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The Cost Efficiency and Competition Relationship: Evidence from Saudi Arabian Banks and Non-Structural Approaches to Analysis

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Abstract: Over the last two decades, the regulators of the financial services sector in Saudi Arabia have aimed to develop a level of fair competition in the provision of banking services across the country. This paper utilizes non-structural approaches, the H-statistic developed by, and the Granger causality test. The second approach involves determining the Granger-based causal relationship between banks' cost efficiency and competition via data envelope analysis (DEA) using the generalized method of moments (GMM) panel. The study's data were drawn from 11 traditional banks in Saudi Arabia, covering the period from 2015 to 2021 (yearly data). The results of the non-structural approach, i.e., the H-statistic, demonstrate that the average fund rate had a positive effect on competition; however, the physical capital price index, the index of leverage, and the credit risk negatively affect the total revenue. Furthermore, a positive H-statistic value reflects the positive causality between competition and cost efficiency (higher efficiency results in a higher level of competition). The DEA results indicate that competition in the year 2021 was influenced by the competition level of the previous year (2020); moreover, the relationship between the previous year's cost efficiency Granger value, the greater availability, and the lower prices of banking products had a significant influence on the competition in the years under consideration (since a positive significant result from the test is available), which reflects the higher level of market structure and the greater availability and lower prices of banking products. Cost efficiency in the year 2021 was also positively influenced by the cost efficiency level of the previous year (2020), with competition forcing efficiency via the cutting of costs.

Keywords: concentration ratio; monopolistic competition; cost efficiency; banking sector in Saudi Arabia

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1. Introduction

In some countries, central banks oversee the regulation of the banking sector, which involves raising entry requirements, such as higher solvency levels and a certain level of national employment. The combined effect of these regulations results in monopolistic competition. In contrast, other bank managers follow modern strategies that involve reducing costs and striving for cost effectiveness, with the aim of improving the stability and safety of banks.

Therefore, the relationship between banks' cost efficiency and competition exhibits mixed evidence in the literature, as, in some cases, banks' regulators deregulate and liberalize banks, with the result of reduced cost inefficiency (Wahyudi et al. 2021; Apergis and Polemis 2016). During the financial crisis of 2008, the relationship between efficiency and competition became more complex (Apergis and Polemis 2016). Other studies have suggested an association between efficiency and monopolistic competition in the banking

industry based on the assumption that competition falls in the range of monopolistic competition (Mkrtchyan 2005; Mlambo and Ncube 2011).

Generally, in the literature, there is no focus on the degree of competition when assessing the correlative relationship between competition and cost efficiency; furthermore, the empirical evidence suggests that there is an ambiguous relationship. It is important to determine whether competition and cost efficiency have a positive relationship if the market is under monopolistic competition or regulations, especially in countries that are making stronger efforts to create a stable financial environment.

Saudi Arabia is one such country; over the past two decades, the regulators of the Saudi financial services sector have aimed to develop a level of fair competition in the provision of banking services across the country. Economic reform plays a vital role in implementing the regulation of development and attempting to determine cost-efficiency requirements.

With the aim of investigating this phenomenon, this article focuses on the Saudi banking sector for four important reasons. First, Saudi national banks have encountered major acquisition cases that have changed the degree of competition. Second, across the literature, there is a lack of studies discussing the Saudi Banking sector's performance, concentration, and the causal relationship between cost efficiency and competition. Third, it is important to study the causal relationship between competition and cost efficiency, as financial technology has changed the concept of efficiency and contributed to reducing service costs in the banking sector. Fourth, there is a need for policymakers to review the impact of economic reform and provide detailed feedback on how reform has influenced the banking sector's competition and efficiency. In 2018, Saudi Arabia British Bank (SABB) and Alawwal Bank announced a merger agreement, which was completed in March 2020. In the same year, the biggest lender, the National Commercial Bank, entered into a merger agreement with a smaller lender bank, Samba Financial Group. Mergers and acquisitions may have a major effect on competition, as stated by (Deltuvaitė and Vilda 2007). Therefore, the core aim of this study is to measure the level of competition in the banking sector in Saudi Arabia using the Panzar–Rosse method and the H-statistic test, as well as measuring efficiency using the DEA or Granger causality test.

For cost efficiency, the most appropriate definition must include the following: fixed assets as a proxy for physical capital, personnel expenses as a proxy for labor, and deposits as a proxy for financial capital. These components determine the cost efficiency. Policymakers in central banks need to explore the existing regulations and determine the threshold of cost efficiency components depending on the bank's size (market share) and the overall market size.

The relationship between competition and cost efficiency is under-explored by economists. This article contributes to the literature and seeks to bridge a gap in the academic research, as it assesses the causality between cost efficiency and competition in a highly concentrated market.

Using non-structural approaches is considered an appropriate method for studying the causality between cost efficiency and competition, which suggests that increasing competition affects efficiency by cutting costs. Empirically, this paper utilizes the H-statistic, which is designed to measure the degree of competition, drawing upon extensive data from Saudi banks for the period 2015–2021; meanwhile, for causality, the Granger causality test is utilized to determine the causal relationship between banks' cost efficiency and competition. This is because financial technology has changed the concept of efficiency and contributed to reducing the cost of services in the financial sector. The findings show that the Saudi banking industry is capable of providing services at the minimum level of cost, which reflects its power. The empirical results of this research are discussed in detail in the discussion sections.

Therefore, an awareness of the importance of banks' competition, economic authorities, and banks' regulators are required to implement further laws, enhance market regulations, reduce barriers to entry, and define the cost efficacy framework. This study will shed light

on the importance of regulators and policymakers devising a definition of efficiency, while only a few studies have considered studying such a relation.

The remaining sections of the article are organized as follows: Section 2 presents the literature review, which enables us to compare the nature of competition in the banking sector, measure the level of competition, and compare this competitive landscape with the cost efficiency level. Section 3 provides detailed explanations of the methodologies and empirical results. Section 4 discusses the data. Section 5 provides the descriptive statistics. Finally, Section 6 discusses the conclusion and links the findings to the most appropriate recommendations and policies.

2. Literature Review

This section presents past studies that have covered multiple regions and highlights the appropriate methodology and results. The purpose is to determine the range of competition within a group of countries, the causality between competition and cost efficiency in the banking sector, and the methodology used. This section further discusses the variables used to calculate the degree of competition in detail (specifically the variables that affect total revenue) and the use of the causality test. Many papers have analyzed and assessed the extent of competition in the case of EU countries, the Middle East, North Africa (MENA), and the South Asian banking sector. However, the focus in this review is shifted to assessing the degree of competition within multiple regions and to ascertain the non-structural approach used.

Table 1 summarizes the most commonly cited papers that assess competition and efficiency in the banking sector. Panzar and Rosse (1987), for example, assessed the degree of competition and found that competition policies in the financial sector are complicated and that more efficient banking systems are more competitive. Casu and Girardone (2009) used the general approach of a causality test, using data from EU banks, with their results indicating a positive causality from efficiency to competition. Panzar and Rosse (1987) used the H-statistic as a competition indicator; this is a non-structural approach and an effective method for determining the degree of competition. However, it is also very interesting to apply the H-statistic approach in the case of one country, as it is one of the most appropriate theoretical approaches available to assess the degree of competition in the banking industry.

Table 1. Competition assessment studies.

Author/s	Data Span	Country	Method	Findings
Claessens and Laeven (2004)	1994–2001	50 countries	Panzar and Rosse (1987)	Competition policies in the financial sector are complicated.
Casu and Girardone (2006)	1997–2003	EU banking market	Panzar and Rosse statistics and Concentration Ratio	More efficient banking systems are more competitive.
Mkrtchyan (2005)	1998–2002	United States	Panzar and Rosse (1987)	US banks are characterized as monopolistically competitive.
Casu and Girardone (2009)	2009	EU Countries	Granger-type causality test	The causality from efficiency to competition is positive. However, the causality is weak, while positive and strong causality exists between market power and efficiency.

Various studies have utilized the Panzar–Rosse H-statistic and concluded that the banking sector is in the range of monopolistic competition (Apergis and Polemis 2016; Murjan and Ruza 2002; Mlambo and Ncube 2011; Polemis 2015; Albaity et al. 2019; Mkrtchyan 2005). Therefore, the Panzar–Rosse H-statistic model has been the most commonly used method to measure the degree of competition. This is achieved by using the reduced form of revenue function that measures changes in the elasticity of total revenue

concerning the prices of inputs (Apergis and Polemis 2016). There are several advantages to using this method. Casu and Girardone (2009) tested causality for a group of EU countries using a Granger-type test and found a strong and positive causality between market power and efficiency. This study concluded that an increase in competition would result in greater efficiency in terms of bank performance; nonetheless, increases in efficiency do not necessarily increase competition in the EU banking sector.

Regarding South Asian countries, Nguyen and Nghiem (2020) tested the causality between competition and efficiency and concluded that competition has a positive influence on cost efficiency. In this article, we further review the literature related to each independent variable in the total revenue function on the basis that the total revenue is a proxy for the degree of competition (Apergis and Polemis 2016). The extant literature suggests that banking efficiency is demonstrated via the consideration of various concepts and types, as defined by Alber et al. (2019). These include cost efficiency, scale efficiency, allocative efficiency, and pure technical efficiency. Furthermore, total revenue is defined as a proxy for the level of competition, while cost efficiency is illustrated in detail in the methodology section.

Many studies from an Indian perspective that apply DEA show that banks always have immense scope to enhance technical efficiency in the long term, which is in line with the basis of our paper. Yadav et al. (2022) focused on evaluating banks' efficiency as a driver for financial inclusion and found that public banks are less technically efficient than private-sector banks.

In terms of cost reduction, El Moussawi and Mansour (2022) studied the relationship between cost efficiency and competition in a sample of 222 commercial banks in the MENA region during the period 1999–2018. Based on the generalized method of moments (GMM) system, the results showed that competition positively affects the cost efficiency and stability of the banks.

Wahyudi et al. (2021) applied a quantitative approach, along with a panel regression analysis model, to measure the levels of competition and banking efficiency within Indonesia. The results revealed a negative correlation between competition and bank efficiency because competition motivates banks to concentrate on profits rather than efficiency, engage in riskier financing projects, and undertake high-lending activities. The banking industry in Indonesia tends to be monopolistic; thus, the degree of monopolistic competition encourages banks to prioritize profits and places bank projects at risk. Providing further evidence from Pakistani banks, Sabir and Qayyum (2018) empirically analyzed the extent of competition in the banking sector during the period 1995–2014. Once more employing Panzar and Rosse, the authors found that Pakistani commercial banks generate revenue under the conditions of monopolistic competition. In addition, Apergis and Polemis (2016) provided an empirical assessment of the relationship between competition and efficiency in the banking sector of MENA countries using the data envelope analysis (DEA) methodology alongside bootstrap data envelopment analysis (BDEA); the empirical result indicated that increases in competition are not accompanied by increases in cost efficiency.

Evidence that monopolistic competition prevails in the MENA banking market structure has been produced by Turk-Ariss (2009). In European and U.S. banks, on the other hand, Schaeck and Cihak (2008) provided evidence that efficiency leads to a transition from competition to soundness; efficiency in the U.S. also appears to have been positively affected by competition.

An important study by Günalp and Çelik (2006) employed the Panzar–Rosse H-statistic to evaluate the Turkish banking industry in terms of the competitive environment over the period 1990–2000. The results indicated that bank revenues behaved as if they were earned under monopolistic conditions. Thus, the high level of profitability experienced by Turkish banks does not seem to be an indicator of an increase in monopoly power. Nonetheless, there is evidence that liberalization and deregulation measures have had a beneficial effect on competition. Generally, revenue has been used to provide an empirical

measurement of competition and, in this study, efficiency was measured by examining the causal relationship (between competition and efficiency levels) using the DEA method.

According to Alber et al. (2019), banking efficiency determinants are influenced by measuring outputs from inputs using regulatory and bank variables (e.g., the bank size, assets, capital, and expenses including wages). In this context, the study conducted by Ab Rahim (2016) investigated whether competition fosters efficiency by focusing on technical efficiency measures and testing the relationship between banking competition and efficiency in Malaysian commercial banks. The DEA method was used to assess efficiency performance in the period between 1996 and 2011 and the learner index was used to estimate the degree of banking competition. In addition, as is the case in many other studies on banking efficiency, the use of these methods was followed by an intermediation approach. The study concluded that competition has a positive effect on technical efficiency within the Malaysian banking industry.

Alber et al. (2019) stated that bank-specific factors, such as the bank size, capital adequacy, and expenses including the physical capital price, should be considered as determinants of banking efficiency. In this regard, Sabir and Qayyum (2018) used physical capital and other variables as factor inputs in fixed-effect and random-effect models; they found that the coefficient of the physical capital price had a negative and significant impact on the total revenues of the banking sector in Pakistan over the period from 1995–2014. The physical capital price has also been considered a dependent variable that might impact competition (Apergis and Polemis 2016).

In a review of the impact of regulatory norms, Elfeituri (2022) suggested that banks working in the economies of the MENA region should maintain an adequate capital ratio in order to perform efficiently and avoid risks linked with leverage and their potential financial ramifications. Nevertheless, Sagatbekovich and Nurmakhanova (2021) examined the effects of activity restrictions, reserve requirements, and capital stringencies on the profitability and stability of financial institutions. Seventeen transitional economies covering the years 2008–2019 were employed in the panel data regressions using the GMM methodology. The results indicated that the regulatory norm of reserve requirements is the only significant factor that enhances profitability and minimizes the risk of financial instability.

In addition, Dudchenko et al. (2020) aimed to assess the impact of the intensity of banking regulation on a bank's efficiency in terms of different forms of capital ownership. Covering a research period from 2001 to 2014, data from Poland, Ukraine, Kazakhstan, Georgia, Belarus, and Estonia were studied. The empirical findings indicated that there is no need to create differentiated regulatory regimes in terms of the form of ownership and the bank's capital. Apergis and Polemis (2016) measured reflections of leverage in terms of shareholder equity over total assets. Furthermore, Hughes and Mester (2013) discussed two empirical approaches to measuring a bank's performance in terms of the bank's risk-taking decisions, which, in turn, affect economies of scale.

Various studies have investigated the effect of risk-taking behavior on a bank's profitability. For example, Rakshit and Bardhan (2022) assessed the profitability of Indian commercial banks in the period from 1996 to 2016 in terms of changes in banking competition, efficiency, and risk taking. The study outcomes revealed that the increasing incidence of credit risk disturbs banks' profitability. At the same time, higher profit levels and increased cost efficiency are positively associated with banks' performance. In addition, Mateev et al. (2022) found that the capital adequacy ratio has no significant influence on the credit risk of Islamic banks. Nevertheless, market competition plays a significant role in shaping risk behavior. The opposite holds true for conventional banks in that an increase in the minimum capital requirements is correlated with an increase in the level of risk.

Tan and Floros (2018) examined the correlation between risk, efficiency, and competition in the Chinese banking sector from 2003 to 2013 using the Granger causality test. The results revealed that Chinese commercial banks with higher efficiency levels have higher insolvency and a higher level of credit risk. Concurrently, they have lower capital

and liquidity risk levels. Furthermore, the researchers demonstrated that a high level of competition leads to lower credit and insolvency risk levels but higher liquidity risk levels.

In this context, Naceur Ben and Omran (2010) investigated the influence of regulation, concentration, and financial development by financial institutions on the profitability and margins of banking sectors within the MENA region between 1989 and 2005. They highlighted the fact that bank capitalization and credit risks, which are considered bank specifications, have a significant and positive impact on cost efficiency, profitability, and the banks' net interest margins.

As a final point of discussion, Alber et al. (2019) note that some studies have used fixed assets as an input variable in evaluating technical, scale, and allocative efficiencies. In addition, Ab Rahim (2016) investigated whether competition fosters efficiency by focusing on technical efficiency measures and testing the nexus between banking competition and efficiency in Malaysian commercial banks. DEA was used to assess the efficiency performance from 1996 to 2011 and the Lerner index was employed to estimate the extent of banking competition. As is often the case, these methods were followed up by an intermediation approach. Fixed assets, deposits, and other variables were considered the input variables, while the output variables consisted of total loans, total securities, and off-balance-sheet items. The study concluded that competition has a positive effect on technical efficiency in the Malaysian banking industry. Apergis and Polemis (2016) used the ratio of fixed assets to total assets as a proxy for banking size. This variable may impact the degree of competition in the banking sector. Their study also tested the causality between competition and cost efficiency by using fixed assets as an input.

3. Methodology

This section discusses two non-structural approaches (A and B) as follows:

(A) Measuring the level of competition using the Panzar–Rosse H-statistic test (including results and interpretation)

To measure the competition level in theoretical terms, Panzar and Rosse (1987) set the profit function, which is subject to revenue and cost, as used by Apergis and Polemis (2016), as follows:

$$\pi_i = R_i(y_i, n, Z_i) - C_i(y_i, w_i, X_i) \quad (1)$$

where π_i denotes the profit, i denotes the bank, R denotes revenue, and C denotes cost, while y, n, and w denote the bank output level, the number of banks, and the vector input price for bank i, respectively. Z and X are vectors that contain some exogenous variables that affect bank i's profits and revenue. The first-order condition is applied as follows:

$$R_i(y_i, n, Z_i) - C_i(y_i, w_i, X_i) = 0 \quad (2)$$

This means that

$$R_i'(y_i, n, Z_i) = C_i'(y_i, w_i, X_i) \quad R_i' - C_i' = 0 \quad (3)$$

where R' is the marginal revenue and C' is the marginal cost. Panzar and Rosse (1987) then rewrote the total revenue function as follows:

$$R_i^* = R^*(y_i^*(n^*, Z_i,\ w_i,\ X_i)), \text{ and } y^* = y_i^*(n^*, Z_i,\ w_i,\ X_i), R_i^* = y_i^*(n^*, Z_i,\ w_i,\ X_i) \quad (4)$$

This represents the maximum output level. Market power is measured according to the changes in the input factor price and their impact on revenue equilibrium (Moshoeshoe and Katleho 2019). To measure market power, the elasticity of the price is defined by the first

derivative of Equation (4) with respect to the input price for each bank w_i, $\frac{\partial R_i^*}{\partial w_i} = \frac{\partial R_i^*}{\partial y_i} \frac{\partial y_i}{\partial w_i}$ and then multiplied by $\frac{w_i}{R_i^*}$.

$$\text{Consequently, we obtain } \frac{\partial R_i^*}{\partial y_i} \frac{\partial y_i}{\partial w_i} \frac{w_i}{R_i^*} = \frac{\partial R_i^*}{\partial w_i} \frac{w_i}{R_i^*} = H \tag{5}$$

Since we have many input prices for i banks, we use w_{ki}, where k denotes the input prices for the ith bank. The function then becomes $\frac{\partial R_i^*}{\partial w_{ki}} \frac{w_{ki}}{R_i^*} = H$, resulting in the following:

$$H = \sum_{k=1}^{K} \frac{\partial R_i^*}{\partial w_{ki}} \frac{w_{ki}}{R_i^*} \tag{6}$$

where

$H \leq 0$ means a monopoly situation.

$0 < H < 1$ means a monopolistic competition situation.

$H = 1$ means a perfectly competitive situation.

To measure the degree of competition empirically, the revenue function is estimated based on Apergis and Polemis (2016) as follows:

$$lnTI_{it} = \alpha + \beta_1 ln(X_{1,it}) + \beta_2\, ln(X_{2,it}) + \beta_3 ln(X_{3,it}) + \gamma_1\, ln(\gamma_{1,it}) + \gamma_2\, ln(\gamma_{2,it}) + \gamma_3\, ln(\gamma_{3,it}) + \varepsilon_{it} \tag{7}$$

where TI is the dependent variable, which takes the form of the total revenue (income) for year t in the case of bank i. α and ε are the interception and the error terms, respectively. The explanatory variables under study are listed in Table 2.

Table 2. List of variables used in Model (7) and their definitions.

Symbols	Variable	Definition	Data Source	Time Period
TI	Dependent variable in the form of total revenue	Revenue	SAMA, Tadawul, and Argaam	2015–2021
X_1	Proxy for the average fund rate	Total operating income/total loans and financing average		
X_2	Proxy for the wage rate	Expenditure on salaries and wages of employees		
X_3	Proxy of the physical capital price [1]	Physical capital price index		
γ_1	Proxy for the leverage reflection [2]	Shareholder equity over total assets = index of leverage		
γ_2	Credit risk proxy	Credit risk estimate		
γ_3	The ratio of fixed assets to total assets [3]	Banking size		

[1] This refers to assets or inputs that are used to provide banking servies, including IT facilities; [2] Leverage reflections differ depending on each bank's risk preferences and the regulator policies; [3] Apergis and Polemis (2016) defined the ratio of fixed assets to total assets as a measurement of banking size.

The H-statistic is estimated using the dynamic system–GMM panel model that deals with lagged dependent variables. This model was chosen because it is capable of estimating the relationship between competition and financial stability (Noman et al. 2017). This technique addresses lagged dependent variables and other issues, such as the indigeneity of the explanatory variables.

The Hausman test, shown in Table 3, shows that the random effect is rejected as a null hypothesis. This means that the fixed effect is the appropriate specification.

Table 3. Empirical results.

	GLS-FE	GLS-RE	GMM
TI-1	**0.0005**	0.021 ***	0.004
TI-2	**0.132**	−1.05 ***	0.130
X_1	**0.676** ***	1.930 ***	0.909 ***
X_2	**−0.0010**	0.049 ***	−0.006
X_3	**−0.619** ***	−0.1351	−0.123
γ_1	**−0.009** *	0.0014	0.0019
γ_2	**−0.3652** ***	−0.800	−0.881
γ_3	**0.043**	0.045	−0.036
α	**−1.861** *	−1.79 ***	−2.128
WALD TEST		45,028 (0.00)	2.05 (0.00)
Hausman Test	**49.44 (0.00)**		
F-TEST	**12.94**		
H statistic [1]	**0.055**	1.8439	**0.78**

*** Significant at 1% level, * Significant at 10% level. [1] The H statistic is the sum of the input elasticities that are listed in Equation (7) and the elasticities in the table above. A value between 0 and 1 means that the market is in the monopolistic competition range.

The results show that the average fund rate (x_1) positively affects the total revenue of banks; however, the physical capital price index (x_3), the index of leverage γ_2, and the credit risk γ_2 (when estimated negatively) all have an effect on revenue.

In comparison, the results for the average fund rate matches those produced by Hamada et al. (2018). They found a positive relationship between an increase in the deposit interest rate and the economic growth rate. However, the credit risk results indicate a negative impact, matching the findings produced by Tan and Floros (2018). They examined the correlation between risk, efficiency, and competition in the Chinese banking sector from 2003 to 2013 and found that a high level of competition leads to lower credit and insolvency risk levels but higher levels of liquidity risk.

We applied two annual lags. The first and second lags of the dependent variable (total income), which reflect the competition, are not significant and the results indicate that competition at time t is not influenced by competition in previous years. The GMM estimators above, developed by Arellano and Bond (1991), deal with lagged dependent variables. The H-statistic is computed according to the sum of three input-estimated elasticities of Equation (7). A value between zero and one means that the degree of competition is in the monopolist range. The Wald test provides evidence that there is no causation among the different variables.

Furthermore, the value of the H-statistic satisfies $0 < H < 1$, which indicates that the banking sector in Saudi Arabia is in the monopolistic competition range. A positive finding also reflects positive causality between competition and cost efficiency (i.e., greater cost efficiency may result in higher levels of competition if it is followed by the greater availability and lower prices of banking products, but this is not always the case). This aligns with the finding of El Moussawi and Mansour (2022).

(B) Efficiency measurement using the DEA–Granger causality test between cost efficiency and competition (including results and interpretation):

This section introduces the Granger causality test, which is employed to determine the causal relationship between banks' cost efficiency and competition. Using the DEA non-parametric approach, the banks' efficiency level can be estimated by use of the input–output selection. Traditionally, DEA is a mathematical approach that measures the relative efficiency of decision-making units (DMUs) (Khan 2011). DEA involves using linear programming and is an important method for evaluating the efficiency of banks in terms of cost efficiency. Furthermore, DEA was selected for this article because it can operate with small sample sizes, taking into account the fact that the number of banks may decrease over the years under study due to acquisitions (Khan 2011).

The standard approach, frontier estimation, does not take into consideration cost minimization. Therefore, in this article, we adopt the DEA approach. Furthermore, this article does not consider the Stochastic Frontier Approach (SFA) as it is used to undertake systematic comparisons of efficiency measures across different countries as opposed to a single country (Khan 2011; Allen and Rai 1996). Therefore, the DEA methodology is applicable and testable within the context of Saudi Arabia's banking sector.

To estimate the efficiency of the banks under consideration, we used an input–output selection, as shown in Table 4.

Table 4. DEA input–output determinants.

Variable		Data Source	Time Period
Net loans	Output 1	SAMA, Tadawul, and Argaam	2015–2021
Total income: output	Output 2		
Fixed assets: proxy for physical capital	Input 1		
Personnel expenses: proxy for labor	Input 2		
Deposits: proxy for financial capital	Input 3		

DEA determines the efficiency score and presents the maximum output that we could obtain with a given input. We classified the variables into two groups—input and output—and these are consistent with the empirical literature regarding this sector (Apergis and Polemis 2016; Mamatzakis et al. 2013).

To determine the efficiency scores and the causal relationship between competition and efficiency levels, it was necessary to estimate the equations as illustrated in the study conducted by Apergis and Polemis (2016):

$$DEA_{it} = \alpha_0 + \alpha_1 DEA_{i,t-1} + \alpha_2 DEA_{i,t-2} + \beta_1 H_{i,t-1} + \beta_2 H_{i,t-2} + \eta_{it} + \varepsilon_{it} \quad (8)$$

$$H_{it} = \alpha_0 + \alpha_1 H_{i,t-1} + \alpha_2 H_{i,t-2} + \beta_1 DEA_{i,t-1} + \beta_2 DEA_{i,t-2} + \eta_{it} + \varepsilon_{it} \quad (9)$$

Equations (8) and (9) are used to determine the Granger causality relationship between the banks' cost efficiency, as measured via the DEA, and the competition H-statistic. DEA_{it} is the bank's cost efficiency level at year t in the case of the ith bank. As explained above, we refer to it as DEA in order to reflect the non-parametric approach. $DEA_{i,t-1}$ and $DEA_{i,t-2}$ are the annual lags for the first and second years under consideration. H_{it} presents the competition index H-statistic at year t and in the case of the ith bank. $H_{i,t-1}$ and $H_{i,t-2}$ are the annual lags for the first and second years under consideration. α_0 is the intercept; α_1, α_2, β_1, and β_2 are the coefficients; ε_{it} is the term of disturbance; and η_{it} is the specific effect of the individual bank. We applied two annual lags. Finally, the GMM estimators above (as developed by Arellano and Bond (1991)) address the lagged dependent variable.

Table 5 presents the results of the Granger causality test. Panel A reports the causality results, from cost efficiency to competition. The estimated function took the form of lagged competition and cost efficiency. The Hausman test shows that the random effect is rejected as a null hypothesis. This means that the fixed effect is the appropriate specification. The first and second lags of the competition, H, are significantly different from zero, which indicates that the competition in year t is influenced by the levels of competition of the previous years. This result matches that of another empirical study that considers the banking sectors in the Middle East and North African region (Apergis and Polemis 2016). The variable in the form of lagged cost efficiency, the coefficient of DEA(-1), is statistically significant. This indicates that the level of cost efficiency in previous years for Saudi banks causes competition, which reflects the expansion of the market structure. In other words, the more efficiency (cost minimization) in the Saudi banking sector, the higher the degree of competition if it is followed by the greater availability and lower prices of banking products, which, in turn, reflects market power. However, this result is not in line with

previous studies, such as Apergis and Polemis (2016), which found sufficient evidence of a one-way (negative) Granger causality from efficiency to competition.

Table 5. Granger causality test.

		GLS-FE	GLS-RE	GMM
Panel A: H-statistic	H(-1)	0.4846 ***	0.776 ***	0.343 *
	H(-2)	12.74 **	0.078	22.20 ***
	DEA(-1)	12.83 ***	7.22 *	17.79 ***
	DEA(-2)	−11.95	−6.77 *	−23.72 **
	α [1]	−117.19 **	−2.59	−119.90 **
	F-test	1.39		
	(prob)	0.219		
	WALD TEST		37 (0.00)	2.05 (0.00)
	Hausman Test	14.22 (0.006)		56.94 (0.00)
	F-TEST	12.37		
Panel B: DEA	**DEA(-1)**	**0.902 *** **	**1.109 *** **	**0.573 *** **
	DEA(-2)	−0.345	−0.238 *	−0.1758
	H(-1)	0.0223 ***	0.0184 ***	0.0248 ***
	H(-2)	0.229	−6.77	0.257
	α [2]	3.008 *	0.250	4.618 ***
	F-test	1.39		
	(prob)	0.219		
	WALD TEST		2499.57 (0.00)	101.96 (0.00)
	Hausman Test	6.76 (0.149)		56.94 (0.00)
	F-Test	0.81		

*** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level. [1,2] Is a constant.

Panel B in Table 5 presents the causality results from competition to cost efficiency. The function that was estimated took the form of lagged cost efficiency and competition. The Hausman test shows that, as a null hypothesis, the random effect cannot be rejected, which means that the random effect is the appropriate specification. The first-year lag indicates that the cost efficiency in this year, at time *t*, is positively influenced by the cost efficiency level of the previous year. However, the second year's lag has a negative effect on cost. The lagged variable of cost efficiency, the coefficient of H(-1), is statistically significant. This indicates that, for Saudi banks, the competition in the previous year led to greater cost efficiency. In other words, the more competitive the banking sector is, the higher the cost efficiency. The Wald test shows that the no-causation hypothesis is rejected, which indicates that there is no causality among the specifications in this panel.

4. Data

The analysis was conducted based on data from the 11 local banks operating in Saudi Arabia from 2015 to 2021. These banks are Al Ahli, Al Rajhi, Al Jazira, ANB, Saudi Fransi, IDB, Riyadh Bank, Samba Group, SABB, SAIB, and Al Awwal. Data were collected from SAMA's statistical reports, financial statements from the Saudi Exchange (Tadawul), and the Argaam portal. The reason we selected this period was based on the decision to analyze the behavior of these financial entities following the bank mergers that occurred over this period, especially after the rise of foreign and digital banks. A key factor in this analysis is how they affected the private sector throughout this period.

It is worth mentioning that the banks' revenue was SAR 109 billion in 2021 and SAR 125 billion in 2022. Profit after tax exceed SAR 50 billion in 2021 and SAR 57 billion in 2022. The operation expenses increased from SAR 40 billion to SAR 46 billion in 2022. The function of loans becomes tighter due to the funding conditions, which reflects the role of banks' management and regulators.

5. Descriptive Statistics

Table 6 presents a summary of the descriptive statistics for the variables under consideration (revenue, fund rate, wage rate, physical capital price index, leverage reflection, credit risk, and banking size), applying Model 7, which is given above.

Table 6. Descriptive statistics (All the variables in this table are expressed in natural logarithms).

Model (7) Variables	Revenue (TI)	Fund Rate (X_1)	Wage Rate (X_2)	Physical Capital Price Index (X_3)	Leverage Reflection (γ_1)	Credit Risk (γ_2)	Banking Size (γ_3)
Mean	10.69	8.78	9.04	−6.171	−2.735	−3.690	7.588
Maximum	17.164	10.256	10.256	−3.55	−1.558	−1.651	9.274
Minimum	7.724	7.724	6.361	−11.52	−9.066	−8.87	6.520
Std. Dev.	3.271	0.6749	3.153	3.162	2.25	3.107	0.739
Observations [1]	76	76	76	76	76	76	76

[1] The lag of the variables has been considered. By taking one lag, it automatically eliminates one observation of each variable.

6. Conclusions

The banking sector is a vital sector, in which consistently higher levels of investment are required to maintain competition in the market. Since cost efficiency results in competition, regulators need to define cost-cutting thresholds to ensure that banks avoid the problems of branchless banks and their associated issues, such as information asymmetries. Given that banks are shifting to digitalization when providing banking services, defining parameters for cost efficiency and cost-cutting measures will allow regulators to make solid assessments when regulating and supervising banking activities.

Since most of the banking sectors in emerging markets fall into the category of monopolistic competition, this study applied the H-statistic of Panzar and Rosse (1987), a non-structural approach, and empirically assessed the causal relationship between competition and efficiency in Saudi Arabia's banking sector.

The findings show that a higher level of competition leads to increased cost efficiency, which reflects the higher level of market structure. The findings of this study contribute to theory and practice. However, EU banking systems behave differently, according to Casu and Girardone (2006). Increased competition forced banks to be more efficient; meanwhile, they found that efficiency does not impact competition. The pressure of cost efficiency appears to be particularly strong under the conditions of low interest rates; this was the case during the pandemic (2020–2021).

This analysis was conducted based on data from 11 local banks operating in Saudi Arabia from 2015–2021, utilizing the Granger causality test to determine the causal relationship between banks' efficiency and competition via DEA.

In line with the scope of the analysis, two main factors limited the results of the article. The first concerns the lack of traditional data from before the chosen period, as there may be important information that is not covered within the scope of the analysis. Second, there is a lack of significant information in terms of assessing the impact of payment systems infrastructure linkages on the behavior of bank customers. It is not clear how these systems may affect the competition between traditional banks or what the consequences of this competition becoming more concentrated may be.

The regulators need to review and evaluate the existing regulations regarding the threshold level for efficiency (in terms of cost) in order to eliminate the problem of branchless banks and associated issues such as information asymmetry. The information asymmetry issue affects small- and medium-sized institutions, as it is necessary to visit the closest branch frequently to review their financial statements and compare them to the daily sales. The problem of information asymmetry is exacerbated when banks close their branches and switch to providing services on an entirely digital basis.

We conclude by proposing directions for future research and analyses that will directly and indirectly affect the performance of the banking sector. For example, there would be significant value in studying the impact of governmental support on the level of competition between banks in Saudi Arabia and identifying the factors involved in the establishment of a cost-efficiency variable. This is because cost efficiency has a direct influence on the level of competition between banks and the quality of the banking services provided. Assessing the impact of payment systems on the level of competition and cost efficiency for GCC banking industries is also an important area worthy of further study.

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