Deng, 2016)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	9/14 =0.64
13	(Kamarudin et al., 2015)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	9/14 =0.64
14	(Rosman et al., 2014)	1	1	1	1	1	1	1	1	1	0	0	1	0	1	11/14=0.79
15	(Mobarek & Kalonov, 2014)	1	1	1	1	1	1	1	1	1	0	0	0	0	1	10/16=0.71
16	(Maghyereh & Awartani, 2014)	1	1	1	1	1	1	1	1	1	0	0	1	0	1	11/14=0.79
17	(Aghimien et al., 2014)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	9/14=0.64
18	(Johnes, et al.,2014)	1	1	1	1	1	1	1	1	1	0	0	0	0	1	10/16=0.71
19	(Rahim et al., 2013)	1	1	1	1	0	1	1	1	1	0	0	1	0	0	9/14 =0.64
20	(Abu-Alkheil et al., 2012)	1	1	1	1	1	1	1	1	1	0	0	1	0	0	10/16=0.71
21	(Mostafa, 2011)	1	1	1	1	1	1	1	1	1	1	0	0	1	0	11/14=0.79

22	(Sufian et al., 2008)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	9/14 =0.64
23	(Al-Muharrami, 2008)	1	1	1	1	0	1	1	1	1	0	0	0	0	0	8/14=0.57

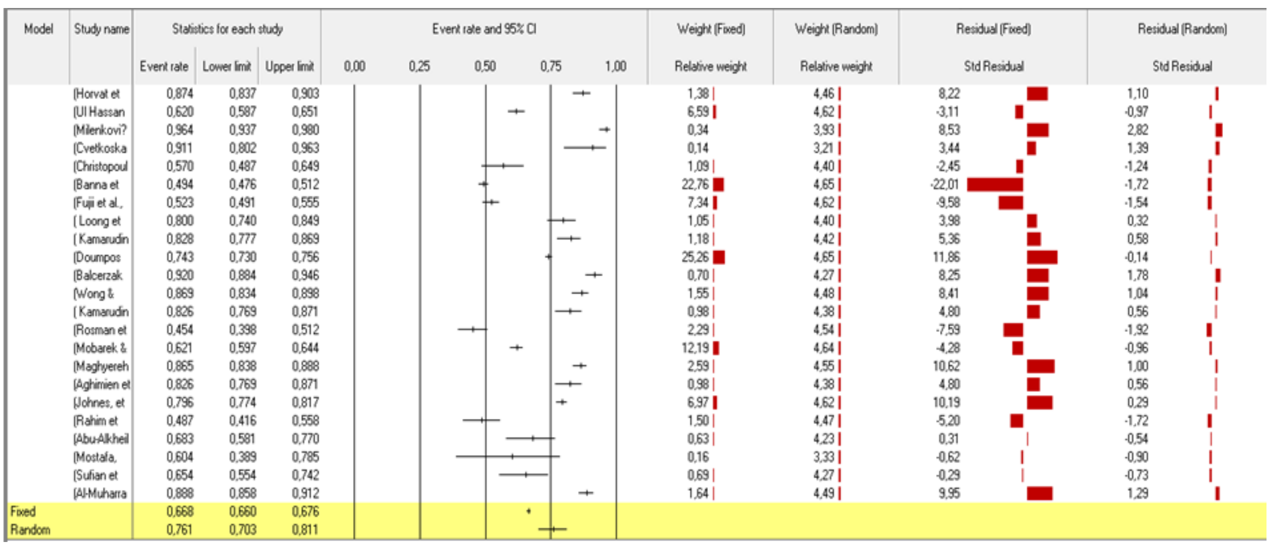
Note: 1=Yes, 0=No/Unspecified, N/A=Inapplicable

2.2. Data Analysis

The number of observations, number of variables, publication year, number of countries, country group, number of data collection year, mean technical efficiency score, software used, and quality score data were collected for each study. 21.73% of the studies using DEA in measuring bank technical efficiency in country groups were conducted in the Gulf Cooperation Council (GCC) countries. The studies in the pool of meta-regression analysis deployed R, Stata, DEAP, Dea Excel Solver, Dea-Max, MaxDEA, Frontier Analyst software to calculate bank technical efficiencies in country groups. Appendix1 shows the key features of the studies examined.

The data analysis encompassed two stages. Initially, analysis was conducted through the Random Effect Model (Table3). The mean effect size is 0.761 (95% CI: 0.703 to 0.811). Heterogeneity across studies was measured with the Q statistic (Q=1360,668 sd=22 p< 0.001).

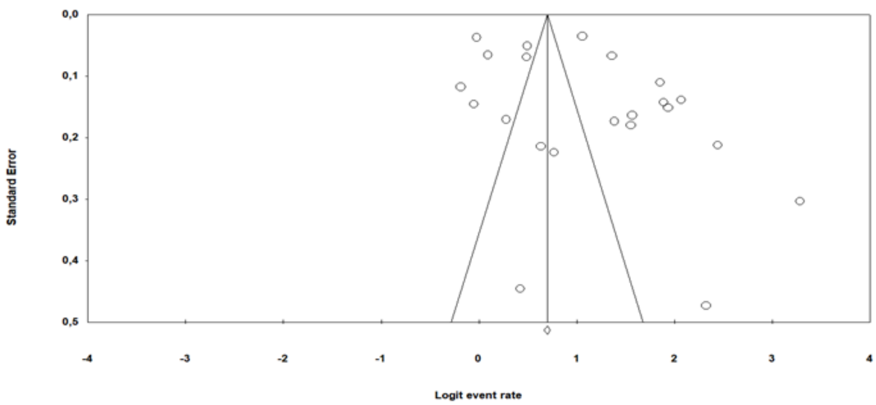
Table 3: Meta-Analysis Results of Studies



Model	Study name	Event rate	Lower limit	Upper limit	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	(Horvat et	0,874	0,837	0,903	1,38	4,46	8,22	1,10
	(Ul Hassan	0,620	0,587	0,651	6,59	4,62	-3,11	-0,97
	(Milenkovi?	0,964	0,937	0,980	0,34	3,93	8,53	2,82
	(Cvetkoska	0,911	0,802	0,963	0,14	3,21	3,44	1,39
	(Christopoul	0,570	0,487	0,649	1,09	4,40	-2,45	-1,24
	(Banna et	0,494	0,476	0,512	22,76	4,65	-22,01	-1,72
	(Fuji et al.,	0,523	0,491	0,555	7,34	4,62	-9,58	-1,54
	(Loong et	0,800	0,740	0,849	1,05	4,40	3,98	0,32
	(Kamarudin	0,828	0,777	0,869	1,18	4,42	5,36	0,58
	(Doumpos	0,743	0,730	0,756	25,26	4,65	11,86	-0,14
	(Balcerzak	0,920	0,884	0,946	0,70	4,27	8,25	1,78
	(Wong &	0,869	0,834	0,898	1,55	4,48	8,41	1,04
	(Kamarudin	0,826	0,769	0,871	0,98	4,38	4,80	0,56
	(Rosman et	0,454	0,398	0,512	2,29	4,54	-7,59	-1,92
	(Mobarek &	0,621	0,597	0,644	12,19	4,64	-4,28	-0,96
	(Maghyereh	0,865	0,838	0,888	2,59	4,55	10,62	1,00
	(Aghimien et	0,826	0,769	0,871	0,98	4,38	4,80	0,56
	(Johnes, et	0,796	0,774	0,817	6,97	4,62	10,19	0,29
	(Rahim et	0,487	0,416	0,558	1,50	4,47	-5,20	-1,72
	(Abu-Alkheil	0,683	0,581	0,770	0,63	4,23	0,31	-0,54
	(Mostafa,	0,604	0,389	0,785	0,16	3,33	-0,62	-0,90
	(Sufian et	0,654	0,554	0,742	0,69	4,27	-0,29	-0,73
	(Al-Muharra	0,888	0,858	0,912	1,64	4,49	9,95	1,29
Fixed		0,668	0,660	0,676				
Random		0,761	0,703	0,811				

Publication bias was demonstrated by funnel plot and Egger's regression test (t=2,10760 df=21 p<0.05) (Figure 2).

Figure 2: Publication Bias of Studies



A meta-regression analysis was conducted to evaluate the estimate of mean technical efficiencies derived from the complied data. In the second stage, the Tobit model employed the mean technical efficiency as the dependent variable. Explanatory variables included the number of observations, the number of variables, the year of data collection, and the number of countries, all guided by relevant literature and model features. Besides, dummy variables such as the country group of the sample and the year of publication were incorporated into the model. The study serves under the key assumption that the reported functional form of technical efficiency scores in the literature can be explained by the characteristics of the studies, including the number of samples, the number of variables in the model and country groups. To explore this, the following 7 models are estimated (Table 4).

Model 1: $MTE = \alpha_0+\beta_1 V_i+\beta_2 O_i+\varepsilon_i$ (1)

Model 2: $MTE = \alpha_0+\beta_1 V_i+\beta_2 O_i+ \beta_3 P_i +\varepsilon_i$ (2)

Model 3: $MTE= \alpha_0+\beta_1 V_i+\beta_2 O_i+ \beta_3 P_i + \beta_4 C_i+\varepsilon_i$ (3)

Model 4: $MTE= \alpha_0+\beta_1 V_i+\beta_2 O_i+ \beta_3 C_i + \beta_4 GC_i +\varepsilon_i$ (4)

Model 5: $MTE= \alpha_0+\beta_1 V_i+\beta_2 O_i+ \beta_3 P_i + \beta_4 C_i + \beta_5 D_i+\varepsilon_i$ (5)

Model 6: $MTE= \alpha_0+\beta_1 V_i+\beta_2 O_i+ \beta_3 P_i + \beta_4 C_i + \beta_5 GC_i+\varepsilon_i$ (6)

Model 7: $MTE= \alpha_0+\beta_1 V_i+\beta_2 O_i+ \beta_3 P_i + \beta_4 C_i + \beta_5 GC_i+ \beta_6 D_i+\varepsilon_i$ (7)

The following variables were used in the proposed model:
MTE: Mean technical efficiency
V: Number of variables
O: Number of observation
P: Year of publication
C: Number of countries
GC: Country group
D: Data collection year

Table 4: Tobit Analysis Results on Technical Efficiency

Variable	Model1		Model2		Model3		Model4	
	Tobit (S.E)	p	Tobit (S.E)	p	Tobit (S.E)	p	Tobit (S.E)	p
Constant	0.642883 (0.067479)	0.000***	0.489336 (0.086606)	0.000***	0.615679 (0.088555)	0.000***	0.0735405 (0.064621)	0.000***
V	0.027415 (0.014168)	0.053	0.036268 (0.013110)	0.005**	0.035763 (0.011409)	0.001**	0.028652 (0.012039)	0.017*
O	-0.000113 (0.0000525)	0.030**	-0.000159 (0.0000500)	0.001**	-0.000159 (0.0000435)	0.000***	-0.000123 (0.0000453)	0.006**

P			0.169066 (0.068725)	0.013*	0.119375 (0.062533)	0.056		
C					-0.008457 (0.003113)	0.006**	-0.010021 (0.003205)	0.001**
CG							0.031399 (0.061917)	0.612
D								
Log-likelihood	12.43566		15.12192		18.32193		16.75841	
Regression S.E	0.155137		0.141727		0.126894		0.135820	
Variable	**Model5**		**Model6**		**Model7**			
	Tobit (S.E)	**p**	**Tobit (S.E)**	**p**	**Tobit (S.E)**	**p**		
Constant	0.654106 (0.101500)	0.0000***	0.595774 (0.089641)	0.0000***	0.635024 (0.101568)	0.0000***		
V	0.036702 (0.011343)	0.0012**	0.034088 (0.011353)	0.0027**	0.035021 (0.011266)	0.0019**		
O	-0.000150 (0.0000447)	0.0008***	-0.000151 (0.0000438)	0.0006***	-0.000141 (0.0000449)	0.0017**		
P	0.122930 (0.061971)	0.0473**	0.129693 (0.062440)	0.0378**	0.133596 (0.061817)	0.0307*		
C	-0.009343 (0.003297)	0.0046**	-0.008013 (0.003096)	0.0096**	-0.008918 (0.003265)	0.0063**		
CG			0.053004 (0.057762)	0.3588	0.054190 (0.057020)	0.3419		
D	0.006759 (0.009047)	0.4550			-0.006982 (0.008878)	0.4316		
Log-likelihood	18.59763		18.73543		19.04058			
Regression S.E	0.129241		0.128469		0.130933			

As in Table 2, the models were estimated using the Tobit method given that the technical efficiency scores of Models 1, 2 and 3 are limited between 0 and 1 (Kaya & Algın, 2022; Bravo-Ureta et al., 2007; Greene, 1991). Considering the data used in the analysis, Tobit is considered as the most methodologically appropriate. Year of publication, number of countries, country group, data collection year were omitted in Model 1. Similarly, Model 2 excluded the number of countries, country group and data collection year; whereas Model 3 ignored country group and data collection year. Moreover, Model 4 did not include publication year and data collection. Moving on to Model 5, the variables of collection year and country group were disregarded, and data collection year was excluded in Model 6. Notably, all variables were encompassed in Model 7, reflecting a comprehensive consideration of their effects.

Most of the variables in the models were significant at least at 5% level. Across all models, variables associated with the data collection year and country groups showed no significant impact on the mean technical efficiency estimate. The number of variables in Model 1, year of publication in Model 3, country group in Model 4, year of data collection in Model 5, and country group in both Models 6 and 7 demonstrated no statistical significance. Notably, most variables in the models exhibited significance at a minimum level of 5%. Conversely, the data collection year and country group variables consistently lacked significant influence on the mean technical efficiency estimate across all models. The number of variables and the number of observations maintained statistical significance in each model.

3. CONCLUSION

The trend towards measuring technical efficiency in banks' country groups has increased since 2008. The study analyzed 23 empirical articles published between 1932 and 2023 employing DEA in calculating the bank efficiency within country groups that adhere to the predefined inclusion criteria. A meta-regression analysis was used to discern the variables affecting mean technical efficiencies across the reviewed articles. This study aims at evaluating the studies that calculate the bank efficiency of country groups with DEA using the meta-analysis method. All studies related to the subject in the literature were reviewed. 73.91% of the sample of studies using DEA in bank efficiency focused on Asian country groups. Western Balkan countries, including Serbia, Bosnia and Herzegovina, Montenegro, North Macedonia and Armenia, possessed the highest mean technical efficiency. The study revealed significant negative associations between mean technical efficiency scores and the number of banks and number of countries, while positive and significant correlations were observed with the number of variables and the year of publication. Importantly, the articles analyzed tended to overlook variations in sample sizes over the years and disparities in economic levels and political structures among countries within the same group. There is no such a meta-analysis study specifically published on bank efficiency in country groups. In this study, variables and methodological assumptions used in bank sector efficiency studies in country groups were standardized through meta-regression analysis. Empirical findings in the relevant literature were combined. The literature was made accessible to researchers.

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Appendix 1: Studies Examined in Meta Regression Analysis

Author(s)	Region	Method	Publication Period	Sample Size	MTE	Software
(Horvat et al., 2023)	West Balkan Countries	DEA	2015-2019 (t=5)	395	0.874	x
(Ul Hassan Shah, 2022)	South Asia Countries	Meta-Frontier DEA	2013-2018 (t=6)	882	0.620	DEA-Max
(Milenković et al., 2022)	West Balkan Countries	DEA, Tobit Analysis	2015-2019 (t=5)	312	0.964	DEAMax
(Cvetkoska et al., 2021)	Developing Countries EU	DEA	2015-2019 (t=5)	55	0.911	MaxDEA 8, Excel
(Christopoulos et al., 2020)	PIIGS Countries	DEA, MPI, Truncated Regression Analysis	2009-2015 (t=7)	140	0.570	x
(Banna et al., 2019)	Sino-ASEAN (Association of Southeast Asian Nations) Countries	DEA, Tobit Analysis	2000-2013 (t=4)	2870	0.494	DEAP 2.1, STATA15
(Fujii et al., 2018)	EU Countries	DEA	2005-2014 (t=10)	927	0.523	x
(Loong et al., 2017)	Neighboring Countries – (Malaysia, Indonesia and	DEA, OLS Regression Analysis	2006-2014 (t=9)	207	0.800	x
(Kamarudin et al., 2017)	Southeast Asian Countries	DEA	2006-2014 (t=9)	261	0.828	x
(Doumpos et al., 2017)	Organisation of Islamic Cooperation Countries	DEA, SFA	2000-2011 (t=12)	4170	0.743	x
(Balcerzak et al., 2017)	EU Countries	DEA, MPI	2014-2015 (t=10)	302	0.920	x
(Wong & Deng, 2016)	ASEAN (Association of Southeast Asian Nations) Countries	DEA	2000-2010 (t=11)	429	0.869	x
(Kamarudin et al., 2015)	GCC (Gulf Cooperation Council Countries)	DEA	2007-2011 (t=5)	215	0.826	DEAP 2.1
(Rosman et al., 2014)	Middle Eastern and Asian Countries	DEA, Tobit Analysis	2007-2010 (t=4)	291	0.454	x

(Mobarek & Kalonov, 2014)	OIC	DEA, SFA	2004-2006 / 2007-2009 (t=4)	1632	0.621	R
(Maghyereh & Awartani, 2014)	GCC	DEA, Truncated Regression Analysis	2000-2009 (t=10)	700	0.865	x
(Aghimien et al., 2014)	GCC	DEA	2007-2011 (t=5)	215	0.826	DEAP 2.1
(Johnes, et al.,2014)	Islamic and Conventional Bank (18 Country)	DEA	2004–2009 (t=6)	1353	0.796	x
(Rahim et al., 2013)	MENA and Asian Countries	DEA, OLS Regression Analysis	2006-2009 (t=4)	189	0.487	STATA 10
(Abu-Alkheil et al., 2012)	Europe and Muslim-Majority Countries Countries	DEA, MPI, OLS Regression Analysis	2005-2008 (t=4)	92	0.683	DEAP 2.1
(Mostafa, 2011)	GCC	DEA	2009 (t=1)	21	0.604	Frontier Analyst DEA 3.0
(Sufian et al., 2008)	MENA and Asian Countries	DEA	2001-2006 (t=6)	96	0.654	DEAP 2.1
(Al-Muharrami, 2008)	GCC	DEA	1993-2002 (t=10)	520	0.888	DEA Excel Solver