Full Length Research Paper

Measuring bank branch performance using Data Envelopment Analysis (DEA): The case of Turkish bank branches

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The aim of this study is to develop a performance model for measuring the relative efficiency and potential improvement capabilities of bank branches by identifying their strengths and weaknesses. Another purpose is to investigate the production and profitability aspects of branches. Under both production and profitability approaches, efficiency characteristics of branches, which are grouped according to different sizes and regions, have similar tendencies. In both analyses, it is apparent that branch size and scale efficiency are related to each other. As branch size increases scale efficiency increases too and after the most productive scale size, however, as size increases efficiency decreases. Too small and too large branches need special attention. Putting production and profit efficiency scores on two scales reveals the performing characteristics of branches. Each region needs different handling. Branches with low production-low profit efficiency should be evolved towards high production-high profit efficiency region.

Key words: Data envelopment analysis, bank branch performance, efficiency, technical efficiency, pure technical efficiency, scale efficiency.

INTRODUCTION

Data Envelopment Analysis (DEA) is a non-parametric performance measurement tool that can be used for analysis and decision making in branch banking. That is because not only it sorts branches according to their performances but also provides much more information that cannot be investigated with other methods such as ratio analysis. The most common strengths of DEA include that it benchmarks branches, it provides potential improvement capabilities, it indicates sources of inefficiency and it takes management preferences into account when measuring performances.

By employing DEA, different aspects of branch efficiency can be further analyzed. Production approach analyses branches' success at producing deposits, loans and other products by making use of some resources like personnel and other expenditures. Profitability approach measures the efficiency of using resources to maximize profit of a branch. In operational approach, mostly transaction side of a branch is measured. Intermediation approach estimates the efficiency of converting deposits into loans. Inputs and outputs are specified in accordance with what we want to learn about branch. Production efficiency, profitability efficiency, operational efficiency and intermediation efficiency can separately be studied and they can also be combined into a single model having multiple dimensions. All dimensions constitute a model and provide an analysis and decision making tool for management.

The first aim of this study is to develop a performance model for measuring the relative efficiency and improvement capabilities of bank branches by identifying their strengths and weaknesses. Another purpose is to investigate the production and profitability dimensions of branches in order to reveal their performing characteristics.

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Data envelopment analysis

Frontier based efficiency measurement goes back to Farrell (1957) who proposed a model that can be applied from a sector to a whole economy. Not only developed a technique to measure the overall efficiency but also he divided the efficiency into its components. Charnes et al. (1978) (CCR) put into practice Farrell's view for the first time and named the model as Data Envelopment Analysis. The CCR model of DEA assumes frontier to have Constant Returns to Scale (CRS) characteristics. Banker et al. (1984) (BCC) relaxed CRS assumption and introduced VRS frontier. After these two basic models, many variations, options, contributions, Slack Based Models, Free Disposal Hull, Stochastic DEA, Network DEA, Dynamic DEA, Super Efficiency Models etc, have also been developed.

DEA measures efficiency of a Decision Making Unit (DMU) by maximizing the ratio of weighted outputs over weighted inputs. This ratio is normalized according to best practical peers and efficiency is calculated to be between 0 and 1, as 1 representing efficient unit. To solve the problem, fractional ratio is first converted to linear form and then the dual case is measured with simplex method of linear programming. By benchmarking, either input minimization or output maximization (or both, non-oriented) is intended. Preferences about inputs and outputs and external factors effecting efficiency can be incorporated into model. Historical progress of efficiency can also be calculated.

LITERATURE REVIEW

After the article of Sherman and Gold (1985), numerous studies have been conducted on bank branch efficiency worldwide. Due to the fact that it is easier to attain publicly available data at bank level, the number of bank performance measurement studies is greater than branch efficiency studies. Fethi and Pasiouras (2009) specify 136 studies that use DEA-like techniques to estimate bank efficiency, while only 28 studies about branch efficiency are listed. Of the 28 studies, 17 adopt production and 12 adopt intermediation approach. Paradi et al. (2004) also, list 42 studies, of which 23 use CCR, 13 use BCC and the remaining 6 use both. Although, early studies measured extent and sources of inefficiencies and aimed to minimize operational costs by looking at optimal operational structure, recent studies have developed new perspectives to raise awareness about different dimensions of branch operations. And also, hybrid applications of DEA and other methods have been put into practice. This provides valuable information for management to implement required strategies according to problematic area.

Manandhar and Tang (2002) incorporated intangible aspects, e.g. the internal service quality, into DEA. They considered internal service quality, operating efficiency and profitability as dimensions of performance. Portela and Thanassoulis (2007) analyzed the three dimensions of branch performance: Usage of new transaction channels, efficiency in increasing sales and customer base and generating profits. Relations between operational and profit efficiencies and also transactional and operational efficiencies were identified. Comparison of different dimensions allows us to see superior and inferior branches. They found positive links between operational and profit efficiency and also between transactional and operational efficiency. Service quality is positively related with operational and profit efficiency.

Giokas (2008a) also studied the efficiency of 44 branches in Greece by searching three perspectives: Efficiency in managing the economic record of the branches (production efficiency), efficiency in meeting the demand for transactions with customers (transaction efficiency) and efficiency in generating profits (profit efficiency). All models indicated that there is a scope for substantial efficiency improvements and again all models identified essentially the same worst performing branches. Gaganis et al. (2009), in first stage, examined the profit efficiency, the effect of risk factor (loan loss provisions) on profit efficiency and the Total Factor Productivity (TFP) change. In the second stage they analyzed the impact of some internal and external parameters, such as personnel, income per capita, loans to total assets ratio, loans to deposit ratio, return on assets, on efficiency.

Paradi et al. (2010) evaluated the bank branch efficiency in two stages. From the point that a single-perspective evaluation cannot fully reflect a branch's multi-function nature, they first measured production, profitability and intermediation efficiency of branches and then aggregated the results with modified Slack Based Model to generate a composite performance index for each branch. Oral and Yolalan (1990) studied the operational efficiency of 20 Turkish commercial bank branches. They indicate that DEA is complementary to traditional financial ratios method and also it is a useful tool in reallocating resources between the branches in order to achieve higher efficiencies.

To have a general view and constitute our models and to decide for input and output parameters, a comprehensive literature review has been conducted. 39 articles, published after 2000 and containing more than 49 studies/ approaches were analyzed (Table 1). In 33 studies production/operation approach, in 7 studies profitability approach is used. In 27 studies CCR and in 29 studies BCC model is employed. In 36 studies input oriented and in 12 studies output oriented approaches are considered. Average number of inputs is 3.9 and, depending on the accepted approach, the most used inputs are related to employee, other operating expenses, rental area or expenses and other equipments. Outputs have wider range of diversity with an average number of 4.7.

Table 1. Studies about bank branch performance published after year 2000.

		Total	Paradi et al	Meepadung et al.	Gaganis et al.	Yang	Lin et al.	Giokas	Giokas	Camanhoa and Dyson	Noulas et al.	McEachern and Paradi	Das et al.	Portela and Thanassoulis	Yang and Paradi	Shermana and Rupert	Camanhoa and Dyson	Wu et al.	Wu et al.	Howland and Rowse
PUBLICATION	Year		2010	2009	2009	2009	2008	2008	2008	2008	2008	2007	2007	2007	2006	2006	2006	2006	2006	2006
	Country		CND	THA	GRE	CND	TAIW	GRE	GRE	POR	GRE	INT	IND	POR	CND	USA	POR	CND	CND	CND
	No. of branch		816	165	458	240	117	171	44	39	58	138	222	57	70	217	144	808	142	162
I/O	Avg / No. of Inputs	3.9	6 5 9	9 4	3	4	4	3	2 2 2	4	2	3 3	4		2 3	3	4 2	7	2	4
	Avg / No. of Outputs	4.7	7 6 9	2 8	2	9	3	3	2 3 3	4	4	2 2	3	4 4	7 3	4	7 4	6	3	4
APPROACH	Production/Operation	33		x	x	x		x	x x	x		x			x x	x	x	x		x
	Intermediation	7		x							x		x	x					x	
	Profitability	7	x		x	x							x							
	Other	6			x			x												
DEA MODEL	CCR	27	x x x				x	x			x	x	x		x	x		x	x	
	BCC	29	x x x		x	x	x	x	x x x					x	x	x	x	x		x
	Other DEA	11			x					x			x	x		x	x			
	Others (FDH or Modified)	8												x	x			x	x	
ORIENTATION	Input	36	x x x		x	x		x	x x x	x	x	x x	x		x	x	x	x	x	x
	Output	12		x				x						x	x x					x
	Non-oreinted	5												x						
INPUTS	Personnel related	46	x	x	x	x	x	x	x x x	x	x	x	x	x	x	x	x	x	x	x
	Nonpersonnal Oper. Exp.	32	x		x	x		x	x x x	x	x		x	x		x	x	x	x	x
	Location (area, rent etc)	15						x							x x		x			x
	Equipments	13	x		x									x	x x	x	x			
	Loan losses	5	x	x	x															
	Interest expenses	5			x		x	x					x							
	Input Prices	1												2006						
	Environmental factors	7		x										CND		x		x		x
	Others	8		x	x x		x			x				162			x			

Table 1. Contd.

PUBLICATION	Author(s)	Total	Paradi et al	Meepadung et al.	Gaganis et al.	Yang	Lin et al.	Giokas	Giokas	Camanhoa and Dyson	Noulas et al.	McEachern and Paradi	McEachern and Paradi	Das et al.	Portela and Thanassoulis	Yang and Paradi	Shermana and Rupert	Camanhoa and Dyson	Wu et al.	Wu et al.	Howland and Rowse
	Year		2010	2009	2009	2009	2008	2008	2008	2008	2008	2007	2007	2007	2007	2006	2006	2006	2006	2006	2006
	Country		CND	THA	GRE	CND	TAIW	GRE	GRE	POR	GRE	INT	INT	IND	POR	CND	USA	POR	CND	CND	CND
	No. of branch		816	165	458	240	117	171	44	39	58	138	138	222	57	70	217	144	808	142	162
OUTPUTS	Deposit balance	28	x	x	x			x		x		x	x	x	x	x	x	x	x	x	x
	Loan balance	26	x	x	x		x	x		x	x			x	x	x	x	x	x	x	x
	No of deposit acc. or trans.	16		x			x				x	x			x						
	No of loan acc. or trans.	13		x			x				x	x			x						
	Other transactions	25		x	x		x				x		x	x	x	x	x	x			
	Interest income	9				x	x		x					x							
	Non interest income	18	x		x	x	x	x	x	x				x	x			x		x	
	Profit	5		x												x					
	Other products	14	x	x	x						x		x				x	x			x
	Service quality factors	4																			x
	Others	13				x									x	x	x	x	x		

PUBLICATION	Author(s)	Total	Sherman and Zhu	Yang	Yang et al.	Yang	Porembski et al.	Portela and Thanassoulis	Camanho and Dyson	Barth and Staat	Sowlati and Paradi	Paradi and Schaffnit	Yang and Paradi	Portela et al.	Pastor et al.	Fiala et al.	Drake	Hartman et al.	Dekker and Post	Cook and Hababou	Sevcovic et al.	Cook et al.	Athanassopoulos and Giokas
	Year		2006	2006	2005	2005	2005	2005	2005	2005	2004	2004	2003	2003	2003	2003	2002	2001	2001	2001	2001	2000	2000
	Country		USA	CND	UK	CND	GRM	POR	POR	GRM	CND	CND	CND	POR	EUR	CZE	UK	SWD	NET	CND	SLV	CND	GRE
	No. of branch		200	1097	14	766	142	57	144	31	79	90	70	24	573	81	190	50	314	20	37 / 591	20	47
I/O	Avg. / No. of inputs	3.9	4	3	5	4	2	2	7	3	3	9 8	3	2	4	3	6	4	2	4	4 3	4	3 6
	Avg. / No. of outputs	4.7	8	9	2	6	11	4	1	8	4	6 4	4	3	8	3	7	3	1	6	3 4	4	4 7

Table 1. Contd.

PUBLICATION	Author(s)	Total	Sherman and Zhu	Yang	Yang et al.	Yang	Porembski et al.	Portela and Thanassoulis	Camanho and Dyson	Barth and Staat	Sowlati and Paradi	Paradi and Schaffnit	Yang and Paradi	Portela et al.	Pastor et al.	Fiala et al.	Drake	Hartman et al.	Dekker and Post	Cook and Hababou	Sevcovic et al.	Sevcovic et al.	Cook et al.	Athanassopoulos and Giokas
	Year		2006	2006	2005	2005	2005	2005	2005	2005	2004	2004	2003	2003	2003	2003	2002	2001	2001	2001	2001	2001	2000	2000
	Country		USA	CND	UK	CND	GRM	POR	POR	GRM	CND	CND	CND	POR	EUR	CZE	UK	SWD	NET	CND	SLV	SLV	CND	GRE
	No. of branch		200	1097	14	766	142	57	144	31	79	90	70	24	573	81	190	50	314	20	37	591	20	47
APPROACH	Production/Operation	33	x	x		x	x			x	x		x	x	x	x	x	x		x		x	x	x
	Intermediation	7						x																x
	Profitability	7																	x		x			
	Other	6			x				x			x											x	
DEA MODEL	CCR	27	x	x		x	x	x	x		x	x	x	x		x	x	x					x	x
	BCC	29		x		x	x	x		x	x	x			x	x	x	x			x	x		
	Other DEA	11						x	x										x		x	x	x	
	Others (FDH or Modified)	8			x										x	x			x					
ORIENTATION	Input	36	x	x		x	x		x		x	x	x	x		x		x		x	x	x		x
	Output	12			x		x			x		x					x						x	x
	Non-oriented	5						x	x						x				x					
INPUTS	Personnel related	46	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Non-personnal Oper. Exp.	32	x			x		x		x		x	x	x	x	x	x	x				x	x	x
	Location (area, rent etc)	15				x	x			x		x	x			x	x	x					x	x
	Equipments	13	x			x						x	x	x		x	x							x
	Loan losses	5										x			x									
	Interest expenses	5													x									
	Input prices	1							x															
	Environmental factors	7						x		x		x	x											
	Others	8			x																x			

PUBLICATION Author(s)	Total	Sherman and Zhu	Yang	Yang et al.	Yang	Porembski et al.	Portela and Thanassoulis	Camanho and Dyson	Barth and Staat	Sowlati and Paradi	Paradi and Schaffnit		Yang and Paradi	Portela et al.	Pastor et al.	Fiala et al.	Drake	Hartman et al.	Dekker and Post	Cook and Hababou	Sevcovic et al.	Cook et al.	Athanassopoulos and Giokas
Year		2006	2006	2005	2005	2005	2005	2005	2005	2004	2004		2003	2003	2003	2003	2002	2001	2001	2001	2001	2000	2000
Country		USA	CND	UK	CND	GRM	POR	POR	GRM	CND	CND		CND	POR	EUR	CZE	UK	SWD	NET	CND	SLV	CND	GRE
No. of branch		200	1097	14	766	142	57	144	31	79	90	70	24	573	81	190	50	314	50	314	591	20	47
OUTPUTS Deposit balance	28	x			x		x				x	x	x		x	x		x				x	x
Loan balance	26				x		x			x	x	x	x	x				x					x
No of deposit acc. or trans.	16	x	x			x								x	x		x			x		x	x
No of loan acc. or trans.	13		x			x								x	x		x			x			x
Other transactions	25	x	x			x		x			x	x	x	x	x	x		x				x	x
Interest Income	9								x		x			x	x						x		
Non-interest income	18			x					x		x	x									x		x
Profit	5											x			x				x			x	
Other products	14	x	x			x				x					x		x						x
Service quality factors	4	x		x					x														
Others	13	x	x				x		x		x				x					x			

with an average number of 4.7. The most used outputs are value/number of deposits, loans, non-interest income and commissions and account/transaction numbers. Table 1, naturally, does not reflect about how to implement the model. Specifying inputs and outputs, deciding the model and orientation depend on the purpose of the research.

METHOD AND DATA ANALYSIS

In this study 128 bank branches located in Istanbul City and Thrace region of Turkey are handled. All these branches employ the same inputs and produce the same outputs and operate in a similar environment. For production approach 3 inputs and 8 outputs, for profitability approach the same 3 inputs and 2 outputs are used. 2007 year-end data of inputs and outputs and descriptive statistics are listed in Table 2. Since non interest income is assumed to be an index, covering all items other than interest bearing products, it is also included in production approach as an output. Management is assumed to have control on all parameters. Service quality and customer satisfaction are two important aspects in banking sector. Since we could not obtain any regular data about service quality and its measurement is not covered by the scope of this study, no service quality parameter is included in our calculations.

First, by considering production approach and using output oriented CCR and BCC models, technical, pure technical and scale efficiency of branches are calculated. By benchmarking efficient and inefficient branches, their references and improvement capabilities are measured.

Branches are grouped according to different size (small, medium and large) and regional properties and their efficiencies are calculated and analysed accordingly. For size classification, a set of criteria such as; weighting time deposits 43%, demand deposit 12%, loans 25%, profit 10%, volume of treasury accounts 5% and ratio of non interest income to operation cost 5%,is used. By applying BCC model and calculating scale efficiency, returns to scale characteristics of branches are also determined. As discussed in Sherman and Zhu (2006) Returns To Scale (RTS) characteristics of a DMU may be different in input and output orientations. All branches on Variable Returns to Scale (VRS) frontier (pure technically efficient) have the same RTS characteristics according to input and output orientation. But the branches that are not on VRS frontier (non efficient or projected branches) may have different RTS characteristics according to input and output orienta-tion. At this point, running BCC model with input and output

Table 2. Inputs and outputs of production and profitability approaches and descriptive statistics.

Input and output of production and profitability		Max	Min	Average	SD	Coeff. of Var.
Inputs of both approaches	Personnel expenses	1,785	168	710	346	0.487
	Operating expenses	1,209	69	311	205	0.659
	Loan losses	2,608	0	93	267	2.871
Outputs of production approach	Demand deposits	165,959	572	8,345	17,608	2.110
	Time deposits	455,663	2,538	79,142	73,610	0.930
	Demand FX deposits	9,050	12	2,017	1,835	0.910
	Time FX deposits	45,728	112	10,096	8,399	0.832
	Commercial loans	39,093	90	4,321	5,445	1.260
	Consumer loans	39,710	769	9,949	6,555	0.659
	No of total transaction	857,195	32,356	226,633	124,185	0.548
	Non-interest income	4,430	108	1,060	827	0.780
Outputs of profitability App.	Net interest income	29,520	174	2,485	3,355	1.350
	Non Interest Income	4,430	108	1,060	827	0.780

orientations helps us to locate the branches on input-output plane. We can see the RTS consistency in different orientations. The branches which do not operate on most productive scale size and their properties are discussed. Large branches are expected, mostly, to lie on Decreasing Returns to Scale (DRS) region and small branches on Increasing Returns to Scale (IRS) region. A branch should be treated according to RTS characteristics that it posses. The results of efficiency and RTS characteristics imply that there is a relationship between efficiency and size of the branches. This relationship is also analyzed.

Then all the procedures are repeated under profitability approach, with three inputs and two outputs. The results of profitability and production approaches are compared to see the differences and similarities. Next, efficiency scores coming from production and pro-fitability approaches are compared and branches are categorized into four groups based on low production-low profit, low production-high profit, high production-low profit and high production-high profit efficiency. Together with the analysis of branches, new strategies are proposed for relatively inefficient branches. Because of page constraints, branch efficiency measurements are not presented in this paper. Instead, results of each model are condensed into a different column of Table 3.

EMPIRICAL RESULTS

Measuring technical efficiency in production approach

Efficiency analysis of production approach with CCR model shows that 52 (41%) branches are technically efficient with an average of 0.896 (1st column of Table 3). In spite of high average efficiency, 76 (59%) of 128 branches are not technically efficient. This implies that they should produce more outputs at a given set of input level (or use less inputs to produce the same outputs), compared to their peers. And also, they should produce at right scale to become efficient. Technical efficiency

measures the branches' overall success at utilizing their inputs by feasible input to output conversion and operating at right returns to scale.

Large branches seem more technically efficient than small branches. Since large branches are mostly located in Istanbul where the population density is high, they have a geographic advantage and their average efficiency figures become higher. Large branches have deposits and credits in greater amounts, which result in more income as well as other income related products. Higher values are transacted with comparatively less personnel and operating costs. Table 4 shows the improvement potentials of inputs and outputs. Output oriented model indicates that outputs can be increased from 12.9 to 24.5% further. Although, model is run in output maximization mode, still 0.7 to 26.1% reduction is proposed for inputs. This implies that even for branches that are projected to efficient frontier, still there is excess usage of inputs.

Measuring pure technical efficiency in production approach

In literature, there is not a consensus on RTS characteristics of branches. Paradi et al. (2004) states that branches have CRS characteristics. In some studies non parametric tests are conducted on results of CCR and BCC models to determine the VRS validity (Giokas, 2008b). In some other studies simply CCR and BCC re-sults are compared. If BCC results are very close to CCR results, branches are assumed to show CRS property (Wu et al., 2006a, b; Yang, 2005; Yang and Paradi, 2006).

In our study, Kolmogorov–Smirnov test showed that CCR and BCC results come from different distributions,

Table 3. Results of production and profitability approaches with different DEA models.

	Production approach			Profitability approach		
	(1) TE (CCR)	(2) PTE (BCC)	(3) Scale (CCR/BCC)	(4) TE (CCR)	(5) PTE (BCC)	(6) Scale (CCR/BCC)
No. of eff. br.	52 (41%)	78 (61%)	52 (41%)	11 (9%)	24 (19%)	11 (9%)
No. of ineff. br.	76 (59%)	50 (39%)	76 (59%)	117 (91%)	104 (81%)	117 (9%1)
Average	0.896	0.939	0.954	0.526	0.641	0.842
SD	0.125	0.102	0.082	0.217	0.238	0.179
Maximum	1.000	1.000	1.000	1.000	1.000	1.000
Minimum	0.558	0.567	0.604	0.156	0.192	0.156
Istanbul 1	0.929	0.961	0.966	0.615	0.680	0.889
Istanbul 2	0.869	0.920	0.945	0.466	0.569	0.844
Istanbul 3	0.888	0.936	0.951	0.500	0.662	0.804
Large	0.937	0.966	0.970	0.625	0.711	0.882
Medium	0.921	0.938	0.982	0.522	0.562	0.929
Small	0.851	0.924	0.922	0.469	0.659	0.751
Istanbul City	0.903	0.936	0.964	0.543	0.616	0.881
Thrace Region	0.865	0.951	0.913	0.461	0.741	0.687

therefore both models are applicable. CCR model measures the distance of a branch to CRS frontier. Actually this reflects the inefficiency of that branch and measurement is normalized with efficient branch to express the efficiency score between 0 and 1. Efficiency measured with CCR model is defined as technical efficiency and it represents a total efficiency consisting pure technical efficiency and scale efficiency, BCC model, on the other hand, measures the pure technical part of efficiency. By using BCC model, together with CCR, scale efficiency can also be calculated. Pure technical efficiency shows the success of management at input to output "conversion" while scale efficiency reflects the success at working at right scale. Pure technical efficiency values are higher than technical efficiency, as expected. 78 branches become pure technically efficient and the average increases to 0.939 (2nd column of Table 3). Pure technical efficiency shows how much a branch can radically increase its outputs when projected to VRS frontier while still remaining at the same input level. Pure technical efficiency measures the scale excluded part of technical efficiency. Since input and output combination does not refer to efficient frontier, this also implies some managerial deficiencies. To become purely efficient, a branch should evolve its input-output combination in such a way that it falls on to VRS frontier.

Scale efficiency in production approach

Scale efficiency measures how much a branch can

improve its efficiency by being projected from VRS to CRS, that is the ability of further increasing its outputs radically. Scale efficiency reflects the success of a branch whether it operates at the right returns to scale or not. For a branch to become scale efficient it should increase its outputs further to reach the most productive scale size. Mostly small branches appear to have scale inefficiency because of IRS characteristics of small operation size. To be efficient, they should increase their transaction volume. Merging small branches which are close to each other may also be considered. Scale inefficiency in large branches may result from DRS characteristics. To increase scale efficiency, opening new branches in close hinterland of large branches may also be considered. Large branches have 0.970, medium branches have 0.982 and small branches have 0.922 average scale efficiencies (3rd column of Table 3). Although, not listed here, 13 of 15 most inefficient branches are small and the other 2 are large branches. These findings imply that some kind of relationship may exist between branch size and efficiency, and between branch size and RTS.

Branch size and RTS characteristics in production approach

On VRS efficient frontier, 18 branches show IRS, 52 show CRS and 8 show DRS characteristics. IRS branches mostly include small and DRS branches large ones, as expected. After projecting 6 branches to CRS, 58 will operate at most productive scale size (Table 5). Even after

Table 4. Sum of improvement potential implied by CCR model.

Inputs and outputs	Sum of data	Projection	Difference	%
Personnel Exp.	90.873	90.220	-653	-0.7
Operating Exp.	39.836	37.981	-1.855	-4.7
Loan losses	11.959	8.835	-3.124	-26.1
Demand Dep.	1.068.168	1.250.975	182.807	17.1
Time deposits	10.130.170	12.025.124	1.894.954	18.7
Demand FX Dep.	258.159	314.476	56.317	21.8
Time FX Dep.	1.292.233	1.517.915	225.682	17.5
Com. loans	553.097	688.699	135.602	24.5
Cons. loans	1.273.430	1.518.026	244.596	19.2
Total no of Trans	29.009.055	32.754.791	3.745.736	12.9
Non Interest Inc.	135.683	157.573	21.890	16.1

Table 5. RTS characteristics of branches.

RTS	Size	Eff. br.	Projected br.	Total
IRS	Large	1	4	5
	Medium	2	15	17
	Small	15	21	36
CRS	Large	17	-	17
	Medium	19	4	23
	Small	16	2	18
DRS	Large	7	4	11
	Medium	1	-	1
	Small	-	-	-
Total		78	50	128

projection to VRS, still 70 branches do not fall on CRS frontier. The RTS properties of a branch guide us about how to handle it. If it is on IRS region, increasing inputs, if it is on DRS region, decreasing inputs may be preferable. Figure 1 shows the RTS region of branches. RTS characteristics of 125 branches are same in both input and output orientation.

Relationship between branch size and efficiency in production approach

To analyze the relationship between branch size and efficiency, since 100% efficient branches cannot be sorted, only scale inefficient 75 branches are considered. Branches are sorted by size from smaller to larger and by efficiency from inefficiency to efficiency (Figure 2). When we consider all 75 branches, Spearman's rank correlation is calculated as 0.305. This indicates not a strong but slightly positive correlation. However, when we look at Figure 2, as the size increases the scale efficiency increases and after a certain point, as the size continue

to increase efficiency decreases. That is why it seems more feasible to divide branches into two groups. Spearman's rank correlation is calculated as 0.510 for the first 50 branches and -0.354 for the next 25. Both represent a stronger relation. In the first part as branch size increases efficiency increases, in the second part as branch size increases efficiency decreases. The small branches at one end and large branches at the other end should be separately handled and analyzed. Same analysis is conducted with profitability approach and correlations are calculated as 0.404 (for 117 branches), 0.631 (for 80 branches) and -0.579 (for 37 branches), respectively. The results are almost parallel with the findings of Drake (2002), Camanhoa and Dyson (1999), Porembski et al. (2005) and Lin et al. (2009) that analyzed bank branch efficiency in this manner.

Measuring technical efficiency in profitability approach

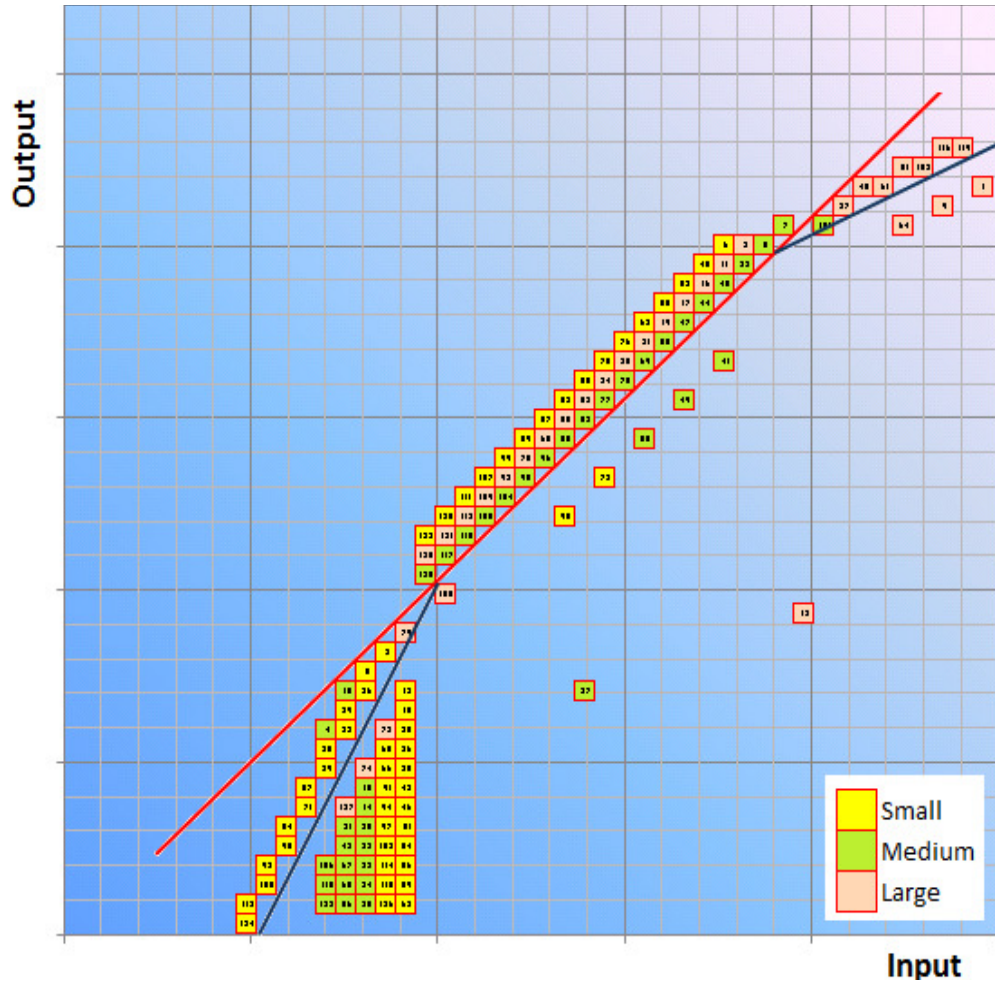In profitability approach, average efficiency is calculated

Figure 1. RTS region of branches according to input and output orientation.

as 0.526. Pure technical and scale efficiencies are measured as 0.641 and 0.842 respectively (Column 4, 5, 6 in Table 3). According to profitability approach, 117 branches are measured as technically efficient and 104 branches as scale inefficient. Under both production and profitability approaches technical and scale efficiency characteristics of branches, grouped according to different sizes and regions, show similar tendencies. In both analyses, it is apparent that branch size and scale efficiency are related to each other. As size gets larger, scale efficiency increases and after the most productive scale, as size increases efficiency decreases.

Comparing production efficiency with profitability efficiency

Putting scores on production and profit efficiency scales shows the working characteristics of branches (Figure 3). When separation branches to indicate the low productive-low profitable, low productive-high profitable, high productive-high profitable, high productive-low profitable

efficient branches, it is reasonable to put the separation level to about average efficiency points. Therefore we analyze the production and profitability efficiency of branches whether they are below or above of 90 and 50%, respectively. The correlation between production efficiency and profitability efficiency is calculated as 0.614. A positive interaction between productivity and profitability, at least in general, is reasonable. A productive branch is expected to be profitable also. Branches with low production-low profit efficiency should carefully be investigated and they should be evolved towards high production-high profit efficiency region or should be considered for moving to another location. Depending on the region separation point, 44 branches' production and profitability efficiencies are below 90 and 50%, respectively. They can be classified as non productive and non profitable. Br036 at bottom-left may represent this group. It is one of the smallest branch and when we deeply analyze its data, we realize that outputs of this branch are really very low.

Branches with low production-high profit efficiency have the potential for more profit and in addition to production
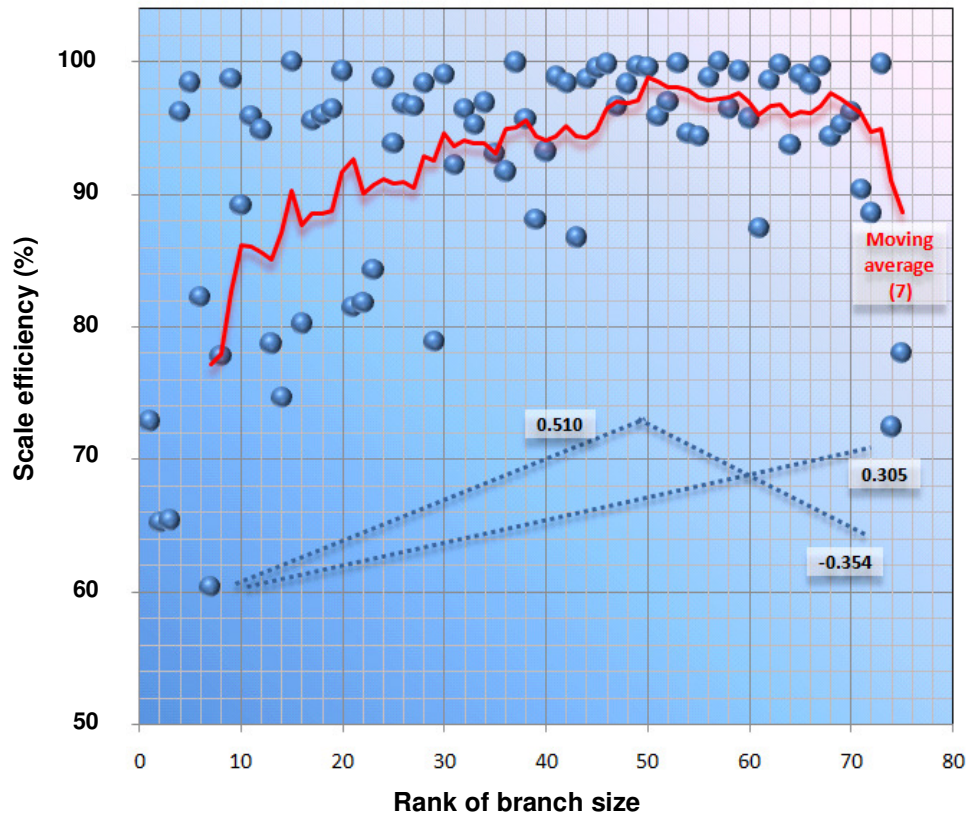
Figure 2. Branch size order and scale efficiency.

side they should be analyzed for higher profits. They make high profits with low production and they are expected to have high production efficiency also. High profit efficiency mostly results from comparatively advantageous environmental conditions and not necessarily from high management quality. 6 branches' production efficiency is below 90%, but profit efficiency is equal or above 50%. Br037 is an example of this region. When analyzed, we see that it is a large branch in a comparatively big city. The bank has only one branch in that city and this brings comparatively profitable transactions in addition to high net interest and non-interest income with relatively small business volume.

Branches with high production and high profit efficiency are at the target zone that others should achieve. These branches convert inputs into outputs satisfactorily and make higher profits in comparison to their peers. 47 branches' production and profit efficiency is above 90 and 50%, respectively. Especially 11 of them (Br021, Br028, Br044, Br048, Br052, Br055, Br060, Br098, Br099, Br109 and Br123) are 100% efficient both in terms of production and profitability. When closely analyzed, 5 of them are really big branches located in the heart of city, with huge amount of transaction and big customers. Of 100% efficient 11 branches, 4 are small and 2 are medium branches.

The number of branches with high production-low profit

efficiency is also relatively low. 31 branches fall into this category. They may accomplish high volumes of non profitable transactions. Typically these branches are characterized with high deposit, credits and transaction volume. But because of low profit margin, either due to high competition or overburdened non-profitable active-ties, their income is not satisfactory. Non-profitability may also results from loan loss provisions. These branches should canalize their intensive 'junk' transactions into alternative distribution channels, like internet banking, ATMs, call centres, and concentrate more on value added products. High production and low profit efficiency may also result from intensive competition. One of the biggest branch Br112 typically represents this group. These branches should be specially handled to achieve profitable transactions.

Conclusion

DEA has been used more extensively for measuring the performance of bank branches. It is an important method that should also be utilized as an analysis and decision making tool in branch banking. Its flexibility provides valuable information depending on the analyst's point of view. DEA shows the way to go for inefficient branches by comparing them with peers. This study specifies a
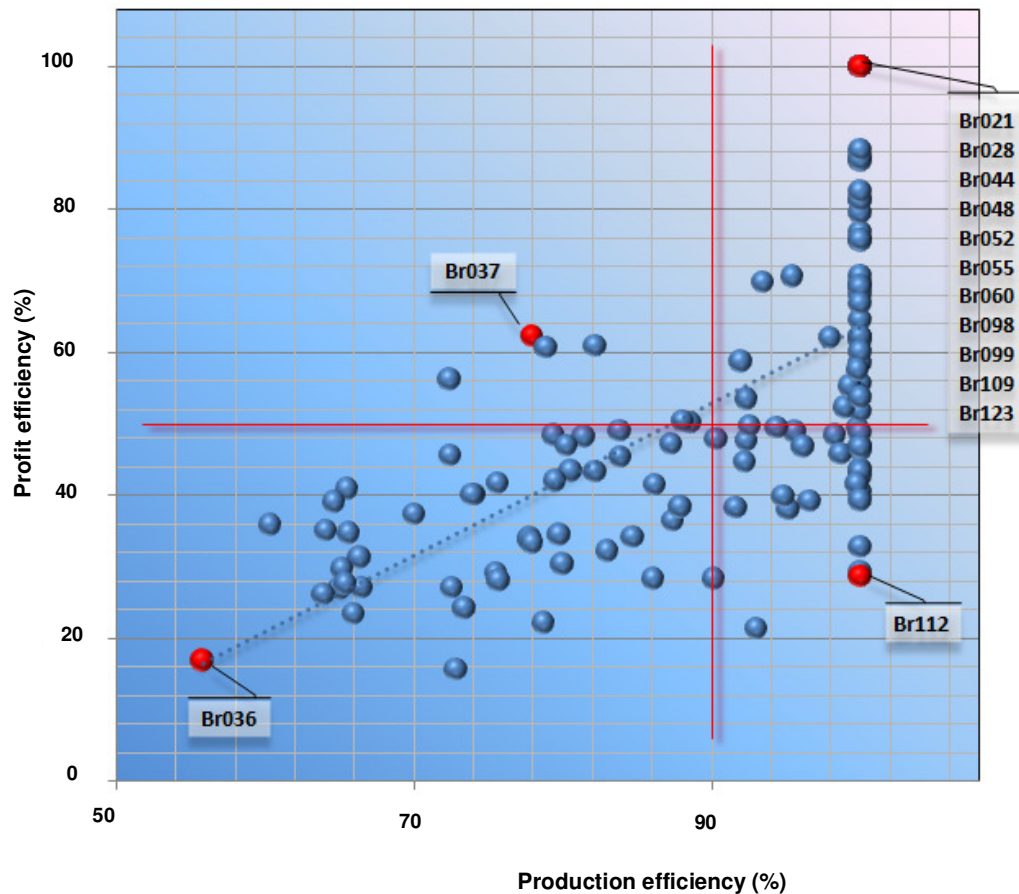
Figure 3. Comparison of production and profit efficiencies.

serious extent of inefficiency. According to output oriented CCR model, compared with efficient branches, outputs of 79 technically inefficient branches 13 to 25% and at the same time inputs 1 to 26% can be improved further. The sources of inefficiency can also be identified. By using DEA the management can realize the properties of a branch and constitutes the strategies accordingly. Different dimensions of branch characteristics can also be analyzed.

Under both production and profitability approaches efficiency characteristics of branches, which are grouped according to different sizes and regions, have similar tendencies. In both analyses, it is apparent that branch size and scale efficiency are related to each other. As size gets larger, scale efficiency increases and after the most productive scale size, as size increases efficiency decreases. Branches at small and large ends need special attention. Putting production and profit efficiency scores on two scales reveals the performing characteristics of branches. Each region needs different handling. Effects of branch segmentation on performance change, the efficiency of different sections within a branch or efficiency of segmented branches by Network DEA and benchmarking the branches of different banks may be

may be the interest of further studies.

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