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COST EFFICIENCY OF SLOVAK COMMERCIAL BANKS UNDER THE STANDPOINT OF THE INTERMEDIATION APPROACH

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Abstract
In the contribution, the traditional Farrell-Debreu approach of DEA as well as a new approach by Tone is used to evaluate the cost efficiency of the Slovak commercial banks. The results obtained are beneficial to the management of individual commercial banks as they suggest how their resources can be effectively utilized comparing to the rest of the analyzed banks.From the gained results it comes out that, in the case of the traditional approach, which assumes that prices of inputs are exogenously given, transformation of human sources and deposits into loans was successfully achieved by four banking institutions under the research. A new measure, which allows endogenity of the input prices, transformation of human sources and deposits into loans was successfully achieved by eight banking institutions under the research.

Key words: *DEA, cost efficiency, new-cost efficiency, banking, intermediation approach.*

1. Introduction

"Technology and cost are the wheels that drive modern enterprises; some enterprises have advantages in terms of technology and others in cost. Hence, the management is eager to know how and to what extent their resources are being effectively and efficiently utilized, compared to other similar enterprises in the same or a similar field." (Cooper et al., 2007, pp. 257).

Cost efficiency (CE) evaluates the ability to produce current outputs at minimal costs. The corner stone of efficiency measurement date back to the work of Debreu (1951) and Koopmans (1951). Debreu provided the first measure of efficiency, which was called the ´coefficient of resource utilization´, and Koopmans was the first to define the concept of technical efficiency. Farrell (1957) extended their work in a seminal paper whose key contributionwastheproposal how to measure cost efficiency by taking into account both concepts. The underlying economic model of the firm assumed that it operates in a competitive market, where prices of inputs and outputs are exogenously given, often taken at the level of actual prices observed at the operating decision making unit (DMU). Under this assumption, cost efficiency reflects cost savings that can accrue from changes in input quantity given their (externally fixed) prices. Units where input (or output) prices are exogenously fixed are said to be *price takers*(Portela andThannasoulis, 2014, pp. 36).

The contribution takes into consideration both situations: one with common unit prices and costs for all decision making units (prices of inputs are exogenously given) and the other with different prices and costs from one decision unit to another decision making unit. The second

approach is calculated by theNew-Cost model introduced by Tone (2002, pp. 1225-1231). Over the last years, many studies which estimated cost-efficiency of firms in a non-competitive market and which captured variation ofinput prices (sometime also variation of input quantities) were published. For instance, Camanho and Dyson (2003) developed a method to estimate the upper and lower bounds for the cost efficiency in the case of price uncertainty.Portela and Thannasoulis (2014) developed a cost model for the simultaneous optimisation of input quantities and prices. This model requires that data on prices and quantities are available, and assumes that DMUs have some degree of influence both over prices and over quantities of inputs.

The main aim of this contribution is to demonstrate that the use of the New-Cost DEA model by Tone can better inform beneficiaries (managers, shareholders, regulatory bodies) on the input utilization in the production process of the commercial banking.This illustrative empirical analysis is based on real-life data set of 15 banking institutions operating in the Slovakia for the year 2012, wherein the meaningful comparison between traditional approach (Farrell, 1957) and Tone´s approach (2002) with the input prices endogenously given is provided. From the gained results it comes out that, in the case of the traditional approach, which assumes that prices of inputs are exogenously given, transformation of human sources and deposits into loans was successfully achieved by four banking institutions under the research.In the case of the new measure, which allows endogenity of the input prices, transformation of human sources and deposits into loans was successfully achieved by eight banking institutions under the research. The ability to adjust the costs increases the efficiency of the banking institutions. To the best knowledge of the author this application was not published in the relevant literature.

The paper is structured as follows. In the next section the methodology of the traditional and Tone´s cost model is reviewed and used data set is disclosed. In Section 3 an illustrative example is demonstrated to highlight the differences in cost management between traditional Farrell-Debreu approach of DEA and a new approach by Tone. Section 4 concludes the paper.

2. Methodology and data

The methodology applied in this contribution is based on (Cooper et al., 2007. pp. 257-267).Figure 1 displays concept of “allocative efficiency” that can be recalled back to M. J. Farrell (1957) which was influenced by G. Debreu (1951). The solid line in the figure 1 is an isoquant (derived from quantity and the Greek word iso, meaning equal) that represents all possible combinations of the input amounts ($x_1$and x_2) that are needed to produce the same amount of a single output. The isoquants are also called equal product curves and they are strictly convex. The dotted linear line in the figure 1 is the isocost. Isoquants are usually combined with isocost lines in order to solve a cost-minimization problem for given level of output.

P is a point representing the activity of a decision making unit (DMU) which produces this same amount of output but with greater amounts of both inputs.

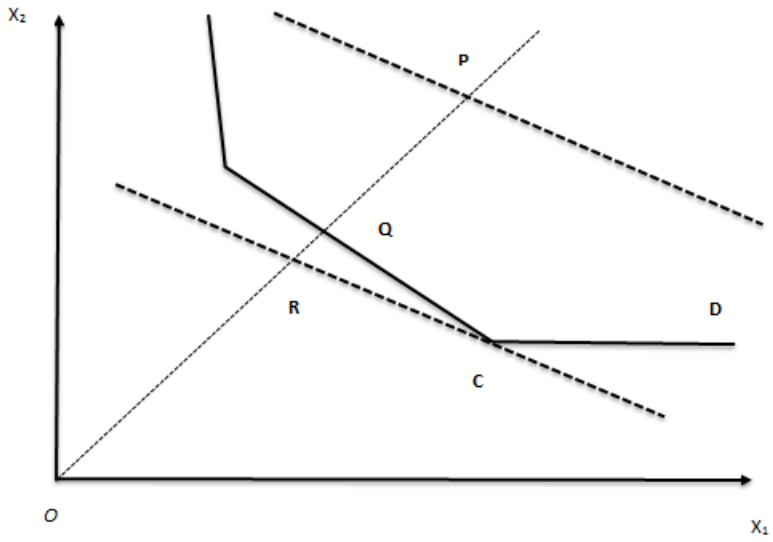

Figure 1.Technical, Allocative and Overall Efficiency
Source: Cooper at al. 2007. p. 258.

To evaluate the performance of *P* we can use the known Farrell´s measure or radial efficiency, which has the following form

$$0 \leq \frac{d(O,Q)}{d(O,P)} \leq 1, \tag{1}$$

and we can interpret this radial efficiency as the distance from *O* to *Q* (the distance from zero to P) relative to the distance from *O* to *P*. The result is the measure of technical efficiency which is denoted as θ_o^*. The component of this ratio lies on the dotted line from the origin through *Q* to *P*. To bring "allocative efficiency" into the analysis, we highlight the broken line passing through *P*. It is the cost line (isocost) which can be written as

$$c_1 x_1 + c_2 x_2 = k_1. \tag{2}$$

This cost denoted as k_1(which the sum of the combinations of costs and input amounts) can be reduced by moving this line in parallel form until it intersects the isoquant at *C*. The coordinates of *C* then give

$$c_1 x_1^* + c_2 x_2^* = k_0 \tag{3}$$

where$k_0 < k_1$ shows the amount by which total cost can be reduced. The position of the broken line passing through *C* is minimal at the prescribed output level. This optimal point *C* is obtained as the optimal solution of the following linear programming model (Farrell, 1957)

$$[Cost]\boldsymbol{cx}^* = \min_{\boldsymbol{x},\boldsymbol{\lambda}} \boldsymbol{cx} \tag{4}$$
$$\text{Subject to} \boldsymbol{x} \geq X\boldsymbol{\lambda}$$

$$\boldsymbol{y_0} \leq \mathrm{Y}\boldsymbol{\lambda}$$
$$\boldsymbol{\lambda} \geq \mathbf{0},$$

where $\boldsymbol{c} = (c_1, \ldots, c_m)$ is the common unit input-price or unit-cost vector,
$\boldsymbol{x}$is a positive input vector
$\boldsymbol{y}$ is a positive output vector
y_o is the output of the decision making unit o,
$\boldsymbol{\lambda}$ is the weight of the decision making unit o,
X is the matrix of inputs,
Y is the matrix of outputs.

Traditionally reduction in costs is prescribed in two steps taken in sequence: (i) reducing the quantities of inputs pro-rata to reach the minimum input levels capable of supporting the outputs; (ii) changing the mix of inputs so that, given the prevailing prices, aggregate input costs are minimised. The technical efficiency model computed using the standard DEA model reflects its scope for savings through step (i) and its allocative efficiency is arrived at residually through step (ii). Usually cost minimizing models are computed under constant return to scale (CRS), but both, cost and the technical efficiency measure can also be computed under variable returns to scale (VRS) (Portela andThannasoulis, 2014, pp. 37).

Farrell refers to the relative distance of *R* and *Q*as a measure of "price efficiency" but the more commonly used term is "allocative efficiency" (Luptáčik, 2010). In either case it provides a measure to which the technically efficient point, *Q*, falls short of achieving minimal cost because of the failure to make the substitutions (or reallocations) involved in moving from *Q* to *C* along the efficiency frontier.

$$0 \leq \frac{d(O,R)}{d(O,Q)} \leq 1. \tag{5}$$

There is one further measure, "overall (cost) efficiency" which is equal to the "allocative" times "technical efficiency" and which can be represented by means of following ratio,

$$0 \leq \frac{d(O,R)}{d(O,P)} = \frac{\boldsymbol{cx}^*}{\boldsymbol{cx_0}} = \frac{d(O,R)}{d(O,Q)} \cdot \frac{d(O,Q)}{d(O,P)} \leq 1. \tag{6}$$

Furthermore, the technical efficiency can be decomposed into the pure technical efficiency and the scale efficiency. Thus we have the following decomposition:

$$\begin{aligned}\text{Overal Efficiency} &= \text{Allocative Efficiency} \\ &\cdot \text{PureTechnicalEfficiency} \cdot \text{ScaleEfficiency}.\end{aligned} \tag{7}$$

Or,

$$\text{OE} = \text{AE} \cdot \text{PTE} \cdot \text{SE}. \tag{8}$$

Coming back to traditional cost model, Tone observed an unacceptable property of the traditional Farrell-Debreu cost efficiency models which can occur when the unit prices of input are not identical among DMUs. In addition, in the traditional Farrell-Debreu cost efficiency models the price adjustments are not possible.

In order to resolve the irrationality latent in the traditional Cost model, Tone (2002, pp. 1225-1231) developed the New-Cost model, which utilizes the cost-based production possibility set as defined by

$$P = \{(\overline{\boldsymbol{x}}, \boldsymbol{y}) | \overline{\boldsymbol{x}} \geq \overline{X}\boldsymbol{\lambda}, \boldsymbol{y} \leq Y\boldsymbol{\lambda}, \boldsymbol{\lambda} \geq \mathbf{0}\} \quad (9)$$

where

$$\overline{X} = (\overline{x}_1, \ldots, \overline{x}_n) \quad (10)$$

with

$$\overline{x}_j = (c_{1j}x_{1j}, \ldots, c_{mj}x_{mj}). \quad (11)$$

$$[NCost]\boldsymbol{e}\overline{\boldsymbol{x}}_{\mathbf{0}}{}^{*} = \min_{\overline{\boldsymbol{x}},\boldsymbol{\lambda}} \boldsymbol{e}\overline{\boldsymbol{x}} \quad (12)$$

$$\text{Subject to} \quad \overline{\boldsymbol{x}} \geq \overline{X}\boldsymbol{\lambda}$$
$$\boldsymbol{y}_{\mathbf{0}} \leq \mathrm{Y}\boldsymbol{\lambda}$$
$$\boldsymbol{\lambda} \geq \mathbf{0},$$

where e is a row vector with all elements equal to one. Let the optimal solution of the above linear programming be $\overline{\boldsymbol{x}}_{\mathbf{0}}{}^{*}$. Then the New-Cost efficiency is defined by

$$\text{New Cost Efficiency} = \frac{e\overline{x}_0{}^{*}}{e\overline{x}_0}. \quad (13)$$

The New-Cost model is equivalent to the traditional one by modifying the data set as follows:

(1) change the input value to input cost for the input, i.e. (input multiplied by unit cost),
(2) set the unit cost of every input to 1, and then
(3) apply the Cost model to the new data set.

Special attention is needed in interpreting the ´projection´ values obtained. They represent not the number but the amount of cost (money) for each input.

There is ongoing controversy in DEA based bank efficiency studies over the determination of input and output indicators. Main approaches which have been developed and used both in theory and practice are the intermediation approach, the production approach and their modifications, see e.g. (Ahn and Lee, 2014, pp. 1-35). Most often discussed issue is the role of deposits, which have both input and output characteristics. The most commonly used approach in the European banking industry is the intermediation approach which recognizes intermediation as the core activity of banks. Sealey and Lindley (1977) are considered as the founders of this approach. Deposits (and other selected variables) are treated as inputs and loans are treated as outputs. Despite broad application in bank efficiency studies, the intermediation approach has several shortcomings. Firstly and most clearly seen, the treatment of deposits as inputs fails to justify the importance of deposit services that a bank provides. Secondly, the intermediation approach is neglecting risk indicators and non-interest related

services (Ahn and Le, 2014, pp. 10). Nevertheless, the intermediation approach is studied as the most common approach. In this paper, two input variables (deposits per one employ and property and equipment per one employ) and one output variable (loans and commercial papers as a proxy for earning assets) are used to measure the technical efficiency of the banks operating in the Slovak Republic.

Table 1. Variables used in the technical and cost efficiency analysis

Variable	Definition	Abbreviation
Inputs		
Employees	Number	I(Emp)
Wages	Cost of Employees	C(Emp)
Deposits	Deposits in thousands of Euro	I(Dep)
Interest rates	Costs of Deposits in thousands of Euro	C(Dep)
Outputs		
Loans	Loans in thousands of Euro	O(Loan)

Source: the author

In our analysis, the banking sector in the Slovak Republic is represented by 15 banking institutions. Ten banks have the status of foreign banks licensed in the Slovak Republic (Slovenskásporiteľňa, a. s. – denoted as SLSP; Všeobecnáúverovábanka, a. s. – denoted as VUB; Tatrabanka, a.s. – denoted as Tatrabanka; Československáobchodnábanka, a. s. – denoted as CSOB; UniCredit Bank Slovakia, a. s. – denoted as UniCredit Bank; Poštovábanka, a.s. – denoted as Postovabanka; Prima bankaSlovensko, a. s. – denoted as Prima banka; OTP Banka Slovensko, a. s. – denoted as OTP banka; SberbankSlovensko, a. s. till 2013 VOLKSBANK Slovensko, a. s. – denoted as Sberbank; Privatbanka, a. s. – denoted as Privatbanka) and five are the branch offices of foreign banks operating in the Slovak Republic (Citibank Europe plc, branch office of foreign bank – denoted as City Europe, plc; Oberbank AG, branch office of foreign bank in the Slovak Republic – denoted as Oberbank AG; Komerčníbanka, a. s., branch office of foreign bank – denoted as Komercnibanka; J & T Banka, a. s., branch office of foreign bank – denoted as J&T Banka; Commerzbank Aktiengesellschaft, branch office of foreign bank – denoted as Commerzbank). This group of the banking institutions concisely represents the banking sector in the Slovak Republic as it covers more than 90 % of the banking assets. Hence the results of this paper can be interpreted as being representative of the total banking sector in Slovakia. To assure consistency of the analysis, building societies and special financial institutions are not under consideration. On the other side, the well-established branch offices of foreign banks are also under consideration, what enables to test the hypothesis that they can be technically and cost efficient too as they benefit from the cost-saving schemes of the head-quarters.

The data used in the empirical analysis are the yearly data of balance-sheet items covering year 2012 disclosed by the TREND Holding, s.r.o., Bratislava.

3. Illustrative example

For the case of VRS cost minimization, the input oriented DEA model, defined by (4), is conducted to obtain the cost-efficiency scores. The DEA model, defined by (12), is conducted to obtain the new-cost efficiency scores.

Table 2. Cost Efficiency and New-Cost Efficiency results

		Cost Efficiency model			New-Cost Efficiency model		
No.	DMU	CE-Score	Rank	erence set	NCE-Score	Rank	Reference set
1	SLSP	1,00	1	SLSP	1,00	1	SLSP
2	VUB	1,00	1	VUB	1,00	1	VUB
3	Tatrabanka	0,99	5	VUB	1,00	1	TATRA
4	Postovabanka	0,54	11	VUB	0,31	11	UNI
5	CSOB	0,87	7	VUB	1,00	1	CSOB
6	UniCredit Bank	0,96	6	VUB	1,00	1	UNI
7	Prima banka	0,66	9	VUB	0,87	9	SBER
8	OTPbanka	0,58	10	VUB	0,79	10	SBER
9	J&T Banka	0,24	13	VUB	0,27	13	SBER
10	Sberbank	0,74	8	VUB	1,00	1	SBER
11	Privatbanka	0,11	15	KBBA	0,05	15	KBBA
12	Komercnibanka	1,00	1	KBBA	1,00	1	KBBA
13	Oberbank	1,00	1	Oberbank	1,00	1	Oberbank
14	COMMERZBANK	0,28	12	Oberbank	0,29	12	Oberbank
15	City Europe	0,13	14	KBBA	0,11	14	KBBA

Source: the author

From the gained results it comes out that, in the case that prices of inputs are exogenously given, transformation of human sources and deposits into loans was successfully achieved by four banking institutions under the research: Slovenskásporiteľňa, a.s., VUB banka, a.s., Komerčníbanka, a. s., branch office of foreign bank and Oberbank AG, branch office of foreign bank in the Slovak Republic. A new measure proposed by Tone, which allows endogenity of the input prices, provides more information. In the case that prices of inputs are adjusted by the management, transformation of human sources and deposits into loans was successfully achieved by eight banking institutions under the research: four banking institutions which reached cost efficiency under traditional approach (Slovenskásporiteľňa, a.s., VUB banka, a.s., Komerčníbanka, a. s., branch office of foreign bank and Oberbank AG, branch office of foreign bank in the Slovak Republic), and additional four banks (Tatrabanka, a.s., ČSOB banka, a. s., UniCredit bank, a. s.,Sberbank, branch office of foreign bank in the Slovak Republic).Among them, five are the foreign banks licensed in the Slovak Republic while three of them have got status of the branch offices of foreign banks operating in the Slovak Republic.Cost efficiency (CE), the ability to produce current outputs at minimal costs, was proved in the cases of those banks which focus mostly on financial intermediation. They transmute the available sources (gathered through a net of branches) into private and public projects financed by loans. The worst performer, the Privatbanka, invests client´s sources predominantly into capital market instruments therefore we should be cautious in interpreting our cost efficiency results in this particular case.

This paper proves that the model which allows flexibility in prices can better reflect the real situations. The extension to this research would be an application of the models with weight restrictions. This idea was introduced by Allen et al. (2007). Tracy and Chen (2005) presented generalized model with weight restrictions, Podinovski (2007) considered weight restrictions for finding targets.This finding enabled not only ex post DEA analysis but also ax ante DEA programming.The target based planning

4. Conclusion

The original contribution of the paper is an illustrative application of the traditional Farrell-Debreu approach of DEA as well as a new approach by Tone with aim to evaluate the cost efficiency of the Slovak commercial banks.From the gained results it comes out that, in the case of the traditional approach, which assumes that prices of inputs are exogenously given, transformation of human sources and deposits into loans was successfully achieved by four banking institutions under the research. In the case that prices of inputs are adjusted by the management, transformation of human sources and deposits into loans was successfully achieved by eight banking institutions under the research. The high Spearman correlation proves that the banking industry is rather competitive and the extent of the cost volatility is limited.

A New-Costefficiency measure proposed by Tone, with the input prices endogenously given, proved that management of eight banking institutionswas able to produce their outputs at minimal costs. Three of them are the largest commercial banks in Slovakia (Slovenskásporiteľňa, a.s., VUB banka, a.s., Tatrabanka, a.s.), two of them are important middle sized banks (ČSOB banka, a. s., UniCredit bank, a. s.) and three of them are branch offices of foreign banks in the Slovak Republic (Komerčníbanka, a. s., branch office of foreign bank and Oberbank AG, branch office of foreign bank in the Slovak Republic and Sberbank, branch office of foreign bank in the Slovak Republic). In the sample of New-Cost efficient banking institutions there are large, middle and little sized units. The banking industry is competitive and main banks are able to manage their costs appropriately. The worst performer, the Privatbanka, invests client´s sources predominantly into capital market instruments therefore we should be cautious in interpreting our cost efficiency results in this particular case.

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References

1. AHN, H., LE, M. H. 2014. An insight into the specification of the input-output set for DEA-based bank efficiency measurement. Wien : Wirtschaftsuniversität. [cit. 07-04-2015] http://link.springer.com/article/10.1007/s11301-013-0098-9#page-1.
2. ALLEN, R., et al., 1997. Weights restrictions and value judgements in data envelopment analysis: Evolution, development and future directions. In Annals of Operations Research, 1997, vol. 73. pp.13-34.

3. COOPER, W. W., LAWRENCE, M., TONE, K. 2007. Data Envelopment Analysis. New York :Springer. 2007. pp. 490. ISBN-13: 978-0387-45281-4.
4. DEBREU, G. 1951. The Coefficent of Resourse Utilization. In Econometrica, 1951, vol. 19, pp. 273-292.
5. FARRELL, J. M. 1957. The Measurement of productive Efficiency. In Journal of the Royal Statistical Society Series A, 1957, vol. 3, pp. 253-281.
6. KOOPMANS, T. C. ed. (1951), Activity analysis of production and allocation. New York : Cowles Commission Monographs, John Willey & Sons, vol. 13.
7. LUPTÁČIK, M. 2010. Mathematical Optimization and Economic Analysis. New York : Springer. 2010. pp. 292. ISBN: 978-0387-89551-2.
8. PODINOVSKI, V. V. 2007. Computation of efficient targets in DEA models with production trade-offs and weight restrictions. In European Journal of Operational Research, 2007, vol. 181, pp. 596-591.
9. PORTELA, M. S., THANNASOULIS, E. 2014. Economic efficiency when prices are not fixed: disentangling quantity and price efficiency. In Elsevier Omega, 2014, vol 47, pp. 36-44.
10. TONE, K. 2002. A strange case of the cost and allocative efficiencies in DEA. In Journal of the Operational Research Society, 2002, iss. 53. pp. 1225-1231.
11. TRACY, D. L., CHEN, B.A. 2005. A generalized model for weight restrictions in data envelopment analysis. Journal of Operational Research Society, 2005, vol. 53, pp. 1225-1231.
12. SEALEY, C. W., LINDLEY, J. T. 1977. Inputs, outputs and a theory of production and cost at depository financial institutions. In Journal of Finance vol32, iss 4, pp. 1251-1266.