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The impact of internet banking on the performance of Romanian banks: DEA and PCA approach

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Abstract

The modernization of the banking sector has been a defining trend in new EU member state economies over the last decade. Financial innovations in particular have provided banks with the necessary tools to obtain competitive advantages. In this context, the aim of our research is to analyze the way in which the financial innovation represented by Internet banking services can contribute to the enhancement of the overall efficiency of Romanian banks. We apply DEA to compute the aggregate efficiency score for each of the 24 banks in our sample and, in addition, we utilize PCA to classify the banks into different operational strategies groups based on their relative efficiency scores. The results show that there are very few banks in our sample that have utilized Internet banking services in their production process to increase their level of efficiency and thus the research proposes a series of solutions and recommendations.

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Keywords: financial innovation; Internet banking; DEA; PCA; bank performance.

1. Introduction

Internet banking, as a financial innovation and means of intermediation, has grown considerably during the last decade. According to Eurostat data, in 2010 almost 36% of households and 82% of firms in the European Union

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(EU) used Internet banking services. This represents a sizeable boost in usage compared with 2004, when only 16% of households and 66% of firms used such services.

The primary reason for the growth in Internet banking services is that they reduce costs and enhance profits for banks, while enriching customer convenience through the ease and rapidity with which transactions are executed. Internet banking helps banks reduce operating costs while diminishing the need for a wide territorial network. Providing this type of service has become a strategic component of any banking institution seeking to improve quality of services. Yet, questions remain within the literature to what extent Internet banking services contribute to the enhancement of the overall performance and efficiency of banking firms. In this context, our research aims to investigate whether Internet banking systems affect the overall efficiency of the banks that provide such services to their clients.

In this paper, we use Data Envelopment Analysis (DEA) to measure the overall efficiency of Romanian banks and to determine their operational strategies in connection with supplying Internet banking services; we employ both financial and non-financial variables as inputs employed and outputs produced by the banks in our sample. The Principal Component Analysis (PCA) approach is then used to classify the banks based on the business strategies that they adopt (see Serrano Cinca and Mar Molinero, 2004). This approach allows us to identify the banks that use the financial innovation represented by Internet banking services to enhance their overall efficiency. The outcome suggests that there are two business strategies in the Romanian banking sector: “cost oriented” and “Internet banking oriented”. Thus, results indicate that only a few of the Romanian banks (i.e., Banca Transilvania and OTP Bank) efficiently use Internet banking services in order to enhance their overall performance, while most of the other banks prefer a mixed approach, consisting of Internet banking services and cost reduction strategies. In this context, and taking into account the negative impact of the global financial crisis, Internet banking services should gain more ground as part of the efficiency enhancement strategies of the banks.

The contribution of the present paper to the existing literature is twofold. First, we clarify which strategies enhance efficiency in cost saving through Internet banking services. Second, we focus on Romania, where banks frequently introduce financial innovations to protect their market share in a growing competitive banking environment. Romania, as a new member of the EU, with a dynamic banking industry, provides a unique case to investigate the relationship between Internet banking and efficiency. The Romanian model may offer banking policy implications for those countries that have join the EU recently, or those that will join it in the near future.

The rest of the paper is organized as follows: Section 2 reviews the literature regarding the impact of Internet banking services on efficiency. Section 3 explains the particularities of the Internet banking services in Romania. Section 4 describes the data and methodology (DEA and PCA) used in this study. The empirical results are presented in Section 5, followed by a summary and conclusions in Section 6.

2. Literature review

In recent years, the interaction between banks and their customers has been facilitated by financial innovations such as Internet banking. Schlie et al. (2008) highlight in their study carried out on a sample of 123 banks from 6 European countries (Denmark, France, Finland, Germany and Sweden), that banks do not have an aversion regarding the adoption of internet banking services, the legacy effect in the case of this financial innovation being rather overstated.

Onay and Ozsoz (2013) underline that Internet banking services, as a distribution channel, allow banks to switch to a “click and mortar” approach so that clients can conveniently open accounts, create deposits, transfer funds across the accounts, and make payments entirely online, any time, at lower cost compared to the traditional banking, leading to a higher banking efficiency.

The usage of the internet banking services as a way to improve the efficiency and profitability of the bank is disputed by the research of Atay (2008). Thus, the author underlines that banks tend to use these services rather as a way to promote themselves and acquire market share rather than a method through which they seek to improve their performance. The success of such an approach is determined by a series of macroeconomic factors like: access to internet, the general level of education in a country or the R&D expenditures.

The literature on the impact that internet banking services have on the overall performance of the banking institutions has increased in the last 10 years tremendously, as these services have been adopted largely by banking institutions all over the world.

Thus, Ciciretti et al. (2008) evaluate the performance of Italian banks which employ multichannel commercial strategy versus those that do not. They found that offering Internet banking services influenced the performance of the banks, measured by return on average assets (ROAA) and return on average equity (ROAE). Similarly, Hernando and Nieto (2007) analyzed the impact of Internet banking on the performance of Spanish banks. These authors found that Internet banking services, as an alternative distribution channel, reduced overhead expenses and improved both ROAA and ROAE over time. However, Onay and Ozsoz (2013) underline, in the case of Turkish banks, that after a period of two years since the introduction of internet banking services, their overall profitability has decreased as a result of increased competition and a diminishing of the interest income.

While most studies have focused on financial performance of banking, Serrano Cinca et al. (2005) posited that excluding non-financial data (such as web-metrics) produces an incomplete representation of performance. Due to these shortcomings, a new body of literature is developing, that tries to employ a more effective approach in order to assess the overall performance of the banks in relationship to their usage of internet banking services.

Thus, Callaway (2011) studies the relationship between different web-metrics (like the ranking on Alexa.com and the number of links) of a bank and its performances in the case of a sample of US banks. The results highlight that high web traffic increases the possibility for alternative sources of revenues for a bank, but that increase spending for web development does not diminish the average overhead/branch. Ho and Wu (2009) employ DEA and PCA to examine the performance of 32 Taiwanese banks and conclude that the outcome of the combination of DEA and PCA offer a superior tool to indentify the areas of weaknesses and strengths of a bank operation. Giordani and Floros (2013) analyze the impact of internet banking services on the performance of Greek banks. Using an econometric model the authors underline a positive and significant relationship between the implementation of internet banking services by Greek banks and the diminishing of their overall operating expenses. However, the profitability of the Greek banks seems not to be affected by the adoption of internet banking services.

In this paper, we follow Ho and Wu (2009) to apply DEA and PCA to a sample of Romanian banks. More specifically, we employ DEA to: a) measure efficiency, and b) examine the effect of Internet banking on the efficiency of a sample of Romanian banks. We believe DEA is a superior approach because it allows us to gauge changes in efficiency over time, and does not require any a priori assumptions regarding the behavior of the efficient frontier and random error. Additionally, DEA provides efficiency scores for each bank included in the sample to ease comparison. We also employ PCA to the banks efficiency values obtained through DEA to identify different strategic groups among the banks in our sample (Serrano Cinca and Mar Molinero, 2004). This approach allows decision makers to understand the different business operation models and orientations of Romanian banks in relationship to their usage of internet banking services.

3. Characteristics of the Internet banking services supplied by Romanian banks

Based on the definition by Liang et al. (2004), the business strategies adopted by Romanian banks in the area of Internet banking services are of the hybrid type. Banking institutions use the "click and mortar" approach to develop online platforms through which customers' transactions are processed in real time, and they are able to receive assistance and consulting services.

Gurau (2002) and Ciciretti et al. (2008) asserted that as customer portfolios become extremely diversified in the EU, approximately 65% prefer a multichannel approach that provides easy access to a wide branch network and a variety of services through mobile phones and Internet portals. Given this multichannel approach, banks must make sure that customers are able to change their traditional habit of banking through an extensive branch network, towards Internet or multiple distribution channels banking (Gurau, 2002).

Figure 1 illustrates the access to and usage of Internet banking in Romania for 2004 to 2010.

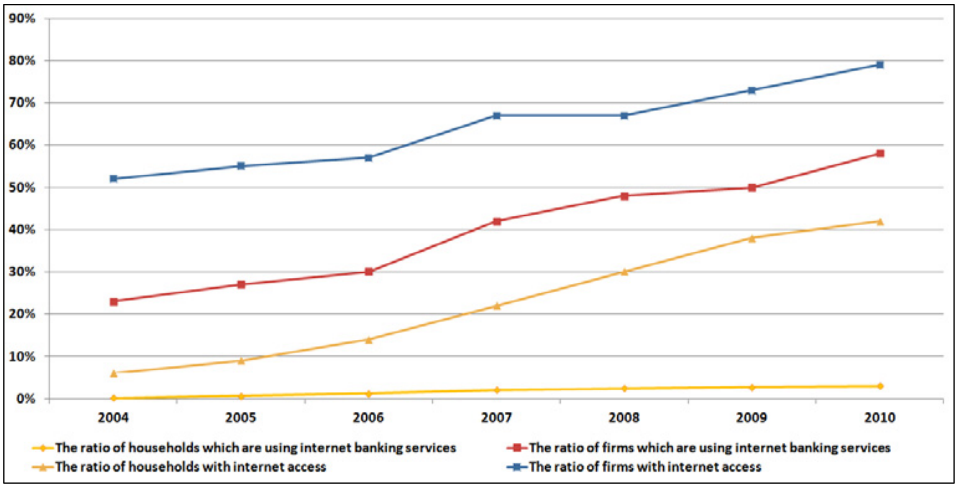

Figure 1 – The growth of the access to Internet and the usage of Internet banking services by households and firms in Romania between 2004 and 2010

Internet access in Romania shows a steady and continuous development. In 2010, according to Eurostat data, over 42% of the households and 79% of firms had access to the Internet. Figure 1 graphs the access to the Internet and the usage of the Internet banking services by households and firms in Romania from 2004 to 2010. Despite yet relatively low access to the Internet, Romania has the second fastest Internet network in the world after South Korea (Pando Networks, 2011).

The first Internet banking service in Romania was launched in 1999 by Banca Turco-Română, representing the starting point for the period in which Romanian banks began to import and implement state of the art financial innovations. The number of households that used Internet banking services has increased approximately tenfold, from 0.20% in 2004 to 3% in 2010. Meanwhile, the increase for business firms was around 150% for the same period, rising from 23% in 2004 to 58% in 2010. This level of growth demonstrates that the banks in Romania are determined to offer Internet banking services along with other financial innovations to both households and corporate customers.

Most of the Internet banking services provided by the Romanian banks offer a relatively limited number of operations, including account examination, national and international transfer of funds between accounts, payment of invoices to a series of merchants and public utility services, and in some cases, the creation of time deposits. Almost half of the banks in our panel use the token system for identification, while most of the others opt for either virtual keyboards or digital certificates in conjunction with a user name and password. A few apply only user name and passwords.

4. Methodology and data

4.1. Methodology

Generally, there are several methodologies in the banking literature to measure the performance and efficiency of banking firms, that can be classified as: 1) data envelopment analysis (Sherman and Gold, 1985; Grigorian and Manole, 2002; Stavárek, 2006; Toçi, 2009), 2) free disposal hull (Berger and Humphrey, 1992), 3) stochastic frontier (Berger and Humphrey, 1992; Hasan and Marton, 2003; Bonin et al., 2005; Koutsomanoli-Filippaki et al., 2009; Fang et al., 2011), 4) thick frontier (Berger and Humphrey, 1997), and 5) the distribution free method (Berger et al., 1993; Weil, 2004). These approaches are different based firstly on the restrictive assumptions imposed on criterion used to determine the efficient frontier, and secondly on underlying assumptions regarding the distribution of random errors and inefficiency (Wu, 2006).

In this paper, we use DEA, introduced by Charnes et al. (1978). This methodology involves mathematical linear programming models to construct optimal Pareto efficient frontier relative to which the efficiency of each bank is gauged (see Cooper et al., 2000; Martins-Filho and Yao, 2008). We consider both financial and non-financial variables as inputs and outputs set in our study. More specifically, we employ four variables as inputs and two as outputs, which provide us with 45 possible input-output combinations for the 24 Romanian banks in our sample. The main advantage of DEA is that it does not require imposing specifications on production technology, and avoids distributional assumptions on the random term. However, this approach is sensitive to outliers and the number of inputs and outputs in the data set.

Let us assume there is a set of data on *K* inputs and *M* outputs for each of *N* banks. For *i* bank, inputs and outputs are represented by vectors x_i and y_i, respectively. Let us label *K* x *N* input matrix – *X*, and the *M* x *N* output matrix – *Y*. To measure the cost efficiency for each bank, we calculate a ratio of all outputs over all inputs, such as (u|yi/v|xi) where *u* is an *M* x 1 vector of output and *v* is a *K* x 1 vector of input weights. To select optimal weights we specify the following mathematical programming problem (MPP):

$$\max_{u,v}\left(u^{|} y_i / v^{|} x_i\right) \tag{1}$$

$u|y_i/v|x_i \leq 1$, i = 1, 2,…,N,
$u,v \geq 0$

The above MPP has a problem of infinite solutions and to remedy this, we impose the constraint v|xi = 1, which leads to:

$$\max_{\mu,\rho}\left(u^{|} y_i / v^{|} x_i\right) \tag{2}$$

$\rho|x_i = 1$,
$\mu|y_i - \rho|x_i \leq 0$, i = 1, 2,...,N,
$\mu, \rho \geq 0$,

Note that we change notation from *u* and *v* to *μ* and *ρ*, respectively, in order to show the transformation. Using the duality in linear programming, an equivalent envelopment form of this problem can be derived:

$$\min_{\theta,\lambda} \Theta \tag{3}$$

$-y_i + Y\lambda \geq 0$,
$\theta x_i - X\lambda \geq 0$,
$\lambda \geq 0$,

Where θ is a scalar and λ is a vector of *N* x 1 constants. The value of θ is the efficiency score for the bank *i*. Note that θ ranges between 0 and 1, where 1 implies bank *i* is 100% efficient. The above problem is solved *N* times to obtain efficiency index for all banks *i* in the sample.

The model used in our paper includes four inputs and two outputs; thus, we denote this model ABCD12. This particular model has 45 possible combinations and generates 45 results based on the DEA. Testing all possible 45 combinations will help us to better identify the weak and strong aspects of the analysed banks. According to the methodology set forth by Serrano Cinca et al. (2005), there are two reasons for the development of such combinations: 1) to evaluate all input-output combination equivalently; 2) to estimate the efficiency score for each bank included in the sample since the level efficiency depends on the chosen variables.

Furthermore, we use principal components analysis (PCA) in order to extract relevant data and eliminate redundant information. PCA is a multidimensional reduction process that facilitates the analysis and simplification of data (Fukunaga, 1990; Dunteman, 1999). Comparing with other linear transformation techniques, PCA has the advantage of not having a fix set of base vectors that depend on what is similar and what is different in various models. In addition, PCA compounds all possible combinations and the entirety of decision-making unites in a robust way in order to identify the similarities, the differences and the inconsistent components.

In this paper, PCA provide possibility to find new measures, principal components, which have different linear combinations of d1 and d2 so that the principal components can be combined by their eigenvalues to obtain a weighted measure of d_{nk}. The PCA process is carried out in four steps as follows: Step 1: we calculate the sample mean vector X and covariance matrix S. Step 2: we estimate the sample correlation matrix R. Step 3: we solve the following equation:

$$\left|R - \lambda I_2\right| = 0 \tag{4}$$

Therefore, we obtain the ordered 2 characteristic roots (eigenvalues) $\lambda_1 \geq \lambda_2$ with $\sum \lambda_k = 2$ (k=1, 2) and the related 2 characteristic vectors (eigenvectors) (l_{m1}, l_{m2}) (m=1, 2). These characteristic vectors compose the principal components Y_m. The components in eigenvectors are, respectively, the coefficients in each corresponding Y_m:

$$Y_m = \sum_{m=1}^{2} 1_m \lambda_n \ , \ m=1, 2 \ n=1, 2,..., N \tag{5}$$

Step 4: we compute the weights (w_k) of the principal components and PCA scores (z_n) for each model (n=1, 2, ..., N). Furthermore, the z vector (z_1, z_2, … z_n) where z_n shows the score of n^{th} model given by:

$$z_n = \sum_{k=1}^{2} w_k Y_k \qquad , \ n=1, 2,..., N \tag{6}$$

Zhu (1998) and Shang (2011) employ PCA, as a ranking methodology, to eliminate ineffective parameters and to determine the efficiency of different units. Likewise, we use PCA as a ranking method to validate the results obtained through the application of DEA. More specifically, PCA provides us with the possibility to differentiate clearly between the banks that employ Internet banking services to improve their overall efficiency and the banks that employ a more traditional approach to enhance their performances, given the costs minimization.

4.2. Data

We collected the inputs and outputs from the annual reports of the banks in our sample, Bureau Van Dijk Bankscope and Alexa.com databases for the year 2010. In order to ensure the comparability of the banks, we excluded the branches of foreign banks that operate in Romania from the sample, as they are subject to different regulations. In addition, we considered only commercial banks engaged in universal banking activities for which the full dataset of inputs and outputs were available. The resultant sample contains 24 banks, which account for 95.2% of the total banking assets (see Table 1), making the sample for this research comprehensive.

Table 1 – Characteristics of the banks from our sample

Name of the bank	Year of Internet banking adoption	Total assets (million RON)	Percentage from the total assets of the banking system
Alpha Bank	2005	21324.9	6.2 %
ATE Bank	2008	1929.7	0.6 %
Banca Carpatica	2007	2933.2	0.9 %
Banca C. R. Firenze	2006	21324.9	6.2 %
Bank Leumi	2005	1150.4	0.3 %
Banca Românească	2006	7659.3	2.2 %
Banca Transilvania	2005	21589.1	6.2 %
Bancpost	2001	13461.0	3.9 %
Banca Comercială Română (BCR)	2001	67647.3	19.8 %
BRD-GSG	2004	47494.1	13.9 %
CEC Bank	2008	21683.2	6.4 %
Credit Europe Bank	2006	4823.3	1.4 %
Emporiki Bank	2000	1063.8	0.3 %
Eximbank	2003	3524.2	1.0 %
Intesa Sanpaolo Bank	2003	3720.4	1.1 %
MKB Nextebank	2004	1448.2	0.4 %
OTP Bank	2006	3966.1	1.2 %
Piraeus Bank	2007	9380.0	2.7 %

ProCredit	2005	971.7	0.3 %
Raiffeisen Bank	2006	21782.9	6.5 %
RBS	2010	6155.2	1.8 %
RIB	2008	479.6	0.1 %
UniCredit Țiriac Bank	2001	20422.3	6.0 %
Volksbank	2003	19755.2	5.8 %
Total	**-**	**325690.0**	**95.20%**
Total banking assets in Romania		**341946.3**	**100.0 %**

In the case of our research, we considered the intermediation approach as most appropriate, taking into account the situation from the Romanian banking sector, where most of the banks are involved in universal banking activities. Concerning the inputs and outputs used, we chose an approach similar to that of Sealey and Lindley (1977), making at the same time a series of small adjustments for our case. Given the size of the chosen sample, and also the particular focus of our research on Internet banking activities, we used four inputs (i.e., deposits, operating costs, number of employees and the value of the owned equipment and software programs) and two outputs (i.e., net revenues and average daily "reach" rate).

Production theory, which is the base for our research, assumes that banks attract deposits in order to provide loans. Adjusting this theory for our particular case, we consider that the employees of the banks operate the owned equipment and software programs in order to provide customers with Internet banking services, which in turn generate charges and fees that boost net revenues and also determine a high daily "reach" average for Internet banking websites. We included deposits among the selected inputs, as banks usually allow costumers with excess liquidity and Internet banking services to easily create deposits online.

Following Ho and Wu (2009), we used four variables to measure inputs and two variables to measure outputs. More specifically, we defined inputs/outputs sets as follows: three financial input variables (A: Deposits, total deposits and remittances, in million RON; B: Total operating costs, in million RON; C: Number of employees), one Internet banking input variable (D: The value of owned equipment and software programs, in million RON), one financial output variable (1: Net total revenues, in million RON) and one Internet banking output variable (2: Daily "reach" average rate, as percentage of the average Internet users that have visited that site in that year).

Concerning the inputs, deposits are the total deposits and remittances that a bank has underlined in its balance sheet. Total operating costs include the costs that a bank has to cover in order to carry out its daily activities. The number of employees is expressed as the number of contractual hired people. We considered the value of the owned equipment and software programs as the book value of these items. The outputs are the net total revenues of the bank and the daily "reach" average represents the percentage of all Internet users who visit the bank's Internet banking web site. "Reach" is an appropriate measure of output, specifically in process of assessing the efficiency and performance of Internet banking services (Floros, 2008). The web metric information has been extracted from the Alexa.com database.

Table 2 – The inputs and outputs of the analyzed banks

Bank	Input A	Input B	Input C	Input D	Output 1	Output 2
Alpha Bank	7216.400	392.600	2483	257.989	764.800	0.000190
ATE Bank	491.300	54.800	335	92.500	59.500	0.000038
Banca Carpatica	2199.000	152.200	1900	116.832	176.000	0.000210
Banca C. R. Firenze	135.102	34.703	189	15.396	30.107	0.000023
Bank Leumi	716.300	70.300	418	22.200	105.500	0.000051
Banca Românească	4531.000	59.900	1650	169.200	423.000	0.000350
Banca Transilvania	14989.200	714.100	6095	317.400	1316.700	0.002380
Bancpost	7982.400	1151.400	3498	639.000	939.100	0.001200
Banca Comercială Română (BCR)	35628.200	1918.200	9012	779.770	5237.200	0.002770

Bank	Input A	Input B	Input C	Input D	Output 1	Output 2
BRD-GSG	29560.500	1637.300	9150	414.600	3692.600	0.001500
CEC Bank	13883.000	617.200	6679	910.500	916.400	0.000460
Credit Europe Bank	2447.300	299.900	1369	115.623	436.300	0.000770
Emporiki Bank	78.400	18.500	398	4.153	8.500	0.000110
Eximbank	257.200	93.400	387	40.114	287.200	0.000056
Intesa Sanpaolo	1090.200	135.900	865	122.906	172.200	0.000160
MKB Nextebank	1116.000	148.200	964	77.200	206.800	0.000018
OTP Bank	2621.700	193.700	1009	134.900	241.300	0.001110
Piraeus Bank	5199.500	416.700	1886	219.700	912.400	0.000430
ProCredit	133.600	25.200	1006	26.358	22.600	0.000130
Raiffeisen Bank	14386.200	1230.900	6903	440.145	1988.000	0.001920
RBS	6331.200	363.200	1129	71.982	606.100	0.000050
RIB	155.100	12.700	324	27.256	15.700	0.000103
UniCredit	10680.000	1096.000	2967	324.115	1250.000	0.001910
Volksbank	2922.400	206.100	1561	94.626	719.400	0.000250

Notes: Input A: Deposits, total deposits and remittances (million RON); Input B: Total operating costs (million RON); Input C: Number of employees; Input D: The value of owned equipment and software programs (million RON); Output 1: Net total revenues (million RON); Output 2: Daily "reach" average rate (percentage of the average Internet users that have visited that site in that year).

Table 2 displays the values of the inputs and outputs, along with the names of the banks included in the sample. As can be seen, Banca Comercială Română (BCR) has utilized the highest level of inputs, except input D, and produced the largest amount of outputs relative to the other banks in the sample.

5. Empirical results

The findings regarding the results of the 45 possible input-output combinations demonstrate that 15 banks achieve 100% efficiency in the case of the complete model ABCD12, which considers all six variables used. These banks are Banca C. R. Firenze, Banca Românească, Banca Transilvania, BCR, BRD-GSG, Credit Europe Bank, Emporiki Bank, Eximbank, OTP Bank, ProCredit, Raiffeisen, Royal Bank of Scotland (RBS), Romanian International Bank (RIB), UniCredit Ţiriac Bank and Volksbank. The variance of efficiency among these 15 banks is very low, preventing us to underline the specific characteristics of each bank, especially since these banks exhibit different scores in the case of all 45 models employed. For instance, Banca Comercială Română reaches 100% efficiency in the case of model ABCD12 and 29 other models, while it shows just 39% efficient for models D12 and D2 and 21% for model D1. This suggests that Banca Comercială Română is fully efficient when all variables are considered, and its strong point is the usage of inputs of A (deposits), B (operating costs) and C (employees) to balance its weak point represented by the usage of input D (equipment). In addition, the results imply that several banks operate at an extremely low efficiency, not even above 20%, once output 2 ("reach") is used to estimate the models. The clear examples are: A2, B2, C2, D2, AB2, AC2, AD2, BC2, BD2, CD2, ABC2, ABD2, ACD2, BCD2 and ABCD2. We also note that when only output 1 or a combination of the two outputs is used, the variation across efficiency measures cannot be identified. The lack of importance of certain variables in the case of a number of models cannot be extrapolated, which hints at the need for additional statistical methods in order to draw conclusions that are more pertinent. Due to paper size restrictions, the estimated efficiency measures of the banks using the 45 possible input-output combinations with corresponding summary statistics can be provided by the authors upon request.

The DEA and the 45 possible combinations provide us with an opportunity to compute the efficiency scores to rank the estimated models and to identify the strong and weak characteristics of each bank. As previously mentioned, in order to fully utilize the results of the DEA, we employed the principal components analysis. More specifically, two principal components are considered: the first represents 54.50% and the second 20.60% for a total of 75.10% of the accumulated variance. The results of the PCA are presented in Table 3. As shown, all of the estimated DEA models show positive values in the case of the first principal component, known as the "general measure of efficiency". We notice that the highest value for this component is generated by the model ABC12 (0.943), followed by the models ABCD12 (0.927) and BCD12 (0.915). Because model ABC12 has a higher value than model ABCD12, we can conclude that input D, the value of the equipment and the software programs owned, contributes least to the overall efficiency of the banks.

Note that one can only conclude that if considered simultaneously, variables A (deposits), B (operating costs), C (number of employees), 1 (revenues) and 2 ("reach"), input D (equipment) would have a lesser impact on the achievement of a superior efficiency score. That is to say, we cannot establish that every model that has input D in its composition necessarily exhibits a drop in efficiency. For instance, if we consider a single input model A1 and replace it with model AD1 (B1 with BD1, etc.), we would observe that the estimated efficiency for the second model would not necessarily decrease.

Table 3 – The results of PCA for the two principal components in the case of the 45 models estimated with DEA

	ABC12	ABCD12	BCD12	AC12	BC12	ABD12	ACD12	AB12	BD12
PC1	0.943	0.927	0.915	0.893	0.889	0.877	0.869	0.859	0.839
PC2	-0.008	0.106	0.145	0.021	0.090	0.072	0.110	-0.139	0.144
	CD12	**ABCD2**	**ACD2**	**BCD2**	**ABC2**	**ABD2**	**A12**	**AD12**	**B12**
PC1	0.805	0.798	0.784	0.772	0.772	0.765	0.764	0.756	0.754
PC2	0.189	-0.509	-0.493	-0.538	-0.538	-0.569	-0.087	0.104	-0.142
	BC2	**C12**	**AC2**	**AB2**	**ABC1**	**AD2**	**A2**	**AC1**	**AB1**
PC1	0.754	0.752	0.752	0.739	0.716	0.714	0.714	0.704	0.702
PC2	-0.515	0.067	-0.534	-0.605	0.554	-0.602	-0.602	0.594	0.426
	CD2	**C2**	**ABCD1**	**BD2**	**B2**	**D2**	**A1**	**ABD1**	**AD1**
PC1	0.693	0.692	0.674	0.673	0.673	0.672	0.669	0.666	0.663
PC2	-0.469	-0.472	0.631	-0.567	-0.567	-0.474	0.484	0.617	0.487
	D12	**BC1**	**BCD1**	**B1**	**BD1**	**ACD1**	**CD1**	**C1**	**D1**
PC1	0.663	0.642	0.642	0.577	0.546	0.647	0.510	0.524	0.521
PC2	0.144	0.596	0.596	0.355	0.451	0.656	0.625	0.621	0.616

Notes: Input A: Deposits, total deposits and remittances; Input B: Total operating costs; Input C: Number of employees; Input D: The value of owned equipment and software programs; Output 1: Net total revenues; Output 2: Daily "reach" average rate.

In order to better recognize the implications of the estimated models, we need to extend the analysis beyond the first principal component. In the case of the second principal component, we consider both the value and its sign simultaneously. The second principal component is associated with the employment of Internet banking services as a mean of diminishing operating costs on the one hand, and the effective usage of cost controls to achieve a higher performance on the other hand. The second component divides the models into two categories. The first category is represented by the models that have output 2 ("reach") in their structure, while the second corresponds to the models that do not contain this component or contain a mixture of the two outputs. It is easy to identify from Table 3 that the models: ABC12, AB12, ABCD2, ACD2, BCD2, ABC2, ABD2, A12, B12, BC2, AC2, AB2, AD2, A2, CD2, C2, BD2, B2 and D2 are associated with negative values and contain the output 2 ("reach"). Consequently, we can regard these models as being "Internet banking oriented". The rest of the models containing output 1 register positive values, and are mainly associated with input A. These models are ABCD12, BCD12, AC12, BC12, ABD12, ACD12, BD12, CD12, AD12, C12, ABC1, AC1, AB1, ABCD1, A1, ABD1, AD1, D12, BC1, BCD1, B1, BD1, ACD1, CD1, C1 and D1. Since these models mostly contain input A (deposits), which constitutes the main component of a bank's total costs, we classify them as "cost oriented" models.

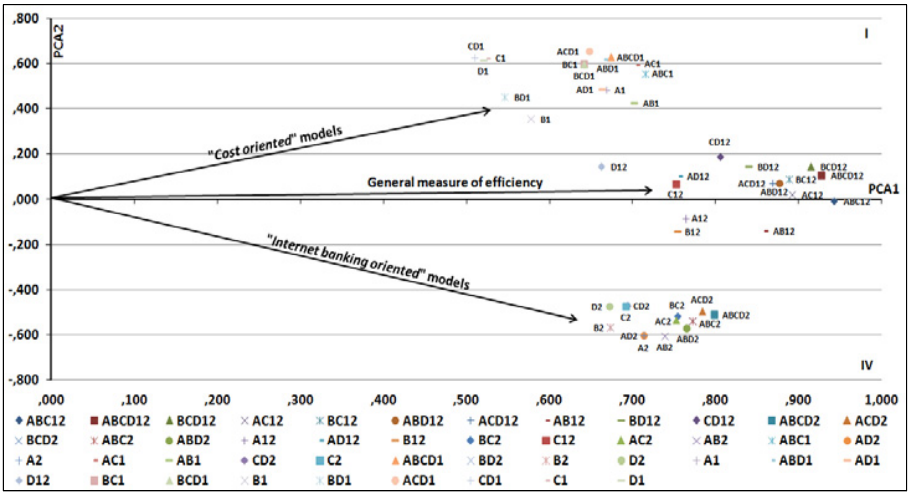

Figure 2 - Graphical representation of the principal component values (models)

We can interpret the outcomes of the DEA using Figure 2. We have drawn on the values provided by the principal components to depict the result of each model in a scatter plot. All of the models are represented in this figure along vector I and IV. The OX axis stands for the general measurement of the efficiency, such that the most efficient models are very close to this straight-line. Above this line are the "cost oriented" models and below it are the "Internet banking oriented" models. Specifically, the models that exhibit a higher efficiency through better cost controls are located above the OX line, while the models that show a higher efficiency by the employment of Internet banking services are placed below this line.

The estimated values based on the DEA in the case of the 45 possible input-output combinations can be analyzed to discover particular characteristics of the banks in our sample. The graphical representation of these results contributes significantly to the analysis of the performance of the 24 banks from our sample that offers Internet banking services as an output. The results of the PCA in the case of the 24 selected banks show no significant difference since the two principal components are responsible for 62.53% of the accumulated variance.

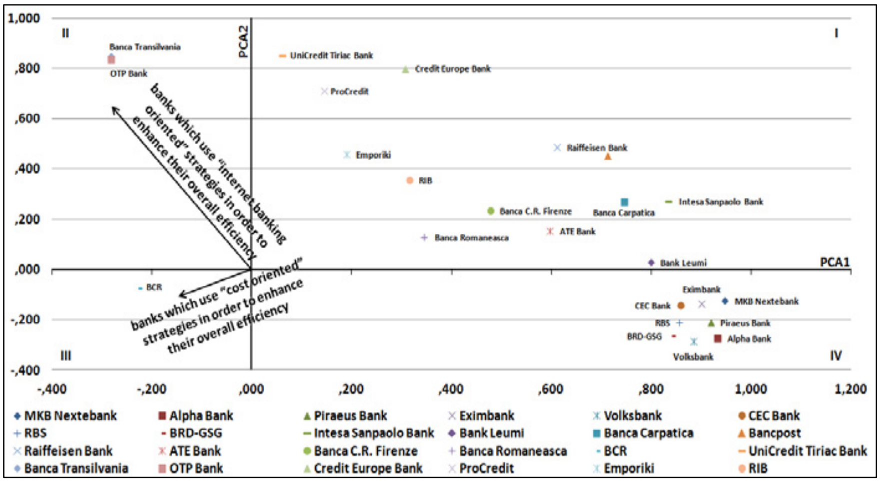

Figure 3 - Graphical representation of the principal component values (banks)

In Figure 3, to the upper far left, we observe OTP Bank with 100% efficient operation in 30 estimated models out of a total of 45. In the lower extreme right, we note MKB Nextebank with the lowest efficiency scores considering all the estimated efficiency models. It becomes clear that the efficiency rises from right to left. Using this approach and taking into account the overall efficiency, the first 10 banks are ranked as follows: OTP Bank, Banca Transilvania, BCR, UniCredit Ţiriac Bank, ProCredit, Emporiki, Credit Europe Bank, Romanian International Bank, Banca Românească and Banca C. R. Firenze. The second principal component represents the orientation of the strategy that each bank chooses in order to enhance its overall efficiency. These strategies are either a "cost oriented" or an "Internet banking oriented". When a bank is placed in the upper part of Figure 3, it uses an "Internet banking oriented" strategy in order to enhance its overall efficiency, while if a bank is placed in the lower part of the figure it uses a "cost oriented" strategy in order to achieve a superior efficiency.

Unlike Figure 2, in the upper left part of Figure 3, there are the banks whose efficiency is directly influenced by the usage of Internet banking. This is highlighted by the fact that Volksbank, which is situated in the lower right side of the figure, has the lowest efficiency scores in the case of all the models that have exclusively output 2 in their components (their value being all the time below 28.8%). In the case of the models that have exclusively output 2 in their component, the following banks: Alpha Bank, BRD-GSG, Piraeus Bank and RBS show the lowest value regarding the "reach" component.

In general, the banks from vector IV exhibit a good overall efficiency, adopting a "cost oriented" strategy to improve their performances. They do not, however, benefit consistently from supplying Internet banking services. On the other hand, Bank Leumi, located very close to the OX axis, uses a mix strategy to enhance its overall efficiency. It combines a strategy to reduce its operating costs and offers Internet banking services in order to obtain a competitive edge. The banks situated in vector I, such as UniCredit Ţiriac Bank, ProCredit and Credit Europe Bank, enjoy relatively high overall efficiency, and they fully use Internet banking services in order to improve their performances.

It is clear when we compare the results, after the application of the PCA on the banks with the different 45 DEA models, that a series of previous unremarked interconnections are revealed regarding the factors that impact the banks performances, as discussed above.

6. Conclusions

The banking industry has benefited tremendously from the development of the Internet. The Internet fundamentally changed the way in which banking networks are designed to meet the client demands and expectations. Despite the upsurge of Internet banking services in the process of intermediation, there is a relatively small body of academic literature that addresses the impact of these services in the banking sectors of the new EU member states, and Romania is no exception to this. Additionally, most studies overlook both financial and non-financial variables in order to underline the performance enhancements that a bank can achieve by employing this particular financial innovation. In our research we investigate the relationship between Internet services and bank efficiency for the Romanian banks, focusing only on the banks incorporated in Romania and eliminating the branches of foreign banks that operate in this country in order to ensure that the banks from our panel are exposed to the same legislative and macroeconomic environment. Using PCA alongside DEA, we were able to identify the Romanian banks that employ the financial innovation represented by Internet banking services in order to enhance their overall efficiency. We believe this approach provides a better understanding of this issue compared to the simple application of DEA, as stated by other researchers, too (see for example Ho and Wu, 2009 or Serrano Cinca et al., 2011).

The results suggest that there are two business strategies practiced in the Romanian banking sector: "cost oriented" and "Internet banking oriented". In addition, we find that only a few of the Romanian banks (i.e., Banca Transilvania and OTP Bank) are able to efficiently use Internet banking services in order to enhance their overall performances. Most of the other banks in our sample prefer a mixed approach between Internet banking services and cost reduction strategies.

These results have interesting policy implications. Citizens and businesses must be encouraged to use Internet banking in their daily activities, including deposits, payments and money transfers. This would cause a surge in the number of Internet banking users, and make these services more viable to be employed by banks in exercising efficiency enhancement strategies. As our results show, only a few banks currently do so. In a period in which the banking activity suffers due to the international financial crisis and one of the main concerns of the banks is to find solutions for the enhancement of the efficiency and the lowering of their costs, Internet banking services are gaining more ground, representing a modern approach for the attraction and retention of customers.

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