EFFICIENCY AND PRODUCTIVITY IN BANKS DEVELOPED THROUGH DATA ENVELOPMENT ANALYSIS: A CROSS COUNTRY-PERSPECTIVE

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1. Introduction

Banking sector is very important for the financial systems stability. The major role of the financial system is to allow efficient allocation of national savings for investments. The financial system must provide the exploitation of the methods of diversification, and also the possibility to reach a compromise, from a macroeconomic point of view, between compensation and risk in what capital allocation is concerned.

A stable financial system must provide that common cyclical or financial shocks don't involve auto perpetuation mechanisms if they surpass the individual agents' capacity from the financial market to deal successfully with the risk. Such evolution could lead to a financial crisis and to major prices changes and even to a temporarily crippling of capital markets. This means that a financial crisis affects the functioning of allocation mechanism or ceases its functioning temporarily. Consequently the financial crises lead to real economic losses of production and growth. Moreover, the excessive prices fluctuations caused by financial crises on capital markets lead to an inefficient big risk premium which hinders the allocation function and blocks the investments, contributing to a smaller growth in the long run. The financial system stability has a crucial importance for the evolution of general economy.

At the base of the current economic crisis, considered to be the most severe crisis since The Great Depression stands firstly a financial crisis. The imprudent policies of the financial institutes led to enormous losses of the worldwide economies. The traditional banks activity, of intermediary of funds, became a secondary one. Banks from developed countries, in their search for new opportunities to make profit, constructed complex financial instruments which dispersed and concentrated the risk in the financial situations of the most banking institutions. The lending between the countries strengthened the interdependences between banking systems and increased the contagion effect. The American banks, closed to the crisis epicentre, were initially the most affected. Soon afterwards, the banks of United Kingdom and the banks of Western Europe followed, thus, breaking out the most severe economic crisis of the last decades.

Taking into account the importance of banking sector in the economy, we wanted, in this study, to render the efficiency and the productivity of banking institutions before and in the course of the crisis using the Data Envelopment Analysis. Banks efficiency and productivity are one of the most

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interesting and important aspects both for government and private sector. The analysis aimed to render the financial crisis implications for every specialized sector of the banking system. Thus, the analysis comprises commercial banks of United States, commercial banks of United Kingdom, commercial and cooperative banks of France, commercial banks, cooperative banks, savings banks and governmental credit institutions of Germany, commercial and savings banks of Spain, commercial, cooperative and savings banks of Italy.[2]

2. Literature review

In literature review, there are many studies which analyze the banking systems efficiency using Data Envelopment Analysis. In the United States of America, there are 40 such studies. There are also studies that make a comparison between countries. Next, we will enumerate some of the most recent studies that use DEA technique to measure the commercial banks performance. Casu and Molyneux (2000) used DEA approach to investigate the efficiency in the European banking sector. They tried to observe if the commercial banks efficiency standardized as a result of the process of European legislative harmonization. Noulas (2001) studied the effect of banking deregulation on private and public banks using Data Envelopment Analysis. The results showed that private banks are much more efficient than the public ones, although the difference between the efficiency levels is not statistically relevant. Barr et. ali. (2002) evaluated the productive efficiency of commercial banks of the United States of America. The results of the study revealed a close interdependence between the scores of banks efficiency and the ratings given by the specialized agencies. Jemric (2002) investigated the banks efficiency in Croatia. The main results highlighted that the banks owned by foreign stockholders are, on the average, the most efficient. Also, the banks recently entered the market are much more efficient than those which operate for a longer period of time. Furthermore, the small banks are more efficient than the big banks. Wu (2002) analyzed the productivity and efficiency of the Australian banks during 1986-2001. The results of the study showed that the efficiency rose during deregulation. Loukoianova (2008) made a comparison between the efficiency and productivity of the banking sectors of Western Europe, USA and Japan, the banking systems being delimitated in terms of the characteristics of each country.

3. Methodology

The efficiency and the productivity of banking sector is one of the most important aspects for the worldwide economists. This statement is reinforced by the various studies aimed to study the efficiency and productivity of commercial banks, the concept of efficiency in banking sector being very widespread in the literature review. Parametric and also nonparametric techniques are used to determine this concept.

Broadly speaking, the concept of efficiency characterizes the method of using the resources in the production process. Consequently, the efficiency should quantitatively express the performances regarding the method of converting the inputs into outputs[3]. Obviously, efficiency is a relative concept because the performance of a unit of production must be compared to a

[2] Each banking sector included in the analysis is defined by a number between 10 and 15 banks, depending on the data availability. The banks were selected in terms of assets size, the study comprising the banks from the first positions in terms of assets.

[3] Inputs – physical conversion of some factors of production (productive inputs) in goods (products), called *outputs*.

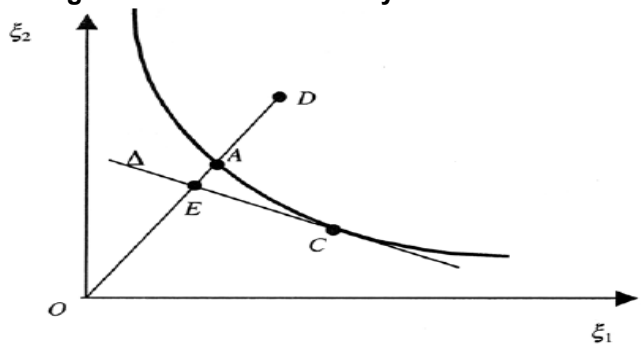
standard and its setting implies a process of decision in which various objectives of the activity of production can be considered.

Econometrics techniques (parametric) are based on the estimation of the least-square methods known from the solving of the regression methods, and the technique of mathematical programming, used to measure the efficiency, is determined by envelopment model (nonparametric). To "envelop" the input and output data, these can be taken either separately or together. Farrel (1957), in his works, presented some suggestions to measure the efficiency. Initially, he introduced three types of efficiency: technical, allocative and cost efficiency. We will present them separately.

Technical efficiency is measured comparing the observed input ratio of a studied unit to the adequate ones on the efficient frontier. The last ones are obtained using a radial conversion of the observed inputs. As an example, we analyzed a unit whose inputs ratios are represented by point D in fig. 1. The technique efficiency (TE^D) of this unit of decision is measured by OA/OD relation and it shows how much the inputs must be reduced proportionally to produce the observed output. Here, the position A indicates the radial projection of point D on the efficient frontier. If we know the inputs prices, we can measure both the allocative and cost efficiency. **Allocative efficiency** is measured comparing the average cost of the inputs used in the technique efficiency to the adequate optimum cost (radial). **Economic (cost) efficiency** is measured comparing the observed cost-average to the adequate optimum cost (radial).

In figure 1 right Δ expresses the minimum adequate costs to produce an output unit for various combinations of input ratios. It intersect (is tangential to) the efficient frontier in point C. Point D is technically inefficient, as we have already seen, and point A is its projection on the efficient frontier. The allocative efficiency of point D is expressed by AE^D = OE/OA relation, while the economic (cost) efficiency is given by the EE^D=OE/OD relation. We observe that the economic efficiency is the product between the technique efficiency and the allocative efficiency. That is why it is also called total efficiency.

Figure no. 1 - The efficiency measurement

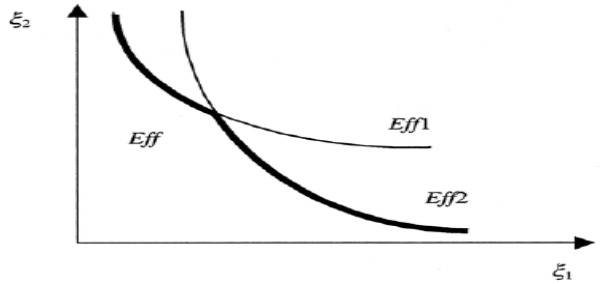


Scale efficiency measures. This type of efficiency measures how close the producer is to the optimum scale. To express quantitatively the efficiency of a unit of production, we firstly determine the "target" plans of technological production, for a designed process of production. With this aim, the concept of efficient frontier was introduced.

In figure 2 it is presented the efficient frontier *Eff* obtained using the

envelopment of efficient frontiers *Eff1 and Eff2* of two units of production (Forsund, Hjalmarsson - 1987).

Figure no. 2 - The efficient frontier Eff obtained using the DEA



For each combination of resources a maximal result is obtained, but the data of these results can actually coincide with this maximum or they can be of a lower level. The enterprise which obtains a maximal result in comparison with a unit of resources is chosen as a model with which all the enterprises are compared according to the level of using resources. The efficient enterprises form "the efficient production frontier". Therefore the estimation of the efficiency is determined through the distance calculation between the studied enterprises and the efficiency frontier.

The changing of the efficiency frontier is usually performed through two methods. The first one- by means of the production possibilities function through the mathematical statistic method for the enterprises with a higher efficiency. The second one-the determination of the maximal results based on the comparison of the partial indices of the using resources efficiency, determining the enveloped data.

These enveloped data create the production possibilities frontier, namely the maximal possibility of the results through the different resources combinations. This method is named data envelopment analysis, DEA.

This method belongs to Farrell (1957). According to Farrell, the efficiency is determined as the ratio of the enterprises productivity to the maximal productivity. The envelopment nonparametric techniques were further on developed by Charnes, Cooper and Rhodes (1978). It is about the methodology named DEA (Data Envelopment Analysis), which uses models of mathematics programming in order to create the envelope of the production possibilities set. The peculiarity of this method consists of the fact that all the observations are supposed to be on the same side of the production frontier and the term "error" catches only the inefficiency. The priority of the envelopment method DEA, as an alternative towards other efficiency estimation method, consists of the following:

- The frontier of the multiple outputs can be easily found;
- It is not necessary to search the type and the form of the function, because the production possibilities frontier is determined as data envelopment.

The Malmquist index (*Malmquist Productivity Index*) is considered to be among the most common methods of determining the factors total productivity. This index is described further on. In order to define the productivity indices, we suppose that the production process is followed by T periods of time. In the technological process S_2 M-outputs are obtained by transforming N-inputs. For the periods of time t {1, 2…T}, the inputs vector is noted as $x_t \in R_+^N$, and the outputs vector

$y_t \in R_+^M$ respectively. The admitted technological space S_t, consists of the set of input-output vectors.

$$S = \{(x_t, y_t | y_{t \le f(x_t)}\} \in R_+^{M+N},$$

Where $f(x_t)$ is the frontier of the technological space. The output distance function can be defined as it follows:

$$D_t^0(x_t, y_t) = \min\{\theta : (x_t, y_t / \theta) \in S_t\},$$

Where $D_t^0(x_t, y_t) < 1$ only when the pair $(x_t, y_t) \in S_t$. When (x_t, y_t) is on the frontier of the technological space (this means that the process of production is technical efficient) then $D_t^0(x_t, y_t) = 1$.

The TFP index, output oriented, compares the pair (x_t, y_t) to the pair (x_{t+1}, y_{t+1}), projecting the output y_{t+1} on the set frontier f (y_{t+1}) and the output y_t on the frontier f(x_t). This index is equal with the ratio of the distance function $D_{t+1}^0(x_{t+1}, y_{t+1})$ at the distance function value $D_{t+1}^0(x_t, y_t)$. The Malmquist index for the period's t and t+1 is the geometrical mean of the TFP values in the respective period:

$$M_0(x_{t+1}, y_{t+1}, x_t, y_t) = \left[\frac{D_t^0(x_{t+1}, y_{t+1})}{D_t^0(x_t, y_t)} \times \frac{D_{t+1}^0(x_{t+1}, y_{t+1})}{D_{t+1}^0(x_t, y_t)}\right]^{\frac{1}{2}}$$

In order to determine the sources of the productivity growth in the technological process, this index is decomposed in two constituent parts:

$$M_0(x_{t+1}, y_{t+1}, x_t, y_t) = \frac{D_{t+1}^0(x_{t+1}, y_{t+1})}{D_t^0(x_t, y_t)} \times \left[\frac{D_t^0(x_{t+1}, y_{t+1})}{D_{t+1}^0(x_{t+1}, y_{t+1})} \times \frac{D_t^0(x_t, y_t)}{D_{t+1}^0(x_t, y_t)}\right]^{\frac{1}{2}} =$$
$$= \Delta TE_0(x_{t+1}, y_{t+1}, x_t, y_t) \times \Delta TC_0(x_{t+1}, y_{t+1}, x_t, y_t)$$

Where $\Delta TE_0(x_{t+1}, y_{t+1}, x_t, y_t)$ is the index of the change of the technical efficiency in TFP evaluation and $\Delta TC_0(x_{t+1}, y_{t+1}, x_t, y_t)$ measures the technical change between the period t and t+1. The change of the technical efficiency firstly depends on the rational use and at optimal values of the material and human resources. The change value of the technological efficiency ΔTC_0 is a geometrical mean of shifting the technology between the period t and t+1 at the outputs level x_t and x_{t+1}.

The calculated index shows that:

a) If TFP>1, then a productivity growth was realized in the period t (between the moment t and t+1);

b) If TFP=1 then the productivity remained at the same level;

c) If TFP<1 then the productivity decreased between the two moments.

4. The used variables and the obtained empirical results

Before analyzing the banks efficiency and productivity we will start to specify the utilized inputs and outputs. In this analysis, a method orientated to the

banks capacity of making profits in staid of the traditional approaches was used. More exactly the inputs which were used in the approach that treated the banks as intermediaries (labor, capital, deposits) were replaced by different elements of costs from the account of profit and loss (Drake, Hall, 2003). Berger and Mester (2003) argue that the approach based on profits will also take into account the quality of the banking services which will be observed in the higher income obtained by the bank. Consequently, the three inputs used are **personnel expenses, other operational expenses and loan loss provisions**. In what concerns the last variable two specifications are necessary. Firstly, the incorporation of a variable which expresses the report between the assumed risk and the assets quality is vital in studying the banks efficiency. Secondly, in the context of the actual financial crisis, where the loan loss provisions became an important element in the financial situations, its inclusion in the analysis surprises, in a certain measure, the aversion for the risk of each bank.

Similarly, in staid of using outputs of the intermediary approach (credits or other earning assets) we will use the generating income elements from the account of profit and loss. The three outputs utilized are **the net interest revenue, the net commissions revenue and other operational income.** The data concerning the outputs and the inputs were obtained from the Bureau Van Dijk (BVD) database. The results obtained for each banking sector are presented in the table no.1.

The scale efficiency scores, which show how much the banks benefited by the economies of scale, knew, on average a significant decrease in 2008 in comparison with 2006. If in 2006 eight of the 13 banking sectors included in the study were situated on the efficiency frontier, in 2008 only three of them succeeded in reaching this frontier.

Table no.1 – The efficiency scores and the productivity of the banking systems

	Scale Efficiency [4]			Total Factor Productivity – Malmquist Index		
	2006	2007	2008	2006	2007	2008
Commercial banks of USA	1.000	1.000	0.763	1.000	0.712	1.021
Commercial banks of UK	0.805	0.882	0.834	1.000	1.100	1.644
Commercial banks of France	1.000	0.998	0.849	1.000	0.681	0.614
Cooperative banks of France	1.000	0.911	0.837	1.000	0.854	0.824
Commercial banks of Germany	1.000	1.000	1.000	1.000	1.080	1.001
Cooperative banks of Germany	0.903	1.000	1.000	1.000	1.037	0.770
Savings banks of Germany	0.904	0.978	0.891	1.000	1.032	0.638
Governmental credit institutions of Germany	1.000	0.884	0.876	1.000	0.586	1.148
Commercial banks of Spain	1.000	1.000	1.000	1.000	1.014	0.944
Savings banks of Spain	1.000	1.000	0.988	1.000	0.979	1.009
Commercial banks of Italy	1.000	0.997	0.981	1.000	0.972	0.820
Cooperative banks of Italy	0.994	1.000	0.918	1.000	1.028	0.738
Savings banks of Italy	0.987	0.990	0.988	1.000	0.940	0.784
Mean[5]	**0.969**	**0.972**	**0.917**	**1.000**	**0.909**	**0.889**

Source: own calculation

[4] Scale efficiency = CRSTE(technical efficiency from DEA CRS)/VRSTE(technical efficiency from DEA VRS). The scale efficency measures are between 0 and 1. If so, the unities included in the study are situated on the efficency frontier and then the score will be 1. The lower the score is the less the unities benefit by the effect of scale.

[5] Calcuted with and through the geometrical mean.

The lowest scores were registered in the commercial banks of USA and of United Kingdom, the banking sectors the most affected by the financial crisis. The good scores of the banks which operate in Spain should be also remarked. This fact can be due to the policies of regulation adopted by the Central Bank of Spain. That is why a system of creating dynamic provisions was introduced: in the conditions of the accelerated credit growth, the banks were forced to create higher provisions for counteracting a future deterioration of the credits portfolio, the procedure being seen as a correction, which doesn't allow the appearance of some excessive profits in conditions of economical boom.

In what concerns the productivity we observe an obvious tendency of aggravation. Therefore this index knew a decrease of 9.1% in 2007 in comparison with 2006 and it also continued to decrease in 2008. We consider as being very interesting the productivity evolution in what concerns the banks of United Kingdom and of USA. Therefore if in 2007 the American banks productivity decreased with 28.8%, in 2008 this index considerably improved. This fact denotes the quick answer that banks had in front of the challenges with which they confronted. They managed to implement rapid policies of operations reorganization and consolidation. On the other hand, we observe that the productivity index decreased more in 2008 for the specialized banking sectors in comparison with 2007. From the productivity we also observe a stronger degree of correlation between the specialized segments in the same banking system, in comparison with the degree of correlation between the same specialized sectors from different countries. For example the productivity indices in the case of the three banking sectors in Italy are between 0.738 and 0.820, while the difference between the savings banks of Italy and of Spain is more emphasized (0.784, 1.009 respectively). Further on we also considered to be necessary to present the way in which each factor contributed to the reduction of the productivity progress within the period 2006-2008 with 11.1% (table no.2).

Table no.2 – The global progress of the resources and their decomposition in the dynamics of the years 2006-2008

	Technical variation	The technological efficiency variation	The pure efficiency variation	The scale efficiency variation	The total factor productivity TFP
Commercial banks of USA	0.759	1.344	1.000	0.759	1.021
Commercial banks of UK	1.113	1.451	1.000	1.133	1.644
Commercial banks of France	0.715	0.858	0.909	0.787	0.614
Cooperative banks of France	0.842	0.979	1.000	0.842	0.824
Commercial banks of Germany	1.000	1.001	1.000	1.000	1.001
Cooperative banks of Germany	1.000	0.770	1.000	1.000	0.770
Savings banks of Germany	0.805	0.793	0.884	0.910	0.638
Governmental credit institutions of Germany	1.061	1.082	1.065	0.996	1.148
Commercial banks of Spain	1.000	0.944	1.000	1.000	0.944
Savings banks of Spain	0.986	1.023	1.000	0.986	1.009
Commercial banks of Italy	1.013	0.809	1.040	0.975	0.820
Cooperative banks of Italy	0.910	0.811	0.952	0.955	0.738
Savings banks of Italy	0.994	0.789	1.000	0.987	0.784
Mean	**0.932**	**0.954**	**0.987**	**0.944**	**0.889**

Source: own calculation

The factors total productivity analysis offers us the possibility to compare the financial institutions' productivity, over the period 2006 to 2008. The productivity diminution with 11.1% is produced by all the factors included in the analysis. Thus the technological efficiency was reduced with 4.6% and the scale efficiency with 5.6%. The only sectors where the integral potential of the resources is efficiently utilized are represented by the commercial banks of Great Britain and by the commercial banks of Germany. The result obtained by the Britannic banks is surprising, taking into account the problems with which some of these banks confronted. This could be explained through the consolidation and reorganization operation undertaken in the banking system.

5. Conclusions

In this article we wished to surprise the banking systems efficiency and productivity in the main developed countries as well as the way in which the financial and economical crisis influenced these variables. The undertaken analysis doesn't want to be an exhaustive one, a continuation being necessary in the next years for a better underlining of the actual economic conjuncture impact over the banking sectors. The results allow us to draw the following conclusions: (i) the resources integral potential of the financial institutions between 2006-2008 was inefficiently utilized; (ii) in this period the banks adopted a strategy of extensive development; (iii) the investments in the technological process re-equipment were reduced for lack of financing sources; (iv) the labour is inefficiently used; (v) the increase of the (global) integral progress is firstly conditioned by the increase of the technological and technical efficiency and only the implementation of new techniques and technologies will offer the possibility to use all the resources efficiently; (vi) the TFP indices application in the (global) integral progress study with nonparametric techniques offers the possibility to realize an ampler evaluation in comparison with the traditional models.

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