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Abstract

Purpose – The purpose of this paper is to measure the performance and relative operating efficiency of mini branches of a commercial bank for internal benchmarking.
Design/methodology/approach – The authors employ data envelopment analysis (DEA) for measuring the relative efficiency of mini bank branches in a region of a state in the USA. In addition, the authors use Tobit regression analysis for finding determinants of the efficiency.
Findings – The authors identified efficient and inefficient branches using pertinent variables along with potential improvements for the inefficient branches. Among the variables, the authors confirmed that number of full-time employees and service charges were statistically significant for explaining the efficiency of bank branches.
Research limitations/implications – The major limitation of this study is the one time measure of efficiency using observations for a month and selected variables. To improve this study: first, the authors need to test other variables related to, but not limited to, assets, bad loans, and number of new account opened; second, it is necessary to measure the efficiency of the branches over time.
Originality/value – The contributions of this study include an application of DEA for measuring and benchmarking the performance of bank branches, especially mini branches located in grocery stores and the use of internal data, which is rarely available to the public.

Keywords Benchmarking, Data envelopment analysis, Banking, Company performance
Paper type Research paper

Introduction

Full-service retail banking requires heavy resources to operate. To reduce operation costs, internet banking has been promoted by the banking industry and has become accepted by its customers. As alternatives to the full-service banks, small or mini-branches of these banks have started to populate the inside of grocery stores and other retail outlets. This development has been motivated by the potentially sizeable reduction in operation costs. For example, monthly lease expenses to utilize physical space in these small branches are only a fraction of the cost to build a stand-alone retail bank. Salary expenses are also greatly reduced as employees at these branches are trained with multiple skills (teller transactions, loan administration, personal investments, and so on). This business model reduces the need for the larger staffs of full-service banks, with each employee normally trained in only one specialty.

Currently, the focal bank for this study operates in 26 states across the USA with 3,020 branches across their footprint. The branches of these banks have grown explosively in recent years, and are now in all of the major grocers such as Safeway®, Kroger®, and Wal-Mart®. In this paper, we demonstrate how to employ data envelopment analysis (DEA) to measure and also to benchmark the performance of bank branches. It is worth

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noting that the data set of 16 mini-branches of this commercial bank, rarely available to the public, is utilized for this DEA study. As it is limited by the relatively small scope of this data, this study mainly serves as a pilot project for assessing performance and developing managerial insights for the bank. Nonetheless, this analysis provides individual branch managers a useful tool not only for identifying which branches succeed and which fail in meeting operational goals, but also for revealing useful information regarding weakness areas in order for managers to develop action plans to improve future performance.

This paper hereafter is organized in the following order: first, related studies; second, methods; third, data and variables; fourth, results and discussion; and finally, conclusion.

Related studies

Because our study focusses on the performance of bank branches, we chose and reviewed major DEA studies at a branch level. The flexibility of the DEA models has enabled researchers to extend their theoretical settings and practical usages to address various perspectives in assessing the performance across different bank branches. These perspectives mainly comprise methodology improvements within a theoretical DEA model, and also the efficiency measures of production, profitability, cost, and the intermediary role the bank branches have served in the financial sector. In addition, the study the overall efficiency ranking and the treatment of service quality in the DEA models are also topics that have received attention in this area of research (Paradi and Zhu, 2013) and were considered in this literature review.

In the area of methodology improvement within a theoretical DEA, two lines of studies have been merged. The first line of research focusses on extensions of the traditional DEA models. Examples of this line of research include a two-stage DEA model by Athanassopoulos (1997), a quasi-concave DEA model by Dekker and Post (2001), a DEA model embedded with a fuzzy logic formulation by Wu *et al.* (2006a), and a culturally adjusted DEA model proposed by Paradi *et al.* (2010). The second line of research in this area is about methodology improvement that combines other operations research techniques into the traditional DEA models. For example, Cook and Hababou (2001) incorporated a separate set of goals into an additive DEA model. Porembski *et al.* (2005) included Sammon's mapping, and Wu *et al.* (2006b) utilized neural network models in their DEA study. In addition, Cook and Zhu (2006) suggested a new way of building performance standards in the setting of their DEA model, which generates a series of standard decision making units (DMUs).

A great volume of research has marked the area of measurements in production, cost, and profitability efficiency for the bank-branches studies. Labor and other tangible resources are often treated as inputs. Making loans and providing services (in terms of the number of transactions) are normally viewed as outputs. Some studies consider the efficiency of cost or profit as output variables. Sherman and Gold (1985) discovered that the clustered customer demand of some branches was a main cause for the personnel inefficiency. The seasonality of this clustered demand furthermore stressed the level of inefficiency in these branches. To address the general concern of many users of the DEA models, Paradi *et al.* (2011) developed a two-stage multi-dimensional (production, profitability, and intermediation) DEA model. Oral and Yolalan (1990) applied a DEA model to a set of 20 bank branches of a major Turkish commercial bank and found that service efficiency was connected to the profitability of branches. Giokas (1991) related the output measure of efficiency to the locations of branches in regions, which were classified into increasing, constant, and decreasing returns of scales. Utilizing the 190 branches in the UK, Drake and Howcroft (1994) dichotomized the productivity output measure into two factors, scale efficiency (SE) and pure technical efficiency (PTE), and found that 56.32 percent of branches were inefficient. Athanassopoulos (1998) applied a DEA model to a sample of 580 branches of a commercial bank in the UK, which decomposed efficiency into market and cost components. Portela and Thanassoulis (2007) chose the bank branches of a Portuguese bank and measured the performance of these branches by considering the branches' usage of new transactional channels, sales, customer bases, and profits. They found that operation efficiency was linked to profit. Additionally, service quality was also found to be positively correlated to either operation efficiency or profit. Schaffnit *et al.* (1997) measured cost and allocative efficiencies of the Ontario-based branches of a large Canadian bank by using outputs from transactions and maintenance measures and inputs from labor expenses.

Bank branches serve an intermediary role in the financial sector by collecting funds from depositors and through various funding sources (mainly from their creditors and equity holders) and then distributing these funds to generate various forms of financial claims, including loans to groups that are in need of capital. A branch's intermediation efficiency in this area of research emphasizes the branch's ability to lend. Attention is also placed on the quality of these loans. In this area of research, loan losses are normally treated as an input variable in order to appropriately reward those with small loan losses. Camanho and Dyson (2005) applied the production modules and value-added (intermediation) method to derive a comprehensive assessment of bank branch efficiency. Paradi *et al.* (2011) treated the intermediation efficiency as one of the three dimensions of their two-stage DEA model.

There are also interesting studies in the area of efficiency ranking among different branches in the DEA applications. Alirezaee and Afsharian (2006) ranked different branches using the DEA efficiency scores and a "balance index." Paradi *et al.* (2011) also developed a more acceptable ranking score for their multi-dimension two-stage model.

For the research that incorporates service quality into assessing branch performance, two approaches are generally applied. One approach is to directly incorporate this factor into the DEA models. The other approach is to conduct a *post hoc* analysis on the relationship between the DEA efficiency scores and the service quality reported. The studies for the first approach include the work by Soteriou and Stavrinides (1997, 2000) and by Sherman and Zhu (2006). Athanassopoulos (1997) adopted a conceptual model of the three quality dimensions (physical, interactive, and corporate) and included a quality component of effort effectiveness in his model. This model took the *post hoc* approach to incorporate the service-quality factor and was applied to 68 bank branches in Greece. Soteriou and Zenios (1999) and Portela and Thanassoulis (2007) also investigated the links between service quality and branch operating and profit efficiency by adopting a *post hoc* analysis.

Methods

For this study, we applied DEA models for measuring the relative efficiencies of a homogenous set of in-store bank branches. DEA is based on the production frontier analysis originally proposed by Farrell (1957) and then later expanded upon by Charnes *et al.* (1978) and by Banker *et al.* (1984). DEA is an approach to measure the relative efficiency of DMUs, which are distinct entities that have some flexibility in the decisions that they make while not having complete freedom or control over all decisions. DEA is commonly used to evaluate the efficiency of a number of producers and makes the assumption that if one top branch can produce (x) outputs with (y)

inputs, then a similar branch, if operating equally as efficiently, should be able to produce the same results.

To explore the mathematical property of the basic DEA model developed by Charnes *et al.* (1978), we include a linear programming DEA model with row vector ν for input multipliers and row vector υ as output multipliers for DMU_o, as shown in the following (Cooper *et al.*, 2007, p. 43):

$$(LP_o)\mathrm{Max}_{\nu,\upsilon}\upsilon y_o$$

$$\text{subject to } \nu x_o = 1$$

$$-\nu X + \upsilon Y \leqslant 0$$

$$\nu \geqslant 0,\ \upsilon \geqslant 0$$

where (X, Y) represents the input and output matrix, and (x, y) are the input and output vectors and at least partially positive.

For this study we use three DEA models: a Charnes, Cooper, and Rhodes model (CCR), a Banker, Charnes, and Cooper model (BCC), and a slack-based measure of efficiency (SBM). CCR estimates technical efficiency (TE) using constant returns to scale. BCC assesses PTE using variable returns to scale. The relationship between CCR and BCC models can be expressed as in the following: TE = PTE × SE, where SE represents scale efficiency that shows efficiency differences due to operating conditions or markets. CCR and BCC models measure proportional or radial efficiency and fail to consider the input excesses and output shortages, which are expressed by non-zero slacks. SBM addresses this issue by assessing mix efficiency (MIX) and measure efficiency as in the following: SBM efficiency = [MIX] × [PTE] × [SE]. By utilizing this relationship among CCR, BCC, and SBM, we can identify the sources of inefficiency such as slacks on variables (MIX), different operating environments (SE), and/or pure managerial issues (PTE). Because bank managers are interested in improving output variables, we chose the output-oriented BCC, CCR, and SBM models. In addition to yield efficiency scores, these models will identify slacks on input variables as well as shortages on output variables.

Data and variables

We collected data for 16 branches in a region for a month of a recent year to measure the monthly performance of the branches for internal benchmarking. We chose two inputs: full-time equivalent (FTE) number of employees and operating expenses. The number of employees was a popular measure in DEA studies for bank branches (Athanassopoulos, 1997; Oral and Yolalan, 1990; Paradi *et al.*, 2010; Porembski *et al.*, 2005; Portela and Thanassoulis, 2007; Wu *et al.*, 2006a, b). Other studies classified employees into different types and used them as inputs (Alirezaee and Afsharian, 2006; Camanho and Dyson, 2005; Cook and Hababou, 2001; Cook and Zhu, 2006; Dekker and Post, 2001; Paradi *et al.*, 2011; Schaffnit *et al.*, 1997; Sherman and Zhu, 2006; Soteriou and Stavrinides, 1997, 2000). Operating expenses or costs were also frequently chosen by bank branch studies using DEA such as Camanho and Dyson (2005) and Giokas (2008). Loan balances, deposit balances, and deposit service charges are included as output variables in this study. Banks' revenues come from two main sources: first, interest income; and second, non-interest (fee) incomes. Loans were the main sources of interest income and used as major outputs in many studies (Alirezaee and Afsharian, 2006; Athanassopoulos, 1998; Giokas, 2008; Paradi *et al.*, 2010; Sherman and Zhu, 2006;

Wu *et al.*, 2006a, b). Similar to loans, deposits also were used as variables in bank branch studies. However, unlike loans, deposits were used as inputs in some studies (Paradi *et al.*, 2010; Yavas and Fisher, 2005) or outputs in other studies (Cook and Zhu, 2006; Giokas, 2008; Sherman and Zhu, 2006; Wu *et al.*, 2006a, b). Since the ability to generate deposits could be a proxy for a branch's productivity in terms of its customer network and its potential for loan-making volume, for this paper it is appropriate to treat that ability as an output variable in the study of a community bank. Service charges were used as output variables, as they are obvious sources of non-interest income (Giokas, 2008; Oral and Yolalan, 1990). Table I shows descriptive statistics of input and output variables.

As shown in Table I, the number of each branch's total full-time employees is between two and six, while operating expenses have a range of approximately $14,000. This implies that there could be room on the input side to make adjustments to increase productivity. The range on the output variables is found to be much larger: for loans, this range is more than US$17 million; for deposits, it is over US$18 million. An interesting finding relates to the drastic range on the deposit service charged by these branches; the maximum generated revenue from this source is more than 138 times the minimum figure from a different branch.

As managers could reallocate resources (input variables) to improve revenue (interest and fee incomes), the levels of these output variables are important, as they are not only an indication of the efficiency of each branch, but also tied to the reward system for their managers. For example, a portion of a branch manager's salary is based upon a revenue-ranking incentive system that is related to the majority of these output variables in this study. By improving these performance variables, branch managers could then show the actual monetary gains that are due to their management ability.

Results and discussion

Using three DEA models – CCR, BCC, and SBM – the efficiency scores of branches were computed and decomposed. Mix and SE scores were calculated by utilizing the relationship between the efficiency scores described in the previous section. Table II shows the efficiency scores.

Four branches (1, 2, 3, and 4) are 100 percent efficient in all models. They are the frontiers of efficiency and can be used for benchmarking for other branches. Five branches (5, 6, 8, 9, and 12), are 100 percent efficient in the BCC model only. That is to say, these branches are 100 percent efficient in a pure managerial perspective. By examining mix and SE scores, which represent efficiencies on different mixes of inputs or outputs and operating conditions, respectively, sources of inefficiencies can be identified. For example, Branch 6 exhibits a low SBM score due to the low mix score (74.21 percent) or the inefficient mix of output variables. Because an output-oriented SBM model is applied, we can easily point to the output variables (between input and output variables) for the

Variable	Maximum	Minimum	Mean	SD	Type
FTE	6	2	4.5	0.93	Input
Operating expenses	32,474	18,131	23,865.3	3,425.30	Input
Loan balances	17,468,748	36,781	7,238,750.1	5,272,615.90	Output
Deposit balances	18,752,769	62,313	7,700,406.3	5,867,836.80	Output
Deposit service charges	34,139	247	17,717.1	8,979.36	Output

Table I. Descriptive statistics for variables

Branch	SBM	CCR (TE)	BCC (PTE)	MIX	SE	Benchmark by SBM
1	100.00	100.00	100.00	100.00	100.00	n/a
2	100.00	100.00	100.00	100.00	100.00	n/a
3	100.00	100.00	100.00	100.00	100.00	n/a
4	100.00	100.00	100.00	100.00	100.00	n/a
5	94.05	97.21	100.00	96.74	97.21	Branch 2
6	70.28	94.70	100.00	74.21	94.70	Branch 4
7	64.40	73.34	85.57	87.81	85.70	Branch 2
8	63.05	68.85	100.00	91.57	68.85	Branch 2
9	43.75	77.87	100.00	56.18	77.87	Branch 1
10	36.27	56.03	58.37	64.73	95.99	Branch 2
11	33.04	33.72	35.13	97.98	95.98	Branch 4
12	28.32	53.56	100.00	52.87	53.56	Branch 2
13	25.27	76.74	95.43	32.92	80.41	Branch 2
14	16.72	59.37	84.91	28.16	69.92	Branch 2
15	10.91	14.53	19.22	75.08	75.59	Branch 2
16	0.72	1.83	99.89	39.34	1.83	Branch 2
Mean	55.42	69.23	86.16	74.85	81.10	

Table II.
Efficiency scores

mix efficiency. Likewise, Branch 8 shows low SBM and CCR scores due to the low SE. In this case, we can say that market conditions are unfavorable to this branch. Branches 9 and 12 maintain low scores in both mix and SE. Accordingly, the sources of inefficiency for these two branches are output mixes and market conditions. The pure managerial score of Branch 16 is close to 100 percent, but other scores are low due to extremely low SE. Branches 10, 11, and 15 show low pure managerial or BCC scores. These branches need to improve the managerial aspect of their businesses. The last column in Table II lists a benchmark for an inefficient branch. Each inefficient branch can improve its performance by benchmarking the operations of the branch listed in the column. Among the benchmark branches in the last column, Branch 2 appears most frequently (nine out of a possible 12). For details about what and how to improve, we should look at projections of variables. Table III displays the variables to improve for the branches projected by the SBM model.

SBM models compute efficiency scores by measuring slacks on variables. DMUs without slacks are said to be efficient. Slacks, which represent underutilized resources or output shortages, are converted to projections in percentage for the variables as shown in Table III. Branches 5 through 16 have slacks in their input variables and suffer shortages in their output variables. Because the manager of a branch is interested in the output variables, we estimate output shortages using an output-oriented SBM model. The results show that the most improvement can be gained district-wide by an increase in loan balances, deposit balances, and service charges. Branch 16 shows the most room for improvement based upon outputs while Branch 8 has the most room to modify its inputs through an FTE reduction or utilization. An unexpected result shows that Branches 1, 2, 3, and 4 should actually reduce their outputs by reducing their loan balances, deposit balances, and/or deposit service charges. This is perhaps due to the overutilization of a not-so-productive mixture of input variables.

The last topic of interest lies in which variable influences efficiency scores most, second most, and so on. To address this topic, a Tobit regression model is employed by regressing the efficiency scores that are transformed with a natural logarithmic function and then exported as variables in the SBM model. A Tobit regression is suitable for analysis with a

DMU	FTE	Operating expenses	Loan balances	Deposit balances	Service charges
1	0	0	−28.00	−37.45	0
2	0	0	0	0	−37.62
3	0	0	0	−22.27	0
4	0	0	0	0	−8.99
5	−13.57	0	0	0	18.98
6	0	−1.70	106.16	20.72	0
7	−21.50	0	118.22	47.64	0
8	−30.90	0	110.62	65.19	0
9	−12.93	0	29.76	355.99	0
10	−3.39	0	205.96	305.40	15.76
11	0	0	190.73	120.78	296.48
12	−24.45	0	343.21	416.00	0
13	−2.73	0	570.65	316.60	0
14	−16.48	0	972.12	522.14	0
15	−15.91	0	999.90	920.45	325.53
16	0	−27.07	999.90	999.90	999.90
Mean	−8.87	−1.80	288.70	251.94	106.45
Type	Input	Input	Output	Output	Output

Note: Negative numbers denote potential improvement by decreasing input or output

Table III. The potential improvement in percentage by the SBM model

censored dependent variable. In addition, we have to transform the efficiency scores with a natural logarithmic function for making them censored on only one side (e.g. right-censored in this case), as is required by a Tobit regression. Table IV exhibits the result of this Tobit regression.

Among the variables, FTE employees and service charges are statistically significant for explaining the dependent variable or efficiency measured with an SBM model. The number of FTE employees is positively correlated with the efficiency scores, meaning that branches with more employees perform better than branches with fewer employees. This finding could result from the fact that the bank assigns employees to branches based on their business volumes, such as number of transactions, deposit balances, so on. The remaining three variables (operating costs, loan balances, and deposit balances) in this paper are unfortunately found to be not significant statistically. These variables have been frequently used by the literature (as stated in the data and variable section) and proved to be appropriate output variables in either theoretical or practical framework for bank management, so the insignificance found here is likely related to the sample size of our data set in this study. We suspect that these variables are not significant because of the small sample size that includes only 16 branches in this study. Thus, this unexpected insignificance is not due to the technical issue of analysis but

Variable	Coefficient	SE	*z*-Value	*p*-Value
FTE	4.860e−01	2.547e−01	1.908	0.068*
Operating costs	−3.458e−05	8.586e−05	−0.403	0.691
Loan balances	1.533e−07	9.410e−08	1.630	0.116
Deposit balances	−3.210e−08	9.345e−08	−0.344	0.734
Service charges	5.821e−05	2.807e−05	2.074	0.049**

Notes: *Significant at $\alpha = 0.10$; **significant at $\alpha = 0.05$

Table IV. Tobit regression results

due to the sensitivity of data disclosure. The method introduced in this study, moreover, contributes to the bank industry a useful technique with which to examine its operation efficiency. We suggest future studies to include more observations and further suggest that regulators should enforce rules to make various bank data available.

Conclusion

Retail banking has changed drastically within the last few years, resulting in the use of smaller and more cost-efficient, in-store banking branches placed inside major retail and grocery stores. Making sure that these branches operate efficiently is an important task to both senior management and branch managers. This paper employed three DEA models – CCR, BCC, and SBM – for measuring the efficiency of 16 branches of a US bank. We identified efficient and inefficient branches (along with related potential improvements) using pertinent variables, and also confirmed that the number of full-time employees and the amount of service charges were statistically significant for explaining the efficiency of the bank branches. Using internal data that is seldom accessible by the general public, this paper provided a valuable initial data examination on a representative bank's internal operation. It not only demonstrates a practical way to measure and benchmark branch operations, but also contributes to the bank industry the groundwork for underperforming branches to create action plans to enhance their performance in output variables, which could easily be incorporated into a manager's monetary rewards or the promotion standards adopted at each bank. Future studies are encouraged to further explore the methods and techniques presented in this paper.

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