“Applying a two-stage TOPSIS approach and stepwise regression in evaluating bank performance: evidence from Turkish banks”

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APPLYING A TWO-STAGE TOPSIS APPROACH AND STEPWISE REGRESSION IN EVALUATING BANK PERFORMANCE: EVIDENCE FROM TURKISH BANKS

Abstract

As a crucial component of the financial sector, banks play an intermediary role in creating and providing financial services to customers. Therefore, the evaluation of banking sector activity is important for stakeholders and managers. This paper investigates the key criteria in analyzing bank performance and efficiency and the relative performance of Turkish banks in terms of the pre-determined criteria during 2008–2018. This study aims to introduce a robust and easy-to-calculate mathematical model for estimating bank performance using stepwise regression and TOPSIS methods. The TOPSIS ranking of banks from the best to the worst allows establishing that the bank with the highest mean score is Akbank (AB), while Ziraat Bank (ZB) and Garanti Bank (GB) follow AB over the period. The results of the stepwise regression analysis show that managing non-performing loans and expenses (both personnel and interest expenses) are critical to high performance in the banking sector.

Keywords bank efficiency, bank performance, stepwise regression, TOPSIS, Turkish banks, financial service sector

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INTRODUCTION

The importance of the banking sector to the national and global economies is great. Since banks convert the public's deposits and savings into businesses, they are the main capital providers for infrastructure, innovation and development. Besides, banks and other financial institutions contribute to job creation and overall well-being. Therefore, a well-functioning banking sector plays an important role in stabilizing the financial markets. A strong and efficient banking system accelerates economic growth and serves as an emergency signal against financial crises and helps to overcome the effects of such negative shocks.

Today's highly competitive business environment forces banks to use their resources effectively (Doğan, 2013). These conditions have led to the necessity for bank managers, investors, customers and policy makers to compare the activities of banks with each other. To compare good and bad practices and to see overall improvement in the banking sector, accurate assessment of bank performance is essential. Measurement of bank's financial performance is important for several reasons: improving management performance, providing information on comparisons between the best and the worst practices for stakeholders, investigating the impact of some macroeconomic changes on bank performance to establish appropriate policies (Berger & Humphrey, 1997).

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For the reasons mentioned above, measuring the efficiency and effectiveness of banks is of high interest to researchers. While the early studies on this topic have focused on commercial banks in developed countries, more attention has been paid to bank performance and efficiency in developing countries and transition economies in the last decade. In addition, the devastating effects of the 2008 global crisis have increased the importance of analyzing efficiency and effectiveness in the financial sector.

Although there is a common sense that how important it is to evaluate bank performance, the methods and performance indicators may vary widely. Financial ratios provide useful information for evaluating bank performance and efficiency. The basic financial ratios related to efficiency are return on equity (ROE) and return on assets (ROA) (Chao, Yu, & Wu, 2015; Svitalkova, 2014; Titko & Jureviciene, 2014; Lee & Kim, 2013). Although in most cases the variables encompass assets quality, capital strength, earnings, and liquidity, the number of variables included in research may differ significantly in the literature (Fethi & Pasiouras, 2010). The selection of variables and the methodology is directly related to the purpose of the model.

During the 1980s, many structural changes were seen in the Turkish economy such as regulations in the financial and banking system. Within this framework, the interest rate ceiling system was abandoned and the exchange rate regime was reorganized. The Interbank Money Market, the Capital Markets Board and the Istanbul Stock Exchange were established to arrange financial markets and banking systems. In 1989, the convertibility of the Turkish Lira was achieved with the Act of 32. Despite these positive regulations, new structural problems commenced in the financial and banking system. With this act, Turkish banks increased their foreign currency debts and loans to use arbitrage opportunities. This move made Turkish banks vulnerable to speculative shocks (Akyüz & Boratav, 2003; Alper & Öniş, 2004; Sayılgan & Yıldırım, 2009).

As a result of liberalization in the 1980s, the Turkish economy faced a set of crises in 1994, 1999 and 2001. Since the Turkish banking system was not deep enough in those years, they were affected by these crises seriously and many banks went bankrupt. After the 1999 crisis, the Banking Regulation and Supervision Agency (BRSA) was established. It played an active role in strengthening the banking system after the 2001 crisis. BRSA and the Saving Deposits Insurance Fund (SDIF) rearranged and restructured the banking system. While banks were the main source of financing government deficit in the 1990s, they started to be a financial intermediary between investors and sectors (Sekmen, Akkus, & Sıklar, 2017). After these transformations in the banking sector, Turkish banks' efficiencies have been followed by investors and researchers.

This study aims to introduce a model to compare the financial performance of Turkish banks using the financial criteria, which can be commonly found in the related literature. The sample financial data belongs to 10 Turkish commercial banks for the period of 2008–2018. A two-stage TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) analysis with stepwise regression technique is carried out to evaluate the relative bank performance. As an initial step of analysis, bank performance is determined by using a set of financial ratios (criteria). Following the first step analysis, stepwise regression is applied to data to determine the criteria that explain the performance better. Afterwards, the bank performance is recalculated by the TOPSIS technique using these refined criteria. The banks are then re-ranked via strengthened performance analysis to define and compare the best performing banks and the worst performing banks.

This study extends the existing literature by checking the contribution of each variable simultaneously to a more flexible and informative model. To the authors' knowledge, this is the first application of a hybrid methodology of TOPSIS and stepwise regression in the literature.

The study is structured as follows: The first section includes a review of the existing literature related to bank effectiveness and efficiency. Examples of various methods are introduced. In the second section, the research methodology is explained. The data are analyzed; the results are explained and discussed in the tables in the third section. The conclusion of the study and further studies are discussed in the last section.

1. LITERATURE REVIEW

There are various methodologies utilized to measure bank efficiency and effectiveness in literature. Data envelopment analysis (DEA) is one of the most important non-parametric analysis techniques used to examine this issue. Wang, Huang, Wu, and Liu (2014) proposed the network DEA method to determine Chinese commercial banks' efficiency after the Chinese banking reform. Paradi, Rouatt, and Zhu (2011) compared the branch efficiencies of a major Canadian Bank. They pointed out that three significant branch performance indicators are production, intermediation function and profitability. Fukuyama and Matousek (2011) examined the three types of efficiencies in 25 Turkish banks using a two-stage DEA network system. According to their study, the performance scores of the banks reflect Turkish economic conditions before, during and after the financial crisis. Fernandes, Stasinakis, and Bardarova (2017) analyzed the efficiency of European banks via DEA, which is utilized on a Malmquist productivity index. They applied truncated regression to get bias-corrected results in the second step and stated that bank performance positively related to profit and capital risk. Salim, Arjomandi, and Seufert (2016) used a two-stage DEA analysis to analyze the interactions between the performances of Australian banks and the corporate governance in Australia. They found that the performances of Australian banks are positively affected by the board size. Furthermore, committee meetings serve as an important factor for performance scores. Staub, Souza, and Tabak (2010) investigated the impact of ownership on the Brazilian banks' efficiency using a DEA approach. They revealed that domestic-private and foreign-private banks are less effective than state banks.

Another frontier analysis used in evaluating bank performance and efficiency is parametric stochastic frontier analysis (SFA). Hsiao, Shen, and Bian (2015) investigated the efficiency of Chinese banks using the SFA method and pointed out that Chinese banks' performance acquired the foreign banks as cost efficiency after financial reform. Another study conducted with SFA is one performed by Dong, Firth, Hou, and Yang (2016). This study investigated the ownership effect on the bank performance in China and found out that foreign banks and state-owned banks are the most cost-effective and profit-efficient banking groups, respectively.

In the literature, multi-criteria decision making methods are effectively used in evaluating bank performance and efficiency. Mandic, Delibasic, Knezevic, and Benkovic (2014) suggested a model using TOPSIS and FAHP methods in measuring bank performance in Serbia. This model included eight criteria such as: portfolio, cash, earnings before tax, equity, sources, liquidity, net interest income, and net income from core business. Seçme, Bayrakdaroğlu, and Kahraman (2009) integrated FAHP and TOPSIS techniques to evaluate and compare the performances of Turkish banks. In this study, financial and non-financial performance variables are weighted by FAHP and then weighted scores are used to determine the bank ranking. Wanke, Azad, Barros, and Hassan (2016b) developed a model to determine efficiency factors in OECD banks using the TOPSIS method and quantile regression analysis. The results indicated that ownership, trend and origin effects on bank efficiency may change depending on the efficiency levels. Wu, Tzeng, and Chen (2009) used a hybrid method to measure the performance of the banks with FAHP, TOPSIS and VIKOR (multi-criteria optimization and compromise solution) by using a balanced scorecard. Gavurova, Belas, Kocisova, and Kliestik (2017) assessed the performances of Czech and Slovak banks using several multi-criteria decision-making tools. They applied SAW (simple averaging method), ORESTE, PROMETHEE and MAPPAC methods to compare 10 CAMEL benchmarks. The authors found out that all of the four methods yield similar results.

Aysan and Ceyhan (2008) investigated the determinants in measuring the performance of Turkish banks through regression analysis. They pointed out that the loan ratio and the bank capitalization affect the efficiency and performance of banks positively, while the effect of return on equity is not statistically significant. Assaf, Matousek, and Tsionas (2013) focused on measuring and comparing the productivity and efficiency of domestic and foreign Turkish banks by using Bayesian stochastic frontier analysis. The study shows the

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importance of NPLs (non-performing loans or bad loans) in estimating the model. Results of the study show that although there was a positive productivity change during 2002–2010, the change in mean efficiency of Turkish banks was negative. Doğan (2013) analyzed the performance of Turkish banks with the main indicators using the Grey relational analysis for 2005–2011. The results revealed that the best performing bank was Akbank. Another finding of the study was that the higher the ratio of Return on Assets, the higher the financial performance could be.

2. METHODOLOGY

This study offers a robust and easy-to-calculate model to evaluate bank performance using TOPSIS methodology combined with stepwise regression analysis. The data set covers the period of 2008–2018 and is obtained from 2019 Annual Report of Financial Ratios of The Banks Association of Turkey.

In the first stage, Turkish banks' performance is measured using a predetermined set of financial ratios (criteria). Following the first stage, stepwise regression is applied in the second stage to determine which criteria explain bank performance better. Before giving the results, the study will discuss the methodology. The next two sub-sections introduce the TOPSIS methodology and the stepwise regression technique sequentially. To prove the reliability of the two-stage analysis, Breusch-Pagan-Godfrey (BPG) test for heteroscedasticity, Q^2 test for autocorrelation, Phillips-Perron test and Augmented Dickey-Fuller test for unit root (stationarity) and Jarque-Bera test for normality are applied.

2.1. TOPSIS method

After being first introduced by Hwang and Yoon as a multi-criteria decision-making tool in 1981, TOPSIS has become one of the most preferred multi-criteria problem solving techniques. "The basic TOPSIS principle assumes that the chosen alternative should simultaneously have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution" (Ertugrul & Karakasoglu, 2009; Barros & Wanke, 2015; Wanke, Azad, & Barros, 2016a). Within the framework of bank performance, the positive ideal solution may refer to profit maximization or cost minimization. On the other hand, the negative ideal solution may refer to profit minimization or cost maximization.

The methodology is summarized step by step as follows (Wanke, Azad, & Barros, 2016a):

1. Formulation of an initial matrix, which consists of m alternatives and n criteria.

2. Calculation of normalized matrix by applying the equation below:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, i = 1,2,..m \ and \ \ j = 1,2,\ldots n, \quad (1)$$

where x_{ij} represents the decision matrix and r_{ij} represents the normalized matrix.

3. Calculation of weighted normalized matrix (if there are weights) for performance evaluation:

$$W = (w_{ij})_{mxn} = (w_j r_{ij})_{mxn}, \quad (2)$$

where w_j indicates the priority (weight) of the criteria j and the summation of the weights is equal to 1.

4. Determination of solutions that give positive ideal and negative ideal values. These are defined as the best and worst alternatives, respectively:

$$\begin{aligned} A_a = &\left\{\min(w_{ij} | i = 1,2,\ldots,m, j \in J_+, \right. \\ &\left. \max(w_{ij} | i = 1,2,\ldots,m | j \in J_-, \right\} = \\ &= \left\{\alpha_{aj} | j = 1,2,\ldots,m\right\} \end{aligned} \quad (3)$$

$$\begin{aligned} A_b = &\left\{\max(w_{ij} | i = 1,2,\ldots,m, j \in J_+, \right. \\ &\left. \min(w_{ij} | i = 1,2,\ldots,m | j \in J_- \right\} = \\ &= \left\{\alpha_{aj} | j = 1,2,\ldots,m\right\}, \end{aligned} \quad (4)$$

where

$$J_+ = \{j | j \in positive\} and \ J_- = \{j | j \in negative\}$$

represent positive attributes such as benefit, and negative attribute such as cost, respectively.

5. Calculation of distances between positive ideal solution (d_{ia}) and negative ideal solution (d_{ib}):

$$d_{ia} = \sqrt{\sum_{j=1}^{n} \left(xw_{ij} - \alpha_{aj} \right)^2}, i = 1, 2 \ldots, m, \quad (5)$$

$$d_{ib} = \sqrt{\sum_{j=1}^{n} \left(xw_{ij} - \alpha_{bj} \right)^2}, i = 1, 2 \ldots, m. \quad (6)$$

6. Calculation of similarities to an ideal solution:

$$S_i = d_{ia} / (d_{ia} + d_{ib}), \quad (7)$$

where $0 \leq S_i \leq 1, i = 1, 2, \ldots, m.$

7. Ranking the alternatives according to S_i values, where a better alternative gives higher value of S_i.

2.2. Stepwise regression

Stepwise regression comprises both forward and backward selection techniques. Goldberger (1961) uses the parameters of the multiple linear regression model for estimating a stepwise procedure as follows:

$$y = X_1 \beta_1 + X_2 \beta_2 + \varepsilon. \quad (8)$$

According to this study, variables and coefficients are determined as below: y is the dependent variable in the multivariate model and X_1 is the N x K_1 matrix of observations on the first K_1 regressors: x_i (i = 1,…, K_1), β_1 is the K_1 x *1* vector of coefficients of the first K_1 regressors, X_2 is the N x K_2 matrix of observations on the second K_2 regressors: x_j (j = K_1+1,…, K_1 + K_2), β_2 is the K_2 x 1 vector of coefficients of the second K_2 regressors, and ε is the N x 1 vector of disturbances.

On the other hand, the stepwise least-squares procedure first estimates β_1, then regresses the residuals. After this process, β_2 is estimated using matrix inversions. In the stepwise regression analysis, the variables are added one by one in every single step, where new variables and the existing ones are checked for their significance. No significant variables are eliminated from the model. Stepwise regression includes two significance levels for the entering and removing variables. The variable selections continue until all variables in the model meet the significance levels (Rawlings, Pantula, & Dickey, 1998).

3. RESULTS AND DISCUSSION

In this study, ten commercial banks with the highest market share are selected for analysis and comparison with between 2008 and 2018. The distribution of these banks is as follows: three state-owned banks, four private domestic banks and three foreign-owned banks. Table 1 lists the banks and their ownership structure.

Table 1. Turkish banks included in the study

Source: The Banks Association of Turkey (2019).

Bank name	Acronym	Ownership
Ziraat Bank	ZB	State
Halk Bank	HB	State
Vakiflar Bank	VB	State
Akbank	AB	Private domestic
Turkish Economy Bank	TEB	Private domestic
Is Bank	IB	Private domestic
Yapı Kredi Bank	YKB	Private domestic
Deniz bank	DB	Foreign
QNB Finans bank	QNB	Foreign
Garanti Bank	GB	Foreign

The data set is compiled from The Banks Association of Turkey, an Annual Report of Financial Ratios (2019). Financial ratios are expressed in seven groups: capital ratios, balance-sheet ratios, asset quality, liquidity, profitability, income-expenditure structure and activity ratios. Selected financial ratios (criteria) and their structures (maximization or minimization criteria) are listed in Table 2.

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Table 2. Financial performance criteria

Source: The Banks Association of Turkey (2019).

Criteria groups	Financial ratios (sub-criteria)	Max/ Min
Capital ratios	Capital adequacy ratio	Max
	Shareholders' equity/Total assets	Max
	(Shareholders' equity – Permanent assets)/Total assets	Max
Balance-sheet ratios	Funds borrowed/Total assets	Min
	Total deposits/Total assets	Min
Asset quality	Financial assets (net)/Total assets	Max
	Total loans/Total assets	Max
	Loans under follow-up (gross)/Total loans	Min
Liquidity	Liquid assets/Total assets	Max
	Liquid assets/Short-term liabilities	Max
Profitability	Average return on assets	Max
	Average return on shareholders' equity	Max
Income-expenditure structure	Net interest income after specific provisions/Total assets	Max
	Net interest income after specific provisions/Total operating income	Max
	Interest expense/Total assets	Min
	Non interest income (net)/Total assets	Max
Activity ratios	Personnel expenses + Reserve for employee termination benefit/Total assets	Min

These financial ratios will be used in TOPSIS analysis to determine banks' first performance scores. The weights of criteria are equally treated in the model. Also, these ratios will be used in stepwise regression analysis as independent variables. The financial ratios included in the models are shown in the descriptive statistics in Table 3.

In this scope, mean, minimum, maximum and standard deviation are given for each criterion in Table 3. After providing descriptive statistics, the results of the first stage of the TOPSIS analysis are indicated in Tables 4 and 5. Table 4 shows the bank performance scores and Table 5 gives the first stage bank rankings.

According to the first stage, ZB's performance score in 2015 is found 0.7717, which is the highest value, and this bank's performance mean is the second rank in the 2008–2018 period. While the lowest first stage mean performance score belongs to DB with 0.3598, AB has the highest mean of 0.6500. The first stage bank rankings are shown in Table 5.

According to the first stage analysis, the first and second ranks are shared between three banks (AB, ZB, and GB) in the 2008–2018 period. These banks have the top three mean performance scores for this period. Four different banks (YKB, QNB, TEB, and DB) are ranked as worst in different years of the period analyzed. These banks are also at the bottom in terms of the mean performance scores. Afterwards, stepwise regression is applied to determine the criteria that explain performance better. The stepwise regression analysis results are shown in Table 6.

According to stepwise regression analysis results, 11 of the 17 criteria are significant at the 1%, 5% or

Table 3. Descriptive statistics of financial ratios (criteria)

Criteria (financial ratios)	Mean	Min.	Max.	St. dev.
Capital adequacy ratio	16.0809	12.800	23.2000	2.0409
Shareholders' equity/Total assets	10.8755	0.7000	15.5000	1.8621
Shareholders' equity – Permanent assets/Total assets	7.6145	2.5000	13.9000	2.0278
Funds borrowed/Total assets	10.1491	0.0000	23.8000	4.3090
Financial assets (net)/Total assets	22.5609	7.3000	57.0000	9.8301
Total loans/Total assets	60.9146	29.5000	73.9000	8.1036
Loans under follow-up (gross)/Total loans	3.6536	1.2000	8.30000	1.5593
Liquid assets/Total assets	26.4827	8.6000	60.5000	8.2322
Liquid assets/Short-term liabilities	46.3000	14.0000	79.3000	13.3141
Average return on assets	1.7518	0.7000	3.1000	0.5502
Average return on shareholders' equity	16.1418	6.9000	39.6000	5.2942
Net interest income after specific provisions/Total assets	3.1755	1.3000	6.0000	0.7725
Net interest income after specific provisions/Total operating income	59.4582	36.6000	87.7000	10.1644
Total deposits/Total assets	61.6909	52.0000	83.2000	6.1485
Interest expense/Total assets	4.6682	2.9000	9.1000	1.3533
(Personnel expenses + Reserve for employee termination benefit)/Total assets	1.0746	0.5000	2.4000	0.3595
Non-interest income (net)/Total assets	2.2082	0.1000	82.3000	7.7290

Table 4. Performance scores of the first stage

Banks	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Mean of the bank
ZB	0.4543	0.6331	0.6187	0.5999	0.6004	0.7105	0.7254	0.7717	0.7052	0.6820	0.5203	0.6383
HB	0.3789	0.5343	0.4974	0.5616	0.5293	0.6180	0.4812	0.5083	0.4551	0.5181	0.4278	0.5009
VB	0.3731	0.5221	0.4280	0.4370	0.4062	0.4572	0.4603	0.4574	0.4171	0.4487	0.4850	0.4447
AB	0.3958	0.6300	0.6593	0.6081	0.6306	0.6993	0.7311	0.7009	0.7250	0.7578	0.6120	0.6500
TEB	0.3135	0.3941	0.3741	0.3386	0.3774	0.4393	0.3681	0.4508	0.3948	0.3764	0.5237	0.3955
IB	0.3519	0.5211	0.5321	0.5483	0.5422	0.5933	0.6293	0.5747	0.5852	0.5520	0.4581	0.5353
YKB	0.3073	0.4475	0.4597	0.4499	0.4182	0.5537	0.4469	0.4151	0.3513	0.4164	0.5267	0.4357
DB	0.3130	0.3595	0.3072	0.4690	0.4609	0.3201	0.3327	0.3160	0.3482	0.3223	0.4082	0.3598
QNB	0.3094	0.4878	0.4502	0.4658	0.3399	0.3984	0.4330	0.3858	0.4075	0.3840	0.4795	0.4129
GB	0.6827	0.5769	0.5582	0.5855	0.5142	0.5625	0.5759	0.5911	0.5758	0.6188	0.6416	0.5894

Table 5. Rankings of banks at the first stage

Ranking	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	GB	ZB	AB	AB	AB	ZB	AB	ZB	AB	AB	GB
2	ZB	AB	ZB	ZB	ZB	AB	ZB	AB	ZB	ZB	AB
3	AB	GB	GB	GB	IB	HB	IB	GB	IB	GB	YKB
4	HB	HB	IB	HB	HB	IB	GB	IB	GB	IB	TEB
5	VB	VB	HB	IB	GB	GB	HB	HB	HB	HB	ZB
6	IB	IB	YKB	DB	DB	YKB	VB	VB	VB	VB	VB
7	TEB	QNB	QNB	QNB	YKB	VB	YKB	TEB	QNB	YKB	QNB
8	DB	YKB	VB	YKB	VB	TEB	QNB	YKB	TEB	QNB	IB
9	QNB	TEB	TEB	VB	TEB	QNB	TEB	QNB	YKB	TEB	HB
10	YKB	DB	DB	TEB	QNB	DB	DB	DB	DB	DB	DB

Table 6. Stepwise regression analysis results

Variable	Coefficient	Std. error	t-statistic
Shareholders' equity/Total assets	0.0077**	0.0369	2.0776
Financial assets (net)/Total assets	0.0078*	0.0012	6.3745
Loans under follow-up (gross)/Total Loans	–0.0279*	0.0041	–6.8010
Total loans/Total assets	0.0874*	0.0012	7.4892
Personnel expenses + Reserve for employee termination benefit/Total assets	–0.0818*	0.0216	–3.7882
Liquid assets/Short-term liabilities	0.0028*	0.0005	5.7219
Average return on shareholders' equity	0.0063*	0.0016	3.8814
Funds borrowed/Total assets	–0.0073*	0.0021	–3.4735
Total deposits/Total assets	–0.0035**	0.0014	–2.4791
Non-interest income (net)/Total assets	0.0018**	0.0008	2.4120
Interest expense/Total assets	–0.0115***	0.0061	–1.8828
R^2 = 0.7768 – Adjusted R^2 = 0.7542			

Note: * – statistical significance at the 1% level; ** – statistical significance at the 5% level; *** – statistical significance at the 10% level.

10% levels. Although the positive coefficient of the criterion corresponds to the positive relationship between this criterion and the performance score, negative coefficients indicate a negative relationship. Equation (9), shows the regression analysis formula.

$$\begin{aligned}\text{Banking performance scores} &= (0.0077\cdot\text{Shareholders' equity/Total assets})+\\ &+(0.0078\cdot\text{Financial assets(net)/Total assets})-\\ &-(0.0279\cdot\text{Loans under follow-up(gross)/Total loans})+(0.0874\cdot\text{Total loans/Total assets})-\\ &(0.0818\cdot\text{Personnel expenses+Reserve for employee termination benefit/Total assets})+\\ &(0.028\cdot\text{Liquid assets/Short-term liabilities})+(0.0063\cdot\text{Average return on shareholders' equity})-\\ &(0.0073\cdot\text{Funds borrowed/Total assets})-(0.0035\cdot\text{Total deposits/Total assets})+\\ &(0.0018\cdot\text{Non-interest income(net)/Total assets})-(0.0115\cdot\text{Interest expense/Total assets}).\end{aligned} \quad (9)$$

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Econometric assumptions for the stepwise regression model are verified by diagnostic and stationarity tests, and the results are given in Tables 7 and 8, respectively.

Table 7. Diagnostic test results

Test statistics	F stat.	$N \cdot R^2$
Breusch-Pagan-Godfrey	1.1521	12.5958
Test statistics	Q-stat	Prob.
Q^2 (5)	8.5157	0.1300
Test statistics	Test score	Prob.
Jarque-Bera	3.5049	0.1734

The study applies Breusch-Pagan-Godfrey (BPG) test and Q^2 test to check heteroskedasticity and autocorrelation problems in the stepwise regression model. Null hypotheses are tested: "There are no heteroskedasticity problems" with the BPG test and "There are no autocorrelation problems" with the Q^2 test. According to test results, two hypotheses cannot be rejected at the significance levels (1%, 5%, and 10%). Therefore, there are no heteroskedasticity or autocorrelation problems in the model. The normality of banking performance scores is also checked using the Jarque-Bera test. According to the test results, the dependent variable shows the normal distribution at all significance levels. After conducting diagnostic tests, the bank performance scores used in modelling stationarity are measured using Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) unit root tests.

Table 8. Stationarity test results

Tests		Test statistic	Probability
ADF	Intercept	–4.3638*	0.0006
	Trend and Intercept	–4.6581*	0.0014
PP	Intercept	–4.4040*	0.0005
	Trend and Intercept	–4.7853*	0.0009

Note: * – statistical significance at the 1% level.

Table 8 shows the results of two different unit root tests with intercept and with trend and intercept applied to the level banking activity. In the unit root tests performed, the null hypothesis: "A dependent variable has a unit root" is tested using ADF and PP tests. If the null hypothesis is not rejected, it means that the variable has a stationarity problem. The score of ADF and PP unit test statistics corresponding to probabilities showed that all hypotheses were rejected at 1% level and all these values are significant. As a result, the dependent variable does not contain a unit root and corresponds to the stationarity condition.

The stepwise regression model corresponds to the econometric assumptions. Therefore, the study continues analyses with these 11 criteria and the performances of the banks are recalculated using the TOPSIS method with these refined criteria. Table 9 indicates the second stage of the TOPSIS results.

The average scores of Turkish banks are in the depth of the year 2008. After the 2008 global financial crisis, the scores rose by about 40% and were

Table 9. Performance scores of the second stage

Banks	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Mean of the bank
ZB	0.4502	0.6400	0.6362	0.6385	0.6460	0.7430	0.7101	0.7847	0.7055	0.6766	0.4793	0.6464
HB	0.3792	0.5733	0.5292	0.5832	0.5832	0.6365	0.5040	0.5518	0.5011	0.6092	0.5224	0.5430
VB	0.3572	0.5391	0.4625	0.4682	0.4560	0.4922	0.5077	0.5138	0.4519	0.4957	0.5462	0.4810
AB	0.3656	0.6197	0.6461	0.6036	0.6558	0.7232	0.7449	0.7419	0.7533	0.7823	0.6007	0.6579
TEB	0.2805	0.4039	0.3799	0.3377	0.4077	0.4617	0.3568	0.4411	0.3643	0.2778	0.4223	0.3758
IB	0.3302	0.5704	0.5943	0.6186	0.6286	0.6542	0.6747	0.6416	0.6272	0.5841	0.4117	0.5760
YKB	0.3239	0.5077	0.5287	0.4882	0.4719	0.5427	0.4880	0.4807	0.3883	0.4647	0.5504	0.4759
DB	0.2726	0.3182	0.2848	0.4325	0.4058	0.3565	0.3499	0.3509	0.3550	0.3328	0.4562	0.3559
QNB	0.2839	0.4616	0.3897	0.4260	0.3305	0.3801	0.4466	0.3838	0.4057	0.3408	0.3905	0.3854
GB	0.7039	0.5719	0.5483	0.5811	0.5244	0.5659	0.5715	0.5970	0.5453	0.5606	0.6495	0.5836
Mean of the year	0.3747	0.5206	0.5000	0.5178	0.5110	0.5556	0.5354	0.5487	0.5098	0.5125	0.5029	–

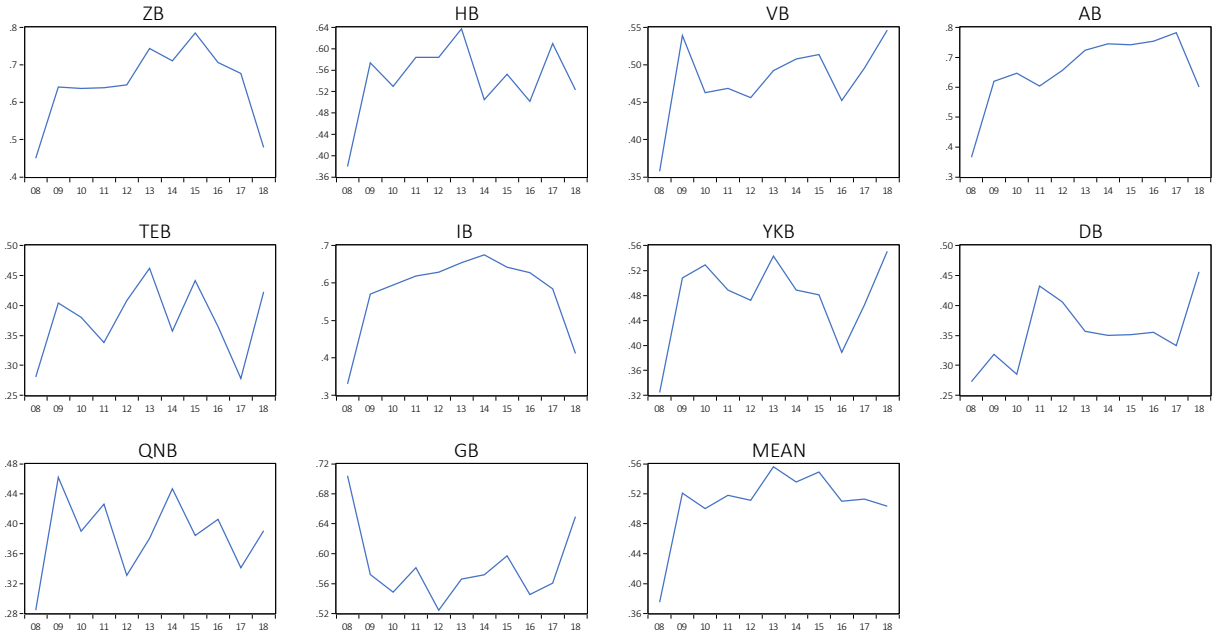

Figure 1. Performance scores for the second stage

rather stable through over 2009–2018. According to the second stage results, the 2015 ZB's performance score and the 2017 AB's performance score were more than 0.78, which are the highest performance indicators for the whole analysis period. The average performance score in the 2008–2018 period is 0.6579 for AB, which is the highest. ZB and GB follow this bank. The mean performance scores of the rest of the banks from the highest to the lowest are IB, HB, VB, YKB, QNB, TEB, and DB, respectively. Only the first two banks' (AB and ZB) mean performances exceed 60% and each year these banks' indicators (except 2008 for two banks and 2018 for ZB) surpass this level. In three banks' (GB, IB, and HB), mean performance scores vary from 0.50 to 0.60. The lowest performance indicators for all banks (except TEB and GB) are observed in 2008. The bank performance estimates for the second stage are shown in Figure 1.

Figure 1 shows the scales of the bank performance in the left axis from 2008 to 2018. All banks' performance increased after 2008 (except GB). After 2008, on a yearly basis, the mean of all banks' performance exceeded 0.50. The ratings of banks at the second stage are shown in Table 10.

According to the second stage analysis, AB, ZB or GB in 2008–2018 ranked first and the second (except 2011). Although the worst score for AB is the fourth ranking in 2011, ZB is the sixth-ranked in 2018. GB ends in the fifth position three times be-

Table 10. Second stage rankings of banks

Ranking	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	GB	ZB	AB	ZB	AB	ZB	AB	ZB	AB	AB	GB
2	ZB	AB	ZB	IB	ZB	AB	ZB	AB	ZB	ZB	AB
3	HB	HB	IB	AB	IB	IB	IB	IB	IB	HB	YKB
4	AB	GB	GB	HB	HB	HB	GB	GB	GB	IB	VB
5	VB	IB	HB	GB	GB	GB	VB	HB	HB	GB	HB
6	IB	VB	YKB	YKB	YKB	YKB	HB	VB	VB	VB	ZB
7	YKB	YKB	VB	VB	VB	VB	YKB	YKB	QNB	YKB	DB
8	QNB	QNB	QNB	DB	TEB	TEB	QNB	TEB	YKB	QNB	TEB
9	TEB	TEB	TEB	QNB	DB	QNB	TEB	QNB	TEB	DB	IB
10	DB	DB	DB	TEB	QNB	DB	DB	DB	DB	TEB	QNB

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tween 2011 and 2013, this position being the worst ranking of GB in the analysis period. IB is ranked once in the second place and six times third in the 2010–2016 period. Only in 2011, it ranks second. However, in the first and the last two years of the analysis period, IB has different rankings, from fourth to ninth. HB's ranking changes between the third and sixth positions. VB is ranked between fifth and seventh steadily. YKB shows a similar performance ranking to VB. Its ranking changes between sixth and eighth. DB and QNB ranked seventh in 2016 and 2018, respectively. These banks and TEB ranked ninth and last (except 2018) in different years of the analysis period.

CONCLUSION

This paper introduces the comparative performance analysis of 10 Turkish banks between 2008 and 2018 using a two-stage TOPSIS analysis and stepwise regression. Since the bank performance analysis includes several criteria that are often conflicting, determining the criteria that fit the financial data best is an important stage of assessments. This study aims to find out bank-specific characteristics, which explain and affect the performance most. The results of this study show that AB is the best performing bank with an average score of 0.6579 over 11 years. This result is similar to other studies on Turkish banks (Assaf, Matousek, & Tsionas, 2013; Doğan,2013; Seçme, Bayrakdaroğlu, & Kahraman, 2009). AB is followed by ZB and GB. According to the mean scores, the rankings order of the rest of the banks are given from the first to the last as IB, HB, VB, YKB, QNB, TEB, and DB. The mean score of Turkish banks is the lowest in 2008, since with the 2008 financial crisis, the Turkish banking system is vulnerable to external economic shocks. Although the average performance has increased after the crisis, it is rather low and stable through the years 2009 to 2018. The results of the stepwise regression analysis reveal that the loan ratio significantly and positively contributes to the bank performance, while non-performing loans have a similar effect in the opposite direction. The results are parallel to previous research (Assaf, Matousek, & Tsionas, 2013; Aysan & Ceyhan, 2008). Indeed, the allocation and management of loans are critical for managers and decision makers. Expenses were other critical criteria in financial performance. The results of the stepwise regression analysis indicate that both personnel and interest expenses have a serious negative effect on bank performance.

In this study, the process of bank performance evaluation is seen as a multi-criteria decision-making problem. The proposed model is based on maximum-minimum criteria instead of traditional input-output oriented approach. In the second step analysis, only the criteria that best describe the model are included in the calculation of the final performance scores. This methodology allows measuring and benchmarking the bank performance in a stronger, more flexible and informative manner. The model can be used to analyze bank performance in other developing countries. Further studies may include making cross-country comparisons with the same methodology or a combination of various techniques.

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