Malmquist Index, an Alternative Technique for Measuring Credit Institutions Productivity

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Abstract. *The present study tackles the banking system's productivity in a more complex manner, that integrates multiple input, multiple output variables, abdicating from the reductionist perspective of clasical methods, which imposed limits in the number of variables, in the process of productivity measurement and interpretation. The advantage of Malmquist productivity indexes consists both in a quantitative evaluation of the global productivity of a credit institution over a specified period of time, and in the decomposition of productivity, in order to underline how much of its change is due to the catch-up effect, and, respectively, to the implementation of new technologies.*

The results obtained revealed that credit institutions placed on the first three places in the banking system, according to assets value, maintained constant their productivity level during the analysed period, meanwhile the other institutions in our sample registered a slowly improvement in productivity, determined, mainly, by technological changes.

Key words: efficiency score; distance function; Malmquist productivity index; technical efficiency; technological efficiency.

Introduction

Economic literature outlines two main methods for productivity measurement: the clasical one and the index method. *The clasical method* assumes the building of productivity ratios as output variable on the unit of input. Input variables are represented by human ressource, capital, materials and other ressources. The most frequent used ratios are:

- partial productivity

$$PP = \frac{O}{L(sau\,M, C, r)}$$

- factor productivity $TFP = \frac{O}{L + C}$
- total productivity

$$TP = \frac{O}{L + M + C + r}$$

where:

O = output variable;
L = labor, human resource;
M = materials;
C= capital;
r = other resources.

Partial productivity PP reflects the influence of a single input. Its main advantage consists in accesibility in understanding and measuring the productivity. *TFP indicator* integrates the influence of two inputs: labor and capital. It is considered more accurate than the precedent indicator, but it is also more difficult to measure. *Total productivity TP* includes all input variables.

The productivity index method. These indexes synthetise the tendency observed in an entity's productivity during a specified time horizon, and allow the identification of causes that have generated productivity changes.

In order to quantify the productivity change for a group of five credit institutions during december 2003- december 2006, we have chosen the Malmquist index approach[1], because they don't assume the definition of a functional relationship on the structure of production technology and don't need informations concerning the input and output prices. Moreover, they can be computed under the assumption of multiple inputs, multiple outputs and allow the productivity's decomposition in two components: technical efficiency change and technological change.

1. Methodological aspects

To determine Malmquist indexes one must compute the distance functions. Empirical studies have revealed a series of techniques that can be employed in order to quantify these functions. In the present study we have chosen one of the most frequently used technique, called Data Envelopment Analysis, proposed by Fare (1994). In consequence, the distance functions value is given by the individual efficiency scores estimated by means of DEA, and those credit institutions whose function value is equal to one are considered technically efficient.

To compute Malmquist index we have used the formula proposed by Caves, Christensen, Divert (1982)

because it is adapted for the output oriented models (one of the assumptionsof our study).

$$M_{t,t+1}(y^t, y^{t+1}, x^t, x^{t+1}) = \\ = \left[\frac{D^t(y^{t+1}, x^{t+1})}{D^t(y^t, x^t)} \times \frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^{t+1}(y^t, x^t)} \right]^{1/2} \quad (1)$$

where:

$M_{t, t+1}$ = Malmquist productivity index for a time period between t and t+1;

y^t, y^{t+1} = output vectors at moment t, respectively t+1;

x^t, x^{t+1} = input vectors at moment t, respectively t+1;

D^t, D^{t+1} = distance function at moment t, respectively t+1.

First ratio represents the Malmquist index computed for moment t, and measures the productivity change during the t, t+1 period, using as reference point (benchmark) the technology in t period. The second ratio reflects the Malmquist index value at t+1 moment, having as benchmark the technology of t+1 moment. A value bigger than one for the index suggests an improvement in productivity level, meanwhile a value smaller than one indicates a deterioration. If M=1, there is no change in the productivity level. Humphrey (1991) argues that, even in the case of a reduced, sometimes negative productivity of a credit institution, the users of banking services benefit from an improvement in the quality of services supplied. The author believes that there is a reallocation phenomena of advantages offered by productivity between customers and credit institutions.

According to Fare (1989), an equivalent manner for writing the Malmquist index, in order to accentuate the two components, is the following:

$$M_{t,t+1}(y^t, y^{t+1}, x^t, x^{t+1}) = \\ = \frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^t(y^t, x^t)} \times \\ \times \left[\frac{D^t(y^{t+1}, x^{t+1})}{D^{t+1}(y^{t+1}, x^{t+1})} \times \frac{D^t(y^t, x^t)}{D^{t+1}(y^t, x^t)} \right]^{1/2} \quad (2)$$

where:

$\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^t(y^t, x^t)}$ represents the technical efficiency change and illustrates how much varies the distance between the observed production and the maximum potential production during the period t, t+1. It is also known as the *catch-up effect.*

$$\left[\frac{D^t(y^{t+1}, x^{t+1})}{D^{t+1}(y^{t+1}, x^{t+1})} \times \frac{D^t(y^t, x^t)}{D^{t+1}(y^t, x^t)} \right]^{1/2}$$

reflects the technological change and indicates the *production frontier shift*, as a consequence of improved technology.

2. Interpretation of results

To compute the Malmquist indexes we have applied initially a simpler model, build on the premise that a credit institution produces only two outputs: *total volume of credits* and *net income from other activities*, by using two inputs: *customers deposits* and *other financing sources*. Subsequently, we extended the analysis by employing a more complex, adequated model to

measure efficiency, in order to observe if the model's specification influences the credit institutions productivity. The model includes as input variables customers deposits, other financing sources, operational expenses and loan loss provisions. Output variables are represented by total volume of credits, net income from other activities, net interest income and off-balance sheet activities. To catch the changes in productivity, we proceeded to the computation of Malmquist indexes, following the next steps:

STAGE 1: computation distance function D 2004 (y 2003, x 2003)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
{X} DMU 1 2003	100.00%	0	1	1	0
{X} DMU 2 2003	100.00%	0	1	0	1
{X} DMU 3 2003	100.00%	0	1	0.3	0.7
{X} DMU 4 2003	100.00%	1	0	0.8	0.2
{X} DMU 5 2003	100.00%	1	0	0	1
DMU 1 2004					
DMU 2 2004					
DMU 3 2004					
DMU 4 2004					
DMU 5 2004					

STAGE 2: computation distance function D 2005 (y 2004, x 2004)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
{X} DMU 1 2004	100.00%	0	1	0.3	0.7
{X} DMU 2 2004	100.00%	0	1	0.7	0.3
{X} DMU 3 2004	100.00%	1	0	0	1
{X} DMU 4 2004	100.00%	1	0	0.3	0.7
{X} DMU 5 2004	100.00%	1	0	0.7	0.3
DMU 1 2005					
DMU 2 2005					
DMU 3 2005					
DMU 4 2005					
DMU 5 2005					

STAGE 3: computation distance function D 2006 (y 2005, x 2005)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
{X} DMU 1 2005	100.00%	0.5	0.5	0	1
{X} DMU 2 2005	100.00%	0	1	0.8	0.2
{X} DMU 3 2005	100.00%	1	0	0.4	0.6
{X} DMU 4 2005	100.00%	1	0	0.5	0.5
{X} DMU 5 2005	100.00%	1	0	0	1
DMU 1 2006					
DMU 2 2006					
DMU 3 2006					
DMU 4 2006					
DMU 5 2006					

STAGE 4: computation distance function D 2005 (y 2006, x 2006)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
{X} DMU 1 2006	100.00%	0.1	0.9	1	0
{X} DMU 2 2006	100.00%	0	1	1	0
{X} DMU 3 2006	100.00%	0.9	0.1	0.9	0.1
{X} DMU 4 2006	100.00%	0	1	0.8	0.2
{X} DMU 5 2006	100.00%	0	1	0.2	0.8
DMU 1 2005					
DMU 2 2005					
DMU 3 2005					
DMU 4 2005					
DMU 5 2005					

STAGE 5: computation distance function D 2004 (y 2005, x 2005)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
{X} DMU 1 2005	100.00%	1	0	1	0
{X} DMU 2 2005	100.00%	1	0	1	0
{X} DMU 3 2005	100.00%	0.8	0.2	1	0
{X} DMU 4 2005	100.00%	0	1	1	0
{X} DMU 5 2005	100.00%	1	0	0	1
DMU 1 2004					
DMU 2 2004					
DMU 3 2004					
DMU 4 2004					
DMU 5 2004					

STAGE 6: computation distance function D 2003 (y 2004, x 2004)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
{X} DMU 1 2004	100.00%	0.8	0.2	0.3	0.7
{X} DMU 2 2004	100.00%	1	0	1	0
{X} DMU 3 2004	117.17%	0.7	0.3	1	0
{X} DMU 4 2004	105.64%	0.7	0.3	1	0
{X} DMU 5 2004	100.00%	1	0	1	0
DMU 1 2003					
DMU 2 2003					
DMU 3 2003					
DMU 4 2003					
DMU 5 2003					

STAGE 7: computation distance function D 2003 (y 2003, x 2003)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
DMU 1 2003	100.00%	0.2	0.8	1	0
DMU 2 2003	100.00%	0	1	0	1
DMU 3 2003	100.00%	0	1	0.9	0.1
DMU 4 2003	103.40%	0.7	0.3	1	0
DMU 5 2003	100.00%	1	0	0	1

STAGE 8: computing distance function D 2004 (y 2004, x 2004)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
DMU 1 2004	100.00%	0	1	0.5	0.5
DMU 2 2004	100.00%	0.2	0.8	0	1
DMU 3 2004	100.00%	0	1	0.5	0.5
DMU 4 2004	100.00%	0.7	0.3	1	0
DMU 5 2004	100.00%	1	0	0	1

STAGE 9: computing distance function D 2005 (y 2005, x 2005)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
DMU 1 2005	100.00%	1	0	0.5	0.5
DMU 2 2005	100.00%	0	1	0.5	0.5
DMU 3 2005	100.00%	1	0	0	1
DMU 4 2005	100.00%	0	1	0.8	0.2
DMU 5 2005	100.00%	0.7	0.3	0	1

STAGE 10: computing distance function D 2006 (y 2006, x 2006)

DMU	Score	Deposits {I}{V}	Other financing sources {I}{V}	Customers credits {O}{V}	Net income other activities {O}{V}
DMU 1 2006	100.00%	0.9	0.1	0.5	0.5
DMU 2 2006	100.00%	0	1	0.5	0.5
DMU 3 2006	111.23%	1	0	0.7	0.3
DMU 4 2006	100.00%	1	0	0.8	0.2
DMU 5 2006	100.00%	0	1	0	1

STAGE 11: computing Malmquist indexes

DMU 1	1
DMU 2	1
DMU 3	1.14
DMU 4	1.01
DMU 5	1

As can be observed from the last results of the analysis, credit institutions 1, 2 and 5 obtained a Malmquist index equal to one for the entire period 2003-2006, which means that there weren't significant productivity changes during the specified period. Institutions 3 and 4 have attained a slowly improvement in productivity. We have continued the analysis to reflect the annual fluctuation in the productivity of each institution, the results obtained being presented in table 1.

Malmquist indexes computed on an annual basis

Table 1

	DMU 1	DMU 2	DMU 3	DMU 4	DMU 5
2003-2004	1	1	1,08	1,01	1
2004-2005	1	1	1	1	1
2005-2006	1	1	1,05	1	1

The results indicate an insignificant improvement in productivity during 2003-2004 and 2005-2006 years for credit institutions 3 and 4. To identify the component that contributed to this evolution in Malmquist indexes, we have computed the technological and technical efficiency change, the results being presented in table 2.

Technological and technical efficiency change

Table 2

Technical efficiency change	DMU 1	DMU 2	DMU 3	DMU 4	DMU 5
2003-2004	1	1	1	0,96	1
2004-2005	1	1	1	1	1
2005-2006	1	1	1,11	1	1
Technological change	**DMU 1**	**DMU 2**	**DMU 3**	**DMU 4**	**DMU 5**
2003-2004	1	1	1,08	1,05	1
2004-2005	1	1	1	1	1
2005-2006	1	1	0,95	1	1

During the period 2003-2004 credit institution 4 faced with a decrease of its production potential concerning output maximization of 4%, compensated by a technological improvement of 5%. For the same period, the productivity improvement of institution 3 was due to technological progress, which registered an increase of 8%. During 2005-2006 years, the total productivity index of the institution 3 increased with 5%, being determined by an increase of technical efficiency with 11%, meanwhile technological fluctuations exerted a negative influence, of -5%. The influence of new technologies materialised not only in a diversification of financial services supplied to customers (electronic payments, internet banking, self banking), but also into an improvement of back-office activity, by using economic and statistical models to evaluate the credit and market risk, by modern, rigorous scoring techniques and discriminant analysis to evaluate the credit demands.

The productivity growth due to the implementing of new financial and software technologies[2] reflects mainly into the quality of the service rendered, into a diminuation of the time of waiting for an operation to be executed, into the degree of satisfaction attained by customers, and implicitly, into their loyalty, but there is extremely difficult to reveal and measure it. Moreover, the costs concerning the implementation and utilisation of software techniques are beared, usualy, by credit institutions, because of pressures exerted from competitors.

The computation of Malmquist indexes has been extended also for the complex model, with four input variables and four output ones, but all credit institutions obtained values equal to one for the entire period analysed, which indicates a maintenance of productivity. It can be observed that there are no significant fluctuations in the value of indexes across the two models. We can therefore conclude that it is enough to analyse the main specific elements of the intermediation activity, to estimate the productivity of a credit institution.

Conclusions

A priority of the top management of a credit institution must be the maintenance of an internal climate that allows for an increase in productivity level. In this context, human ressources and technology represent key elements of this desideratum. Personal's productivity should be analysed related to the volume of operations realised in a certain period of time (the number of new deposit accounts at the end of a day, the volume of new supplied credits etc.). Also, it must be monitored the frequency in using those banking services that integrate new technologies (internet banking, self banking, smart card etc.).

The productivity growth reflects itself in the improvement of quality of services supplied, diminuation of production costs, increase of profitability and market share. Productivity appears, therefore, as being equivalent to a comparative advantage.

Notes

(1) Malmquist S., in the study "Index numbers and indifference curves " (1953), proposed for the first time the computation of an index as ratio between the distance functions, index that bears its name.

(2) The typology of the new financial and software technologies and their impact on banking system's productivity had been described in the study of Berger A.N., "The economic effects of technological progress: evidence from the banking industry", *Journal of Money, Credit and Banking*, vol. 35, no. 2, 2003

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