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Changes in the productivity of banks situated in Poland during the years preceding the financial crisis

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Abstract

The aim of this analysis is the assessment of productivity changes of banks performing in Poland in the years 1996–2007. The analysis comprises 27 biggest banks which performed their activities in the above mentioned period of time. The level of productivity was assessed by the means of non-parametrical DEA method. In particular, we assessed how the level of productivity in banks being examined has changed depending on the profile of their activity.

To assess the changes of bank productivity during the time two ideas were applied. The first approach we set indicators of technical efficiency supposing that the cross-time data create one set of data. This allows us to make direct comparisons of the banks examined in a period of time. The second approach was based upon the methodology of defining Malmquist indexes for changes in annual productivity. Then we examined the accordance of productivity changes made on the base of the two approaches.

Keywords: productivity, DEA, financial crisis, Polish banks

JEL: G-20, G-21, G-14

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1. Introduction

The issues concerning efficiency and productivity of a banking enterprise are within the mainstream of knowledge of banking research in theory as well as in practice. This is confirmed by a number of studies concerning this idea, in which measurement methods and research results on bank efficiency have been presented. The reasons of growing interest of bank efficiency can be found in the tasks performed by these entities in the market economy, changes which take place in the bank environment and growing competition at the market of banking services. However, the superior cause seems to be that a development of each bank strongly depends on its level of efficiency. An analysis of efficiency and productivity of the bank is a significant element of the efficient evaluation of its performance and competitiveness (Heffernan 2005). In the research on European banks it was shown that the most important challenge and the aim of the banks is to reduce costs and increase profits, yet costs efficiency has become the issue of the strategic meaning (Molyneux, Altunbas, Gardener 1996; Sherman, Gold 1985; Brockett et al. 1997).

The aim of this research is to assess the functioning of commercial banks in Poland in the years 1996–2007 looking at changes at their productivity level. To assess them we applied non--parametrical DEA method (Charnes, Cooper, Rhodes 1978) applying two ideas of examining changes of bank productivity within the time. Furthermore, the issue of differentiating the level of productivity of banks having different scope of activity was taken into account (we distinguished universal, retail and corporate banks).

In the first idea called uniform for this study, the data having cross-sectional and time series character (27 banks in 12 years), are treated as one sample having 27×12 units examined. This makes that efficiency measures, estimated according to DEA model for individual banks in various years, are determined according to the common efficiency frontier curve. That is why they can be compared in time as well as cross aspect.

In the second case we applied the Malmquist index, which is a measure of efficiency changes in two periods of time (t_1 and t_2), which relies on a certain synthesis of assessing productivity of a given bank in the two periods of time in relation to other units from the period t_1 and t_2.

2. Selection of units examined and sources of data

The research covered 27 commercial banks which performed in Poland in the years 1996–2007. These banks accumulated joint assets worth 637 944 million PLN, which makes 80% of all assets in the bank industry in Poland. The choice of banks to the research depended on two factors. Firstly, the characteristics of the DEA method, which usually requires collecting a set of uniform data of all units examined, describing inputs and outputs in a bank's activity. Secondly, the sources of financial data concerning banks doing their activity in Poland. The sources available in Poland are not a uniform and integrated data base, from which one can obtain financial information about banks' activities. The data were obtained mainly from Monitor Polski B. However, changes in the bank accounting procedures, which

took place during the analysed period made it necessary to be completed incidentally from annual rankings of 50 biggest banks in Poland. The rankings are published in the *Bank* magazine. In selected cases data were obtained from financial reports published by banks on their websites. The limitations described above made it possible to gather a comprehensive set of quantity data concerning the combination of inputs and outputs coming from the idea of an intermediation approach for the 27 banks during the whole period 1996–2007. Ownership changes and consolidation processes which took place particularly in the second half of the 1990s and at the beginning of the 2000s made some banks to be bought by other companies, changed their name or disappeared completely from the market.

As the group of 27 banks selected to the analysis constitutes a very differentiated set according to their activity profile the 27 banks can be divided into serving all clients, retail and corporate ones. The agreed classification according to the profile of their activities was based upon the information provided by banks in the ranking of 50 biggest banks in Poland (see Bank 2008).

Over a half of the analysed banks (16 banks) could be defined as serving all clients in the basic product offer, performing at the same time selective strategies directed to chosen segments of clients. Banks serving all clients offer a range of financial services from taking deposits and granting loans to insurance and buying and selling security services. We also included banks which are leaders in servicing corporate clients. However, they were classified as serving all clients ones since they do not aim their offer exclusively to one type of clients.

Among banks defined as retail ones we included these which concentrate on serving the most affluent clients as well as these which concentrate on non-affluent clients and offer highly profitable loan products, including mortgage and car loans. We included smaller banks which almost exclusively serve companies and possess highly specialized product offer directed to corporate clients (5 banks). However, as it was mentioned, the biggest banks which dominate in the segment of serving companies were considered for the purpose of this study as serving all clients because they apply a strategy of such a bank serving all clients focusing on selected financial products. No internet or mortgage banks were included in this study.

The productivity of the banks was assessed by the means of both inputs and outputs. It comes out of the notion of an intermediation approach, in which the activity of a bank relying on receiving deposits and granting loans as well as other investment means is stressed (Casu, Molyneux 2001; Freixas, Rochet 1997). According to Sealey and Lindley (1997) deposits are inputs in the production process of banking services, while the profitable assets (loans, securities, etc.) are the result of the bank's operations.

It was accepted that inputs are fixed assets, liabilities and operating costs. We classified all receivables, securities and commission sum as outputs. The model structure is presented in Figure 1. As a wide time range of the analysis was considered all amounts were quoted in the prices at the end of the year 2007 that is the level of inflation was taken into account.

It is worth noting that a selection of inputs and outputs in the models of efficiency assessment of banks operating is the subject of a constant debate. The choice of variables in the model is arbitrary in the majority of analyses based on the idea of an intermediation approach and it often results from data availability.

We took into account bank's operating costs in the set of inputs. These costs are one of the basic factors which decide about the level of management effectiveness. Operating costs are connected with operating of the bank and should be correlated with a scale of operation. The development of a bank, opening new branches, increase in employment, implementing IT systems most often cause the increase of operating costs. Operating costs can be called functioning costs or out-of-interest costs. Personnel and material costs are included in them. Personnel costs include salaries and surcharges on salaries as derivatives. However, material costs include costs connected with premises usage and ensuring conditions for operation of the bank, e.g. telephone costs, property insurance, use of materials, electricity, outside services, etc. (Kopiński 2008). In this way we stated the labour rate valuably and costs of using material capital.

Net commission income is an element influencing the financial result achieved by a bank, its amount influences the level of commission margin of a bank. In the traditional attitude to the problem of bank management it is assumed that the net commission income should allow to cover a bank's activity. A bank obtains a commission income from financing transactions, for instance loan granting or guaranteeing share issues as well as from intermediary transactions, for instance transfer order and pays commission, for instance from money clearing or intermediating in buying shares.

Bank's operating costs were considered as investment in the research of bank effectiveness in Poland applying DEA method were discussed, in the works of Gospodarowicz (2000) and Stępień (2004). Also, Mielnik and Ławrynowicz (2002) include this category in the set of input. Labour costs were included in the research of Eastern Europe bank effectiveness in the combination of input and output based on the concept of value-added (Pawłowska 2003).

In Table 1 and 2 we presented information about the breakout of parameters taken into account in the efficiency analysis in the whole group of banks in the defined years. Because of a definitely asymmetrical character of the breakdown of these variables, we took into consideration values of position statistics: lower quartile, median and upper quartile. All analysed inputs and outputs are characterized by a real increase in the whole period under research. The biggest dynamics was shown by receivables and liabilities which were 10 times higher in the year 2007 than in the year 1996.

3. Methods of efficiency measurement

Data Envelopment Analysis (DEA) is a non-parametrical method of examining relative efficiency of companies worked out by American scientists in 1978 (Charnes, Cooper, Rhodes 1978). Although this method was developed not long ago, it has gained a lot of popularity. It is applied in many areas of economy (banking included) to assess productivity of businesses.

The basic idea of productivity analysis is the reference of result levels achieved by a company to the result possible to achieve with the optimal use of inputs possessed by a company. The basic difficulty, while analysing efficiency, is to define the function correlating the investment level with the optimal level of production (so called the curve of production possibilities). The characteristic of the DEA method is the way of defining the

curve of production possibilities. Contrary to parametrical methods, where it is necessary to define initially the functional form of dependence between inputs and outputs, in the DEA method the boundary curve is set by positioning of these units, which are characterized by the highest efficiency in the considered set.

There are a lot of ways to formalize DEA models mathematically. In this study we gave one of the possible sets of equations and limiting conditions, for a model oriented to inputs with so called constant returns to scale (the presentation of the model oriented to effects requires only some small corrections).

To assess technical efficiency of a certain object N, some conditions concerning outputs (y_{ij}), next inputs (x_{ij}) achieved by an object N in relation to the remaining decisive units were formulated. The aim of the model is a proportionate reduction of inputs and at the same time not diminishing outputs. Mathematically it leads to the following notation:

$$\min_{\lambda_1,\ldots,\lambda_n} \theta$$

$$\lambda_1,\ldots,\lambda_n \geq 0$$

$$\left.\begin{array}{l} \lambda_1 y_{11} + \ldots + \lambda_n y_{n1} \geq y_{N1} \\ \qquad\qquad \vdots \\ \lambda_1 y_{1l} + \ldots + \lambda_n y_{nl} \geq y_{Nl} \end{array}\right\} \text{ outputs do not change}$$

$$\left.\begin{array}{l} \lambda_1 x_{11} + \ldots + \lambda_n x_{n1} \leq \theta \cdot x_{N1} \\ \qquad\qquad \vdots \\ \lambda_1 x_{1k} + \ldots + \lambda_n x_{nk} \leq \theta \cdot x_{Nk} \end{array}\right\} \text{ inputs decrease } \theta \text{ times}$$

The above mentioned model has an obvious solution:

$$\lambda_i = 0 \quad i \neq N \qquad \lambda_N = 1 \qquad \theta = 1$$

If there is no solution that $\theta \neq 1$ the decision unit is considered as effective. Otherwise, the value θ shows how much inputs can be cut down in order not to decrease outputs (company production). The basic result quoted in studies based on DEA models is the set of θ values which are called indicators of technical efficiency.

In numerous bibliographical items, also in the Polish language, we can find a detailed description of numerous modifications of the DEA models (Coelli et al. 2005; Gospodarowicz 2000; Domagała 2007). In this study we used the input-oriented DEA model with constant and variable returns to scale.

In order to enable the assessment of bank productivity changes during the time we used two ideas utilized in analyses of this type. According to the first one, data having cross-time character (27 banks during 12 years) are treated as one trial having 27×12 units examined. This attitude makes that efficiency measurements estimated with the help of DEA model for the selected banks in different years are determined according to the common efficiency

frontier curve. It is possible to compare received indicators of technical efficiency in the time aspect as well as in the cross one (Canhoto, Dermine 2003). However, applying this approach eliminates an element concerning technological progress from the considerations about productivity factors. This element is taken into consideration in the second idea which uses Malmquist index – measurement of efficiency changes during two periods of time (t_1 and t_2) which relies on a certain synthesis of productivity assessment of a given bank during the two periods of time in relation to other units from the periods t_1 and t_2.

The Malmquist index is set according to the following formula:

$$M_{t,t+1}(A) = \underbrace{\frac{E^{t+1}(A_{t+1})}{E^{t}(A_t)}}_{\text{Efficiency change}} \underbrace{\sqrt{\frac{E^{t}(A_t)}{E^{t+1}(A_t)} \cdot \frac{E^{t}(A_{t+1})}{E^{t+1}(A_{t+1})}}}_{\text{Technological change}}$$

The above mentioned formula is not the simplest way of expressing Malmquist index in the accounting meaning but it allows us to distinguish two elements of the index, which allows us to understand better its construction and practical meaning.

The first factor in the formula is the relation between a relative productivity achieved for an object A at the moment t and $t+1$. The relative efficiency change does not have to draw the improvement of results of a given unit. Furthermore, the increase (decrease) in relative productivity can take place even when a company has worsened (improved) its results. Simply, it is enough for other examined units to improve (worsen its performance to a greater extent). That is why it is necessary to introduce another factor in the formula which defines the technology shift. The amount $E^t(A_t)$ defines the efficiency of a company A in the period t, that is it defines how many times a company can reduce inputs not lowering its outputs (in the model oriented to inputs), while the amount $E^{t+1}(A_t)$ defines the A company efficiency in a similar way but with reference to production possibilities defined by results of other companies during the period $t+1$. If the ratio $E^t(A_t)/E^{t+1}(A_t)$ is bigger than 1 this means that a company A becoming effective could lower inputs to a greater extent in the period $t+1$ than in t.

The calculations connected with the technical efficiency assessment of banks were carried out by using DEAP software.[1] The STATISTICA software was used to statistical measurement analysis of efficiency obtained from the DEA models. Apart from the presentation of the results of efficiency analysis in the form of descriptive statistics we applied methods of statistical conclusions in order to assess the reliability of differences found at the efficiency level – according to profile activity of a bank and the year of the examination.

[1] DEAP is a freeware software containing implementation of basic DEA models. The freeware software is available on the website: www.une.edu.au/econmetrics/cepawp.htm.

4. Results

4.1. Changes at the level of efficiency of banks in Poland in the years 1996–2007

Basing on the input-oriented DEA model, built for one trial and containing all data concerning inputs and outputs for the 27 banks during the defined period we have received technical efficiency indicators with the assumption of constant and variable returns of scale and the measure of scale efficiency. In Table 3 we present information about an average level of efficiency of the analysed banks in Poland during the above mentioned years. The table data include average values calculated for banks in each year. Applying the DEA model to all cross--time data allows us to make comparisons between the years in this case. By means of non--parametrical Wilcoxon test we assessed statistical importance of changes of effectiveness indicators between the defined years (the Table contains a comparison a year after a year as well as the test result of a comparison of the effectiveness level in 2007 with its assessments in 1996).

Taking into account the average E_{CRS} level, we can state that changes of the average efficiency level of the examined banks in the years 1996–2007 are not too big. In a year to year relation, there are visible statistical differences in the years 2001 and 2002 when technical efficiency in the examined set rose considerably. However, a comparison of the results in 1996 and 2007 does not allow us to draw credible conclusions about the change of efficiency level of the banks in 12 year time.

After a small decrease in the years 1997–2001 an average increase of efficiency level took place, slightly above the 1996 value (Figure 2). You can also notice, in this period, a certain cyclical nature in the tendency to shape the technical efficiency level. The lowest average level of using invested resources amounted to 67% during the examined period of time while the highest one was 75%.

More visible changes concern the level of pure technical efficiency – the maximum difference in the years 1996–2007 amounts 0.14. Since 2001 the level of average technical efficiency E_{VRS} of the examined banks showed a rising tendency. In 2007 the average technical efficiency of the 27 banks was the highest in the whole period taken into analysis. In 2002, 2005 and 2007 the changes of the level of pure technical efficiency were statistically significant, also a comparison of the efficiency level at the end and beginning of the analyses period (1996 vs. 2007) leads to a conclusion about its non-accidental rise ($p = 0.0022$).

Beginning since 1998 the scale efficiency diminishes, which means that the examined banks has become less uniform – groups of banks emerged according to their size and activity profile. The lowest level of the average efficiency scale indicator happened in 2007. Although the banks used resources invested in the production of financial service more effectively, the did not benefit from the achieved amounts.

In order to analyse the efficiency indicators in the years more exactly, we presented information about the minimal and maximal value, the lower quartile, median and upper quartile indicators E_{CRS} and E_{VRS} (Figures 3–4). Although the present study has a general character concerning the whole population of commercial banks functioning in the years

1996–2007, generally we presented in the two diagrams information about the level of efficiency of the two biggest banks in Poland: Pekao SA as well as PKO BP are units bigger than the remaining banks, which is reflected in the results of efficiency analysis, taking into account constant returns to scale these banks are characterized by an average E_{CRS} efficiency because a lot of smaller banks used their resources more effectively. The introduction of variable returns to scale make the DEA model made the efficiency of Pekao SA and PKO BP was not referred to banks being smaller. Because of this the two banks were assessed as highly effective.

4.2. Malmquist index

The second idea of a comparison of productivity level of banks in Poland in the years 1996–2007 was based on the values of the Malmquist index. We marked it year by year and for the whole examined period (2007 vs. 1996). In the years 1996–1997, 1999–2000 and 2003–2004 the average productivity level of the examined banks decreased. During the remaining years we saw a rising tendency (Table 4). The biggest increase in the productivity was noted in the years 2001–2002.

We can talk about a remarkable rise of productivity of banks in the whole examined period (2007 vs. 1996), particularly in their technological possibilities. The use of these possibilities did not change significantly.

4.3. Profile of bank activity versus its efficiency

We undertook a problem of the influence of the activity profile on technical efficiency of banks in Poland during the examined period. To do this we divided the examined banks into: serving all clients (16), retail (6) and serving corporate clients (5). The average values of technical efficiency with constant and variable scale returns in the banks were presented in Tables 5 and 6. We applied the Kruskal-Wallis test to assess the importance of statistical differences in the level of bank efficiency. Significantly statistical differences concerned almost all the years during which the bank sector was in a better condition for a model with constant scale returns.

During the first years analyzed a relatively low technical efficiency took place in retail banks. Since the year 1999 corporate banks showed relatively the highest technical efficiency. During this period the average level of efficiency of retail and serving all clients banks was similar. Corporate banks were characterized as having a higher level of total technical efficiency in the years 2001–2007 (for these years the difference in the distribution of E_{CRS} between the groups of banks being compared was statistically significant).

We have not noticed statistically significant differences between the average level of pure technical efficiency of banks serving all clients, retail and corporate banks in any year (Table 6). The lack of influence of the activity profile on the assessment of pure technical efficiency may result from the differentiation of the banks' size belonging to different groups. In the model taking into consideration the scale effect, bank efficiency is marked in relation to the results of banks with similar sizes of inputs and outputs.

5. Comparison of two ideas of analysis of dynamics of bank productivity

In order to enable a comparison of productivity levels of banks in the years 1996–2007 we applied two ideas. In section 4.1 we presented the technical efficiency level (E_{CRS}, E_{VRS}) assuming that the whole cross-time data constitutes one set. The results achieved by a bank each year were referred to a common boundary of production possibilities. This boundary was established on the base of all results in the whole examined period of time. In the second idea we applied the measure of dynamics – Malmquist index.

The synthetic results are presented in section 4.2. The two ideas of dynamics of productivity changes show benefits and drawbacks which are discussed in textbooks and articles.[2]

We stated whether there is a correlation between the assessments of productivity changes made in the two ideas. We marked the value of correlation coefficients between the values of Malmquist index (taking elements into account) and indexes of dynamics marked from the cross-time model DEA (with constant and variable returns of the scale). We examined the correlation of productivity changes year after year. We used two kinds of rank correlation coefficients – Spearman and Pearson. The first one allows us to assess accordance of order of banks according to the two applied methods. The second one defines the power of dependence with a linear character (Table 7 and 8).

The level of Malmquist index and element defining changes of productivity possibilities is distinctly correlated with the dynamics of changes of efficiency defined on the base of pooled panel data model with constant returns to scale. Also, the dynamics of productivity changes from the model with variable returns to scale is correlated with values of Malmquist index, although the force of this correlation is lower in some cases. For the majority of comparisons carried out information about the force of linear dependence achieved upon the value of Pearson's correlation coefficient are convergent with the values of Spearman's rank correlation coefficient.

Describing the dynamics of the changes of the productivity level of the analysed banks in the years 1996–2007, we can interchangeably use the cross-time results and Malmquist index. This statement concerns exclusively the analysed set of banks and contributes to considerations about the accordance of the two ideas of the analysis of productivity dynamics. We chose the idea of data analysis as one set taking into consideration a broad time scope of research. We should remember that Malmquist index allows to analyse the reasons of the efficiency in the banks. It is possible thanks to the decomposition of the index into elements concerning the changes of technological possibilities and technical efficiency.

Apart from the correlation of values of the two kinds of dynamic index, these two kinds should show similar level of amount. The fact itself of high correlation does not eliminate

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[2] The most important advantages of the time-spatial data approach in common DEA model are:
- ease of comparisons of productivity level between any time moments (in case of Malmquist index to make an evaluation of productivity changes in the period of 12 years requires to make 66 comparisons);
- possibility to look for the objects which optimally use the received expenditure, not only in one time period but also in other years (an exemplar for the inefficient bank can be the results of another bank in earlier years);
- possibility of introduction of variable scale effects.

On the other hand the greatest advantage of the Malmquist index concept is a deeper insight in to the reasons of productivity changes – a possibility of decomposition into the element which describes the technological possibilities and their actual application.

the possibility of such joining values that upon one idea all the banks will be assessed as lowering their productivity while upon the second idea as increasing their productivity. For example, the productivity assessment in the years 2004–2005 performed according to the two ideas gives unanimous information about the direction of the changes (increase or decrease) of the productivity of the 24 banks and not unanimous in the case of three banks (Figure 6). We presented information about the number of banks whose dynamics was assessed in a similar way for all the periods (Table 9).

The bigger differences in the assessment of the dynamics of productivity changes carried out by the means of the two method were visible in the years 2006–2007. It is possible that they were symptoms of the approaching financial crisis visible in the relation of inputs and outputs of the analysed banks.

6. Conclusions

We stated, according to the performed research, that the pure efficiency of the analysed banks increased in the years 1996–2007 at a different pace. The total technical efficiency did not change much. We did not find statistically important differences between the results achieved by the banks at the beginning and end of the defined period of time. The level of technical efficiency increased significantly in the corporate banks. The average results achieved by retail and serving all clients banks were characterized by a lower dynamics. A detailed analysis of productivity changes, carried out by the means of Malmquist index showed an increase of the total technical efficiency of the banks in the years 1996–2007, mainly due to an increase of their technological abilities (about 60% increase). We compared the results of the two ideas of assessment of productivity change dynamics having data for a long period of time. Dynamics indexes determined for the productivity assessment in the whole set of time-cross data as well as Malmquist index were similar in the years 1996–2006. This allows us, with considerable care, to conclude that in practical use the results of the two ideas may be similar. The incompatibility of the assessments of productivity level changes was found in the years 2006–2007, whereas at this stage of the analysis it was difficult to define the reasons of this state. The research will be continued for the years 2008–2011 in order to assess the productivity changes of the banks as a result of the financial crisis.

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Appendix

Figure 1
Inputs and outputs considered in the DEA model

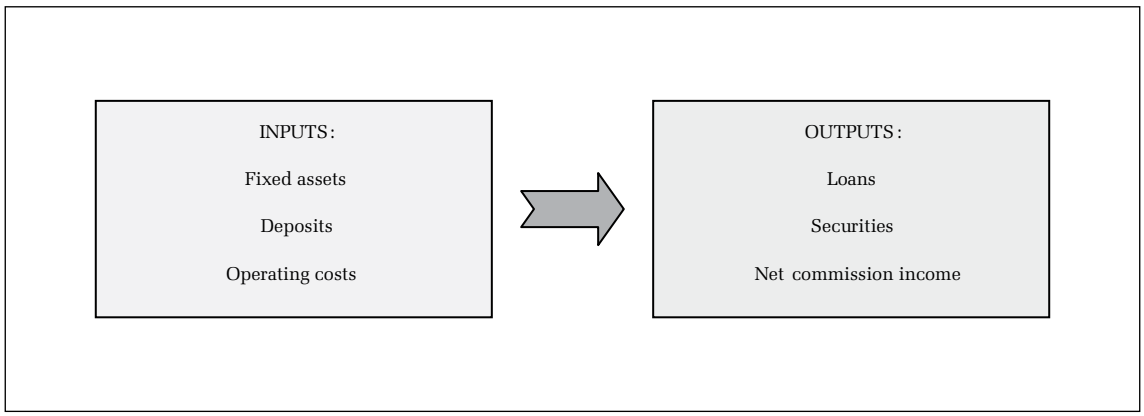

Figure 2
Comparison of average bank productivity in the years 1996–2007

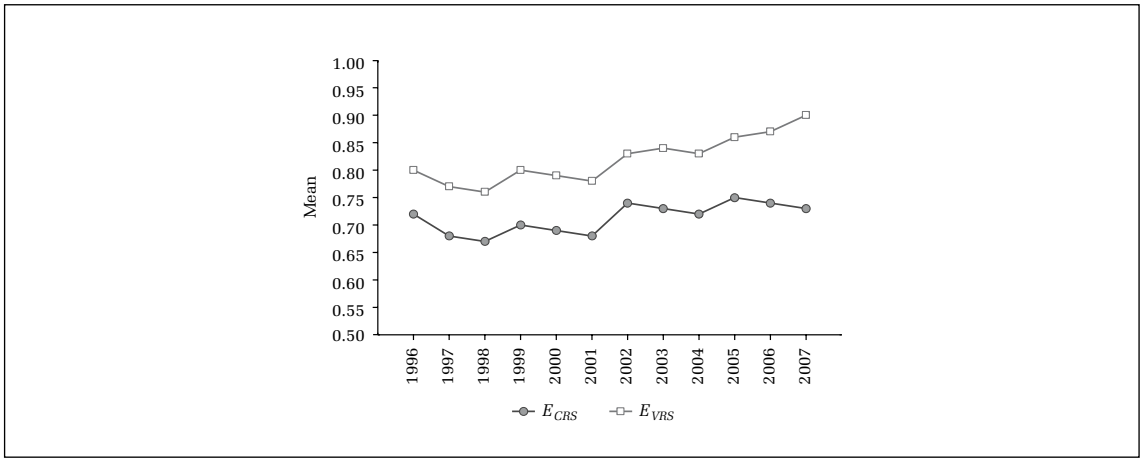

Figure 3
Distribution of technical efficiency (E_{CRS}) during the years examined taking into account the two biggest banks performing in Poland

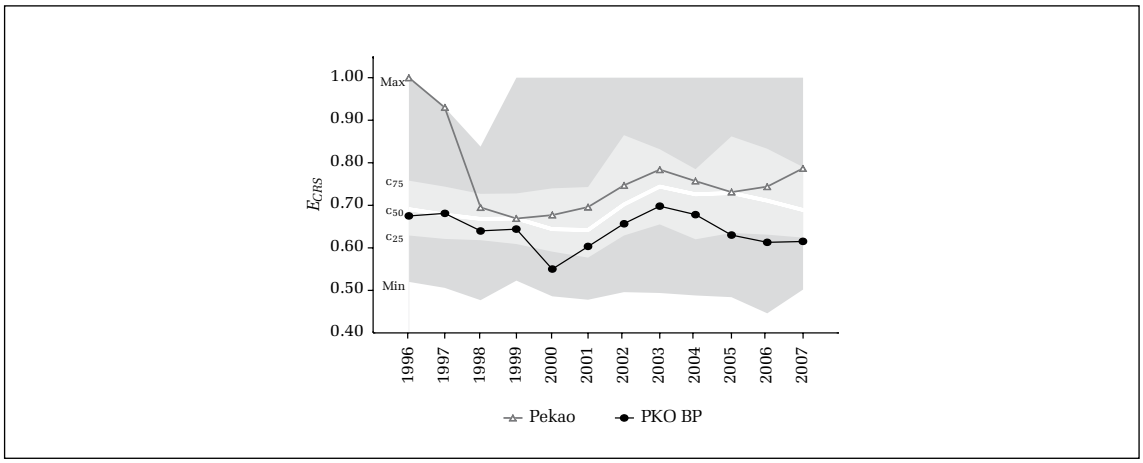

Figure 4
Distribution of pure technical efficiency (E_{VRS}) during the years examined taking into account the two biggest banks performing in Poland

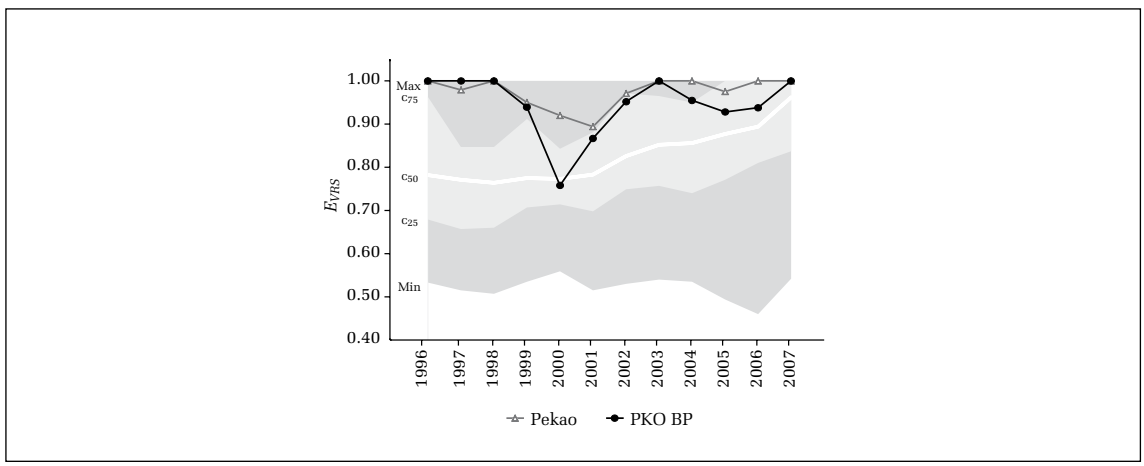

Figure 5
Total technical efficiency (E_{CRS}) depending on the profile of a bank's activity

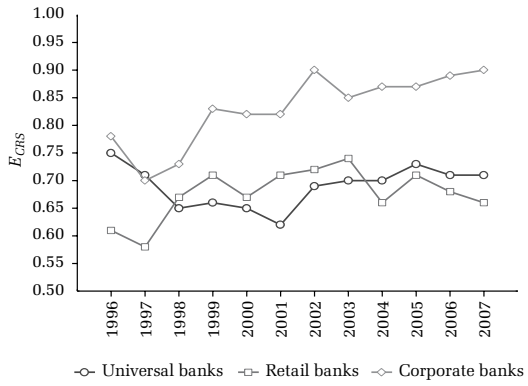

Figure 6
Values of Malmquist index and dynamics of E_{CRS} changes in the years 2004–2005

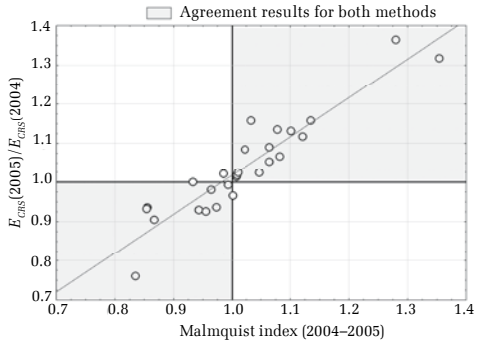

Table 1
Overall information about the inputs level in the years 1996–2007

Year	Operating costs			Fixed assets			Liabilities		
	c_{25}	*Me*	c_{75}	c_{25}	*Me*	c_{75}	c_{25}	*Me*	c_{75}
1996	34	56	385	22	42	379	367	759	7 178
1997	38	69	487	20	39	424	530	1 272	11 027
1998	51	80	578	18	44	567	1 146	1 794	13 740
1999	72	110	599	34	56	622	1 359	2 716	16 355
2000	65	147	791	24	74	746	1 867	3 053	17 921
2001	66	162	870	29	84	688	1 678	3 166	21 217
2002	81	167	1 050	18	83	928	1 871	3 382	21 794
2003	88	164	907	30	92	836	2 087	3 622	20 986
2004	84	190	934	32	89	553	2 110	4 836	21 444
2005	103	203	922	29	88	537	2 117	6 234	23 255
2006	112	238	901	30	95	585	2 413	9 192	25 721
2007	128	332	975	43	114	427	3 476	9 016	24 369

c_{25} – lower quartile, *Me* – median, c_{75} – upper quartile

Table 2
Overall information about the outputs level in the years 1996–2007

Year	Receivables			Net commission income			Securities		
	c_{25}	*Me*	c_{75}	c_{25}	*Me*	c_{75}	c_{25}	*Me*	c_{75}
1996	406	812	5 880	2	20	108	92	202	2 527
1997	662	1 288	8 088	5	23	169	118	197	2 974
1998	1 133	1 723	9 888	10	26	187	114	440	4 281
1999	1 708	2 411	12 644	19	49	281	285	494	3 561
2000	1 729	3 181	13 862	22	49	309	212	465	4 987
2001	1 686	3 436	17 498	29	64	328	214	832	6 183
2002	1 653	3 415	16 395	22	82	495	255	1 033	6 949
2003	1 737	3 956	18 313	25	83	551	337	937	7 415
2004	1 989	4 947	16 556	25	77	538	433	1 181	7 861
2005	2 138	5 808	16 570	26	80	399	310	968	9 753
2006	2 231	7 354	19 507	31	92	318	216	822	8 921
2007	4 697	8 905	20 309	40	126	385	337	857	6 491

c_{25} – lower quartile, *Me* – median, c_{75} – upper quartile

Table 3
Comparison of average efficiency of banks in the years 1996–2007 (results achieved for a uniform set of panel data)

Year	E_{CRS} (p_W)	E_{VRS} (p_W)	E_S (p_W)
1996	0.72	0.80	0.91
1997	0.68 (0,0926)	0.77 (0,1996)	0.90 (0.0355*)
1998	0.67 (0,5971)	0.76 (0,6158)	0.89 (0.9696)
1999	0.70 (0,2588)	0.80 (0,0680)	0.88 (0.1428)
2000	0.69 (0.2277)	0.79 (0.7032)	0.87 (0.1996)
2001	0.68 (0.7982)	0.78 (0.9785)	0.87 (0.8612)
2002	0.74 (0.0006***)	0.83 (0.0034**)	0.89 (0.2139)
2003	0.73 (0.3488)	0.84 (0.1373)	0.88 (0.8889)
2004	0.72 (0.5642)	0.83 (0.7164)	0.88 (0.9139)
2005	0.75 (0.1663)	0.86 (0.0397*)	0.87 (0.1783)
2006	0.74 (0.5763)	0.87 (0.8303)	0.86 (0.0865)
2007	0.73 (0.5998)	0.90 (0.0251*)	0.82 (0.0016**)
1996–2007	0.71 (0.6918)	0.82 (0.0022**)	0.88 (0.0025**)

E_{CRS} – technical efficiency
E_{VRS} – pure technical efficiency
E_S – scale efficiency
p_W – statistical significance of efficiency measures changes in a given year in relation to a previous year (p-value from Wilcoxon test)
** p-values less than 0.05
*** p-values less than 0.01

Table 4
The average value of Malmquist index and its components during the years examined (geometric mean[a])

Period	Malmquist index	Change of technological possibilities	Efficiency change
1996–1997	0.98	1.00	0.99
1997–1998	1.02	0.93	1.09
1998–1999	1.03	1.00	1.02
1999–2000	0.95	0.94	1.01
2000–2001	1.05	1.03	1.02
2001–2002	1.14	0.98	1.16
2002–2003	1.00	1.08	0.93
2003–2004	0.96	0.96	1.01
2004–2005	1.01	1.02	0.99
2005–2006	1.03	1.01	1.01
2006–2007	1.05	1.02	1.02
1996–2007	1.57	1.60	0.98

[a] Because the Malmquist index is a measure of changes of efficiency to average it geometric mean was applied.

Table 5

Comparison of average productivity of banks during the years 1996–2007 (E_{CRS} values)

Year	E_{CRS}			*p*
	U	*R*	*C*	
1996	0.75	0.61	0.78	0.0112*
1997	0.71	0.58	0.70	0.0034**
1998	0.65	0.67	0.73	0.3519
1999	0.66	0.71	0.83	0.0818
2000	0.65	0.67	0.82	0.1599
2001	0.62	0.71	0.82	0.0404*
2002	0.69	0.72	0.90	0.0429*
2003	0.70	0.74	0.85	0.0342*
2004	0.70	0.66	0.87	0.0693
2005	0.73	0.71	0.87	0.0815
2006	0.71	0.68	0.89	0.0193*
2007	0.71	0.66	0.90	0.0130*

U – universal banks, *R* – retail banks, *C* – corporate banks
p – Kruskal-Wallis tests results
* *p*-values less than 0.1
*** *p*-values less than 0.05

Table 6

Comparison of average productivity of banks during the years 1996–2007 (E_{VRS} values)

Year	E_{VRS}			*p*
	U	*R*	*C*	
1996	0.83	0.71	0.80	0.2255
1997	0.81	0.69	0.74	0.0905
1998	0.77	0.74	0.76	0.8132
1999	0.80	0.75	0.86	0.3601
2000	0.79	0.74	0.86	0.3134
2001	0.75	0.78	0.87	0.3145
2002	0.83	0.78	0.92	0.2058
2003	0.85	0.79	0.87	0.6663
2004	0.84	0.75	0.88	0.2675
2005	0.88	0.79	0.90	0.4623
2006	0.88	0.80	0.91	0.6747
2007	0.91	0.84	0.92	0.9774

U– universal banks, *R* – retail banks, *C* – corporate banks
p – Kruskal-Wallis tests results

Table 7
Dependence between Malmquist index and dynamics of the uniform model (Spearman's rank correlation coefficient)

Period	E_{CRS}			E_{VRS}		
	MI	MI_{TECH}	MI_{EFF}	MI	MI_{TECH}	MI_{EFF}
1996–1997	0.71**	0.34	0.53**	0.73**	0.38	0.50**
1997–1998	0.84**	0.36	0.71**	0.72**	0.03	0.80**
1998–1999	0.88**	0.55**	0.77**	0.75**	0.59**	0.47**
1999–2000	0.88**	0.56**	0.66**	0.59**	0.59**	0.25
2000–2001	0.85**	0.49**	0.59**	0.53**	0.31	0.48**
2001–2002	0.68**	0.25	0.59**	0.46**	0.15	0.39**
2002–2003	0.83**	0.25	0.68**	0.66**	0.27	0.52**
2003–2004	0.78**	0.47**	0.41**	0.89**	0.22	0.61**
2004–2005	0.93**	0.48**	0.69**	0.84**	0.39**	0.64**
2005–2006	0.82**	0.51**	0.42**	0.71**	0.19	0.66**
2006–2007	0.45**	-0.03	0.57**	0.52**	0.07	0.63**

MI – Malmquist index
MI_{TECH} – technical possibilities change
MI_{EFF} – efficiency change
** statistical significance of correlations (p-value less than 0.05).

Table 8
Dependence between Malmquist index and dynamics of the uniform model (Pearson's correlation coefficient)

Period	E_{CRS}			E_{VRS}		
	MI	MI_{TECH}	MI_{EFF}	MI	MI_{TECH}	MI_{EFF}
1996–1997	0.63**	0.38**	0.33	0.73**	0.51**	0.27
1997–1998	0.83**	0.48**	0.78**	0.69**	0.22	0.82**
1998–1999	0.91**	0.68**	0.64**	0.85**	0.59**	0.63**
1999–2000	0.85**	0.64**	0.54**	0.72**	0.68**	0.32
2000–2001	0.55**	0.30	0.64**	0.43**	0.25	0.48**
2001–2002	0.93**	0.72**	0.79**	0.89**	0.76**	0.64**
2002–2003	0.78**	0.43**	0.71**	0.60**	0.39**	0.47**
2003–2004	0.84**	0.63**	0.42**	0.83**	0.12	0.82**
2004–2005	0.93**	0.58**	0.65**	0.88**	0.53**	0.63**
2005–2006	0.61**	0.50**	0.31	0.44**	0.21	0.61**
2006–2007	0.24	0.07	0.46**	0.22	-0.04	0.70**

MI – Malmquist index
MI_{TECH} – technical possibilities change
MI_{EFF} – efficiency change
** statistical significance of correlations (p-value less than 0.05)

Table 9
Relation between the Malmquist index and the dynamics determined on the sectional-time model (number of agreed evaluations of dynamics)

Period	Dynamics according to E_{CRS} vs. Malmquist index	
	N	**%**
1996–1997	21	78
1997–1998	25	93
1998–1999	22	81
1999–2000	22	81
2000–2001	24	89
2001–2002	23	85
2002–2003	23	85
2003–2004	20	74
2004–2005	24	89
2005–2006	21	78
2006–2007	16	59

N, % – number and percentage of banks classified according to both methods.