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The Impact of M&A on Technical Efficiency, Scale Efficiency and Productivity Change in the Polish Banking Sector: a Non-Parametric Approach

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Małgorzata Pawłowska[2]

Abstract

In recent decades, the banking sectors of many transition countries have been subject to globalization, deregulation and liberalization similar to that in industrialized countries such as the EU countries and the USA. Those changes are linked with merger and acquisition (M&A) processes aimed at increasing banking competitiveness and efficiency. Banking efficiency is a crucial issue for transition countries. For most advanced transition countries, the question of the degree of their banks' competitiveness and efficiency has become an important issue in relation to EU accession. This paper examines the impact of M&A on the efficiency of Polish commercial banks in the period 1997-2001. The aim of this paper is to check whether M&A increased the efficiency and productivity of commercial banks. This paper employs Data Envelopment Analysis (DEA)[3] to investigate technical efficiency, scale efficiency and productivity. It considers all the models that are based on the output measures of technical and scale efficiency. Productivity growth has been analyzed via the Malmquist output-based productivity index (M), which was divided into technical efficiency change (E) and technological change (TC).

JEL Classification: G21, G34.

Keywords: Efficiency, DEA, Merger and Acquisition.

[1] This views expressed in this paper are those of the author and do not necessarily represent those of NBP policy. I would like to thank Ryszard Kokoszczyński, Paweł Wyczański for helpful comments.

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[3] DEA is a non-parametric linear programming technique that computes a comparative ratio of outputs to inputs for each unit, which is reported as the relative efficiency score.

1
Changes in the structure of the banking system in Poland

Commercial banks dominate the market in Poland. Commercial banks' share of total assets in the banking sector in December 2001 was 94.5%, while the share of cooperative banks in the market was 4.5%. When analyzing the processes taking place in the banking sector during recent years, we notice a high degree of foreign ownership. There were 48 banks with a majority of foreign equity at the end of December 2001 while there had been 29 at the end of December 1997 (see Statistical Annex Table A1).

If we identify foreign ownership by country of origin: banks of German, Dutch, French and US origin have the biggest share of capital. The commercial banks with a majority of Polish equity can be divided into private and state-owned banks. Despite the bigger number of private banks, they have a smaller influence on the economy which is expressed by a lower share of net loans granted by the banking sector for the non-financial sector and by deposits of the non-financial sector (see Statistical Annex Table A2).

A significant slow-down in economic growth in Poland followed by lower creditworthiness in the economy and continuing high interest rates, has resulted in a decrease of the efficiency of the Polish banking sector. This tendency has been observed since the end of 1997. As the result of the slow dynamics of financial results, the average coefficients of effectiveness of the commercial banks decreased in 2001. This was reflected in a deterioration (compared to 2000) of the following ratios: gross profitability was 2.65 %, net profitability was 1.9%, return on assets (ROA) was 1.36%, return on equity (ROE) was 18.5% (see Statistical Annex Table A3). The decrease of net interest margin (NIM) to 3.38% in 2001 was a result of the decrease of net interest income.

Ongoing privatization has caused a gradual decrease of the share of state ownership in the banking sector. The restructuring and privatization agenda of the banking sector has not been completed yet. Three banks directly owned by the state still represent 22% of assets and more then 27% of deposits. The market is also fairly concentrated and consolidation processes have resulted in an increase of concentration of the banking sector. To measure the concentration of the Polish banking sector, we have used concentration indices: Herfindahl-Hirschman (HH)[4] and CR5[5]. In 2001 the value of HH indices for loans, for assets and for deposits increased. That development of this indicator also clearly demonstrates the increasing concentration level of the Polish banking sector (see Statistical Annex Table A3). The market share of the five largest banks also increased (in 2001, it accounted for 54% of assets and more than 62% of deposits).

M&A in Poland (1997-2001)

As the literature on this subject[6] shows, the motives for banks' M&A are varied. The commonly stated reasons are: cost economies of scale[7], brand economies of scale[8], cost

4 Since HH is calculated as the sum of squared market share of each firm in a market in the terms of assets, deposits, and loans. In the literature, Herfindahl-Hirschman indices in the range below 0.1 show a very low concentration, in the range 0.11 – 0.18 show moderate concentration, in the range above 0.18 show a very high concentration of the banking system and 1 shows full concentration.
5 This index is calculated as market share of the five largest banks.
6 See: J. Dermine „European Baking: Past, Present and Future", conference paper „Second ECB Central Banking Conference, October 2002.
7 Lowering average cost per unit of output through expanding a single line of business.
8 Large size will allow brand recognition to be obtained at a lower cost.

economies of scope[9], financial diversification based upon economies of scope[10] and market power[11]. European mergers have led to massive consolidation processes in many transition countries and also influenced Poland. The level of M&A in the Polish banking sector has been as high as in the EU during the last five years.

In the first part of the 1990's, the main reason for M&A was the acquisition of weaker or troubled banks cheaply and their subsequent incorporation into stronger banks (for example the merger of Powszechny Bank Kredytowy SA and Pierwszy Komercyjny Bank SA). M&As taking place in 1997-2001 were a natural consequence of privatization and foreign investments in the Polish banking sector and were influenced by international consolidation.

Due to the increase in M&A during the sample period (1997-2001) there has been a significant reduction in the number of Polish commercial banks (the other reason for this reduction was the liquidation of some banks during the period). The number of commercial banks fell from 83 at the end of 1997 to 71 at the end of 2001. Over this period twenty M&As took place: four in 1997 (involving nine banks), two in 1998 (involving four banks), five in 1999 (involving thirteen banks), three in 2000 (involving six banks) and six in 2001 (involving thirteen banks).

The study of M&A processes in 2001 shows the following types of mergers in the Polish banking sector:

- merger between Polish bank acquired by foreign investor and a foreign bank operated subsidiary in Poland – for example:
  - Citibank (Poland) SA merged with Bank Handlowy w Warszawie SA, and both banks are controlled by Citibank Overseas Investment Corp.,
  - acquisition of ING Bank N.V. Oddział w Warszawie by ING Bank Śląski SA owned by ING Bank NV;
- merger between two Polish banks having common foreign shareholder – for example:
  - merger of the Bank Zachodni SA and Wielkopolski Bank Kredytowy SA, both controlled by Allied Irish Bank European Investments Ltd..
- merger between banks operating within the same capital group– for example:
  - acquisition of BIG BANK SA by BIG Bank GDAŃSKI SA and earlier the banking group Pekao SA which was formed from four state banks that were part of this group merged in 1999.
- merger between banks in Poland initiated by merger of shareholding banks outside Poland – for example:
  - merger of Bank Własności Pracowniczej with NORDEA Bank Polska, as the result of merger of Danish bank Unibank with Swedish-Finish-Norwegian group Merita Nordbank.
  - merger of Powszechny Bank Kredytowy SA with Bank Przemysłowo Handlowy SA as the result of merger of shareholders - Bank Austria Creditanstalt and HypoVereinsbank, resulting in the creation of the third largest bank in Poland.

Banks participating in the M&A deals during the period 1997-2001 and summary statistics of M&As that took place during 1997-2001 are presented in Statistical Annex Table A4 and Table A5.

[9] Cost efficiencies achieved by offering a broad scope of products or services to customer base.
[10] Standard portfolio theory shows that a portfolio of imperfectly correlated risks will reduce the overall volatility of profit.
[11] Horizontal mergers which reduce the number of firms operating in one market. may lead to less competition and higher margins.

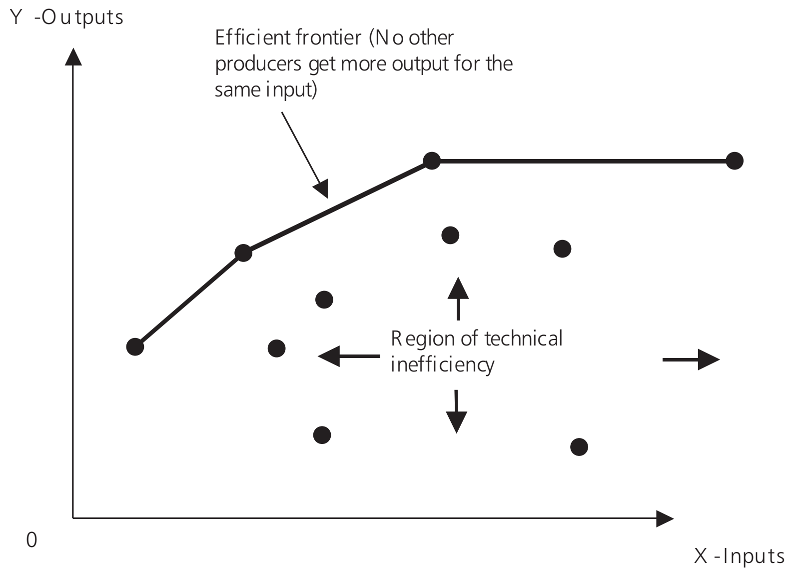
2

Measuring bank efficiency

Efficiency is a broad concept that can be applied to many dimensions of a firm's activities and there are many definitions of efficiency (for some narrow definitions of technical efficiency see in Annex 1). This paper will deal with two definitions of efficiency: technical efficiency and scale efficiency. Technical efficiency is related to the production of outputs given some inputs: a production plan is technically efficient if there is no way to produce the same output(s) with less input(s) or to produce more output(s) with the same inputs. Scale efficiency is defined relatively to the form of the locus of technically efficient production plans[12]. Technical efficiency considers scale and scope economies:[13] an efficient firm is one that reaches the optimal size. The definitions call for different measurement methodologies. The simplest approach consists of comparing balance sheet ratios that describe cost (e.g. operating costs over gross income) and profitability (return on assets or equity). However, this methodology does not fully take into account the complexity of the financial industry. More complex analyzes measure efficiency by comparing firms to the best practice of the industry[14].

The most common efficiency estimation techniques are parametric and non-parametric.

Figure1. Input –Output Production Space and Efficient frontier



Source: wg. James Odeck, (1997).

There are two main non-parametric approaches: Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH). These approaches add material to the basic specification of the best practice frontier. There are three main frontier approaches. The Stochastic Frontier Approaches (SFA). Thick Frontier Approach (TFA) and Distribution-Free Approach (DFA).[15] In this paper, Data Envelopment Analysis (DEA) has been used to analyze efficiency in the Polish banking sector.[16] DEA is a non-

12 Favero C.A., L. Papi (1995) pp. 38.
13 In this paper we consider only economy of scale, without prices.
14 See Group of Ten Report on consolidation in the financial sector (January 2001), which can be obtained through the websites BIS, The IMF and the OECD: www.bis.org, www.imf.org, www.oecd.org.
15 For a review of estimation techniques and more details, see Berger and Master (1997).

parametric linear programming technique that computes a comparative ratio of outputs to inputs for each unit, which is reported as the relative efficiency score. The efficiency score is usually expressed as a number between 0 and 1. This method assumes that there are decision-making units (DMUs) to be evaluated. Each DMU consumes varying amounts of *m* different inputs to produce *s* different outputs. A decision-making unit with a score less than 1 is deemed inefficient relative to other units. An efficient DMU depicts the efficient frontier that represents achieved efficiency. The efficient frontier envelops all other data points, thus giving rise to the name data envelopment analysis[17]. Figure 1 shows a simple DEA model for one-input and one-output.

[16] This method is considered to be suitable for transition economies, see Grigorian D.A, V. Manole (2002).
[17] The mathematical programming approach to the construction of production frontiers and the measure of efficiency relative to the constructed frontiers is frequently given the descriptive title of data envelopment analysis.

3
Basic DEA models (CCR-model and BCC-model)

The mathematical programming approach to the construction of production frontiers and the measure of efficiency relative to the constructed frontiers is frequently given the descriptive title of data envelopment analysis. The Data Envelopment Analysis (DEA) is used to provide a computational analysis of relative efficiency for multiple input/output situations by evaluating each decision-making unit (DMU) and measuring its performance relative to an envelopment surface composed of best practice units. Units that do not lie on the surface are termed inefficient. Thus, this method provides a measure of relative efficiency.

Data Envelopment Analysis (DEA) is also a source of concepts and methodologies that have now been incorporated into several models. Among a number of DEA models, we would like to present the ones used most frequently (CCR-model and BCC-model and NIRS –model). The first DEA model was the CCR ratio model (as defined by Charnes, Cooper, Rhodes (1978)) which yields an objective evaluation of overall efficiency and identified inefficiencies. The CCR model estimates efficiency on the assumption of constant return to scale (CRTS). The BCC model was defined by Banker, Charnes, Cooper (1984) and estimates efficiency on the assumption of variable return to scale (VRTS). The BCC model distinguishes between technical and scale inefficiencies by estimating pure technical efficiency at the given scale of operation. The NIRS model identifies in which region the entity is functioning: increasing, decreasing or constant returns to scale.

Charnes, Cooper and Rhodes introduced a measure of efficiency for each DMU which is obtained as a maximum ratio of weighted outputs to weighted inputs. The efficiency measure for each DMU can be calculated by solving a mathematical programming problem.

The DEA provides computational analysis of relative efficiency for multiple input/output situations by evaluating each decision-making unit (DMU) and measuring its performance relative to an envelopment surface composed of best practice units. Units that do not lie on the surface are termed inefficient. Thus this method provides a measure of relative efficiency.

Let us provide a brief description of the linear programming model. We assume that there are **m** inputs and **s** outputs for every DMU. For the i[th] DMU the inputs and outputs are represented by vectors x_{io} and y_{ro} respectively. For each DMU we intend to obtain a measure of the ratio of all outputs to all inputs, where v_i and μ_r are vectors of weights. To select the optimal weights, the following problem is proposed:

$$\max_{u,v} \; h_0(\mu, v) = \frac{\sum_{r=1}^{s} \mu_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \tag{1.1}$$

$$\text{s. t.} \quad \frac{\sum_{r=1}^{s} \mu_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \leq 1$$

$$u_r \geq 0, r = 1,2,\ldots,s$$

$$v_i \geq 0, i = 1,2,\ldots,m$$

A problem with this formulation has an infinite number of solutions. This can be avoided by introducing a constraint $\sum_{i=1}^{m} v_i x_{io} = 1$, and by transforming (1.1) mathematical programming problem by the Charnes-Cooper transformation (1962) to obtain the multiplier form of the linear programming problem:

$$\max_{u} z_o = \sum_{r=1}^{s} u_r y_{ro} \qquad (1.2)$$

$$\text{s.t.:} \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \; j = 1,2,...n$$

$$\sum_{i=1}^{m} v_i x_{io} = 1,$$

$$u_r \geq 0, r = 1,2,...,s$$

$$v_i \geq 0, i = 1,2,...,m$$

3

Using the duality property of this linear programming problem, one can derive an equivalent form: [18]

$$\min_{\theta,\lambda} \theta_i \qquad (1.3)$$

$$\text{s. t. } \theta X_o - X\lambda - s^- = 0$$

$$Y\lambda - s^+ = Y_o,$$

$$\lambda, s^+, s^- \geq 0$$

The above linear problem yields the optimal solution θ, which is the efficiency score[19]. However, the above approach is somewhat simplified as it assumes a constant return to scale. The CRST assumption is only appropriate when all banks are operating at optimal scale. Factors that may cause banks not to operate at an optimal scale include imperfect competition, leverage concerns, certain prudential requirements, etc. This phenomenon led Banker et al (1984) to suggest an extension of the CRST DEA model to account for variable return to scale (VRST)[20]. The DEA model that exhibits variable returns to scale is called the BCC-model (after Banker, Charnes and Cooper (1984)). The BCC linear problem yields the optimal solution q, which is the efficiency score, so-called pure technical efficiency scores or BCC-efficiency[21]. In order to identify types of return to scale effects the NIRS DEA model is used.[22] The NIRS model identifies in which region the entity is functioning: increasing, decreasing or constant returns to scale. Measure θ_{NIRS} can be calculated by solving BCC- model[23] with additional condition that $\vec{1} * \lambda \leq 1$ (with a weak inequality on the convexity constraint). Fare, Grosskopf, and Lovell (1985) show that source of scale inefficiency (increasing or decreasing returns to scale) may be found for each DMU by comparing the measures of technical efficiency found under assumptions of CRST, VRTS and NIRTS. In this paper the efficiency has been investigated on the following assumptions: constant returns to scale (CRTS)[24], variable returns to scale (VRTS) and non-increasing returns to scale (NIRTS)[25].

The following symbols have been applied in this paper: e_crs – measure of efficiency under constant returns to scale assumption (CRST), e_vrs - measure of efficiency under variable returns to scale assumption (VRST), e_nirs – measure of efficiency under non-increasing returns to scale assumption (NIRST). For the above three efficiency measures (e_crs, e_nirs, e_vrs), the following property also holds: 0 < e_crs ≤ e_nirs ≤ e_vrs 1 (see Fare et al.1994 p. 73). We should notice that VRTS technical efficiency scores are greater than or equal to CRST technical efficiency scores.

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18 Grigorian D. A., V. Manole (2002).
19 So-called technical efficiency or CCR-efficiency and which is sign q_{CCR}, (see Annex 1 in Basic DEA models).
20 They added a convexity constraint that $\vec{1} * \lambda \leq 1$ to linear problem (1.3).
21 We are sign – θ_{BCC}, (see Annex 1 in Basic DEA models).
22 This measure we are sign – θ_{NIRS} (see Annex 1 in Basic DEA models).
23 Notice: θ measure with models CCR, BCC in output and input oriented are not equal.
24 If technology exhibits constant returns to scale (CRTS) then *P(ay) = aP(y), a* > 0, (for definition *P(y)* see Annex 1).
25 For non increasing returns to scale (NIRTS), *P(ay)* ⊆ *aP(y), for a* > 1.

Following the scale properties of the above two models we have the definition of scale efficiency: e_s = e_crs/e_vrs. If 0 < e_crs < e_vrs ≤ 1, this means that scale efficiency e_s< 1 and the given DMU is scale inefficient (but we do not know if it is too big or too small). Based on scale efficiency measure (e_s) only, it is not possible to distinguish in which region the given DMU is operating: increasing or decreasing returns to scale, to make this distinction, these measures must be compared with e_nirs measure. If e_crs = e_nirs this means that DMU is not scale efficient and is operating with increasing returns to scale. If e_nirs > e_crs that DMU is operating with decreasing returns to scale.[26] Returns to scale for commercial banks based on the relationship between: e_crs – measure of efficiency with constant returns to scale assumption, e_vrs - measure of efficiency with variable returns to scale assumption, e_nirs – measure of efficiency with non-increasing returns to scale assumption and e_s - scale efficiency measure (see Table 1).

Tab. 1 Classification by returns to scale for commercial banks

Classification	Dependence between efficiency measure	Description
BC	e_crs = 1, e _vrs = 1, e_s = 1, e_ nirs = e_crs	Banks technically efficient and scale efficient (the best practice).
A	e_crs < 1, e_vrs = 1, e_s <1, e_nirs = e_crs	Banks technically efficient but scale inefficient. Bank is operating with increasing returns to scale region, because e_nirs = e_crs.
D	e_crs<1, e_vrs = 1, e_s<1, e_ nirs > e_crs	Bank technically efficient but scale inefficient. Bank is operating with decreasing returns to scale region because e_nirs > e_crs.
E	e_crs < 1, e_vrs < 1, e_s <1,e_ nirs = e_crs	Bank technically inefficient and is operating with increasing returns to scale region, because e _s<1 and e_nirs = e_crs.
F	e_crs <1, e_vrs < 1, e_s = 1, e_nirs = e_crs	Bank technically inefficient and is operating with constant returns to scale region, because e_s = 1, e_nirs = e_crs.
G	e_crs < 1, e_vrs < 1, e_s < 1, e_ nirs > e_crs	Bank technically inefficient and is operating with increasing returns to scale region, because e_s < 1 and e_ nirs > e_crs.

Source: T. Kopczewski (2000).

[26] Rogowski G. (1998).

4
Malmquist Output-based Productivity Index

DEA method may be used for the investigation of productivity. Productivity indices are based on the comparison of input to output ratios at time t and t+1. In this paper, the productivity of the banking sector is investigated with the Malmquist productivity index. As in the case of efficiency measures, there are two types of productivity indices. One of the indices is related to outputs, while the second index is related to inputs. To secure the comparability of the results of technical efficiency measures and productivity indices, productivity growth was analyzed by the Malmquist output-based productivity index (M). This index is divided into two components: technical efficiency change (E), technological change (TC). That is, an increase in productivity from one year to the next may be due to improved technical efficiency (E), technological progress (TC), or a combination of two (M). In other words, an increase in productivity from one year to the next may result from improved technical efficiency, technological progress, or a combination of both factors (see Annex 1, the non-parametric Malmquist approach). The Average value of the Malmquist index (M) is higher than 1 shows an increase of productivity between period t and t+1.

5
Output and input specification

5

Measuring efficiency and productivity requires the specific description of inputs and outputs. This can be difficult because there is no consensus amongst researchers about bank inputs and outputs. In the literature on this subject, one can identify five approaches to the input-output specification[27]. Three of these are related to the same functions carried-out by banks: the production approach (PA), where banks are mainly considered as producers of deposit accounts and loan services, the intermediation approach (IA) where banks are viewed as mediators who transform and transfer financial resources from units in surplus to units in deficit and the asset approach (AA) where banks are considered only as financial intermediaters between liability holders and funds beneficiaries (i.e. debtors). The remaining two approaches are not related to macroeconomic functions carried out by banks. Under the user cost approach (UCA), the net contribution to bank revenue determines the nature of inputs and output and finally in the value added approach (VAA), the identification of inputs or outputs is based on the share of value added[28]. In this study, input-output specification is based on the value added approach, which has been developed specially for the Polish banking system. On the above assumption, four output variables: net loans[29], current deposits, time deposits, net fees and commissions, and three input variables: labor (number of employees), total fixed assets[30], non-performing loans have been used in this study[31]. An efficiency measure based on specification in which one of the outputs used is net total loans without non-performing loans in input variables, does not take into account that the increasing of net total loans would cause an improvement of efficiency in both a bank which improved its technology, decreasing the amount of non-performing loans in its credit portfolio and as well in a bank which has not improved its portfolio quality[32]. The relatively high non-performing loan ratio in the Polish banking sector in the late 1990s, and nowadays, has posed a substantial financial burden on banks, influencing their profitability. Because of this, non-performing loans are treated as a separate input factor.

27 Wheelock C., P. W. Wilson (1995).
28 Favero A., L. Papi (1995).
29 Net loans are defined as loans net of loan loss provisions.
30 Due to the fact that banks may calculate in different way „intangible assets", or other non material assets, that value may by not comparable among banks.
31 A similar solution to the risk problem is suggested in Charnes et. al. (1990), where provisions for losses are included among inputs.
32 Kopczewski T., M. Pawłowska (2001).

6
The Data and Empirical Results

An unbalanced panel of data has been constructed by retaining pre-merger banks as separate banks and treating the merged ones as new banks. The panel data for this analysis comprises all Polish commercial banks covered by the National Bank of Poland's balance sheet statistics. These statistics consists of annual data for the period 1997:Q4 to 2001:Q4.

Technical efficiency, scale efficiency and Malmquist productivity index have been investigated for individual bank for each year, as well as the mean of those measures for the period 1997-2001. All banks in the sample have been divided into four groups according to their asset size[33] and into three groups according to the classification followed by the General Inspectorate of Banking Supervision by degree of capitalization[34]. All the aforementioned measures have been examined for each group accordingly[35].

The process of changes of technical and scale efficiency and productivity growth in the Polish commercial banks in 1997-2001 was analyzed by comparison of technical efficiency measures e_crs, e_vrs, e_nirs and Malmquist output-oriented productivity indices. In 1997-2001, a slight improvement of effectiveness in the Polish commercial banking sector was noticed (see Table 6 in Statistical Annex), as the result of an increase of value of average measures of technical efficiency (e_crs) and scale efficiency (e_s). The increase of scale efficiency measure e_s reflects the positive effects of scale economies taking place in the Polish banking sector.

It is not possible to draw direct conclusions from the assessed technical efficiency measures about the ongoing process of technical efficiency increase in the Polish commercial banking sector because those are relative measures. To determine if efficiency improvement is achieved at a certain time, the Malmquist productivity index must be analyzed. Following the results of the Malmquist productivity index estimation (presented at Table 7 in Statistical Annex), it can be seen that the productivity increase in 1997-1999 stopped in 2000 and increased again slightly in 2001. In the period 1997-1998 the average value of the Malmquist index (M) is higher than 1 showing an increase of productivity. The increase in this period is caused by a significant improvement of technical efficiency (E) and in parallel to technological change (TC) improvement in the sector. In 1998-1999, the main reason for the increase of the Malmquist index (M) was the improvement of relative technical efficiency change (E). In 1999-2000, the value of the average Malmquist (M) index decreased. That was caused by a significant technical regression in parallel to an improvement of relative effectiveness. In 2000-2001, the value of average Malmquist index (M) slightly increased. That was caused by an improvement of relative efficiency at slight technological regress.

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33 *"very large bank"* - is a bank with assets above 10 billion PLN (assets above $2.5 Billion), "*large bank*" - is a bank with assets between 5 to 10 billion PLN (assets between Billion $1.25 and 2.5), "*medium bank*" - is a bank with assets between 1 to 5 billion PLN (assets between $250 Million to $1.25 Billion), "*small bank*" - is a bank with assets below 1 billion PLN (assets below: $250 Million).

34 "*Banks with majority of state ownership*"- at least 50% of assets owned directly or indirectly to the state treasury, "*Banks with majority Polish equity*"- at least 50% of assets owned by Polish investors, "*Banks with majority foreign equity*"-at least 50% of assets owned by foreign investors.

35 A computer program was written in Gauss language and used to calculate all measures of efficiency.

Benchmarks for Polish commercial banks

Following the results of the assessment of technical and scale efficiency measures, banks were classified as set out in Table 1.

Banks defined as "BC" are the best practice frontiers. Those are the banks that are both technically and scale efficient and are the best practice in the sector of Polish commercial banks. In 1997-2001 this group consisted of 12-19 commercial banks. The group is stable, and is still growing (the decreasing number in this group in 2001 resulted from mergers and acquisitions). Members of this group are "very large" and "medium" banks (see Table 2).

Banks defined as "A" are technically efficient, but scale inefficient. Those banks are too small to achieve optimal input to output ratio. Those banks are operating in the increasing returns to scale region. Only a few banks belong to the group of "A" banks. Banks defined as "D" are technically efficient but are too large to be efficient with regard to the scale and were operating in the decreasing return to scale region. Banks defined as "E" are a number of technically inefficient banks that are too small to be efficient. This is a relatively large group of banks and future mergers and acquisitions in this group could improve the efficiency of the banking sector.

Banks defined as "F" are technically inefficient and are scale efficient. Those banks should not change engaged inputs because they are operating in the constant return to scale region. No banks have been classified in this group. Banks defined as "G" are inefficient both technically and with regard to scale. Those banks should reduce inputs and should improve technology in parallel. This is a relatively large group of banks, but is constantly decreasing. This confirms that the efficiency of the banking sector improved in the analyzed period.

The benchmark of the banks with regard to assessed technical and scale efficiency measures shows that a majority of the analyzed banks were operating with increasing and constant returns to scale region.

Tab. 2 Benchmark Classification in 1997-2001

	1997	1998	1999	2000	2001
BC	13	12	18	19	16
A	0	1	3	3	0
D	9	12	8	2	5
E	8	6	7	13	15
F	0	0	0	0	0
G	23	22	17	16	11

Source: M.Pawłowska (2003).

Size of Banks and efficiency

To compare the technical efficiency of the small and large banks, they have been divided into four groups depending on the size of their balance sheet totals (Table 5 in Statistical Annex shows values of ROE and ROA ratio in years 1997-2001). The values of the profitability ratios ROE and ROA are differentiated within groups in the years 1997-2001. The number of banks belonging to the "large" group is increasing significantly, while a number of "small banks" is decreasing in favor of "medium" banks. Banks belonging to the "very large" group have the highest values of ratio ROA and ROE during the whole of the analyzed period. In 1999 and 2001 the number of M&As was increasing in comparison with the other years. This has been reflected in an increase of ratios ROE and ROA for the "very large" group. It should be noted that the "small banks" have the lowest values of ROE and ROA during the analyzed period.

For each analyzed period, "small" banks achieved the lowest technical efficiency measures (see table 8 in Statistical Annex). The average values of scale efficiency measures (e_s) for the group of "small" banks were stable in the analyzed period. Constant improvement of scale efficiency of the "very large" banks was noticed.

The increase of relative technical efficiency (E) in 1997-1999 in the Polish banking sector was caused mainly by an improvement of relative efficiency of "small" banks (see table 9 in Statistical Annex). In 1999-2000, the decrease of the Malmquist index was caused by technical regress and a lack of improvement of relative effectiveness of "small" banks. In 2000-2001 the measure of technical efficiency of "small" banks stayed at the same level, in parallel to a decrease of relative efficiency, which resulted in the lowest productivity index (M) for the group.

The increase of the productivity index (M) in 2000-2001 in the Polish banking sector was caused by an increase of the technical development measure (TC) for all groups of banks.

Ownership structure of Banks and efficiency

The M&A process is strictly connected with the process of privatization, based mostly on foreign capital. To analyze the impact of the ownership structure on efficiency, the banks were grouped according to the classification followed by the General Inspectorate of Banking Supervision. The values of coefficients ROE and ROA in the years 1997-2001, from the ownership point of view, are also differentiated (as shown in Statistical Annex Table 3). It should be mentioned that "banks with majority Polish equity" have the lowest values of typical efficiency ratio during the analyzed period, and "banks with majority foreign equity" have the highest values.

Private foreign capital is more efficient than state capital in the analyzed period because of the high values of technical efficiency and productivity measures of "banks with majority foreign equity". "Banks with majority Polish equity" have achieved the lowest efficiency (see Table 8 in Statistical Annex). Investigation by the Malmquist productivity index (see Table 9 in Statistical Annex) shows that, starting from 2000, "banks with majority foreign equity" had a slight technical regress resulting from the economic recession.

7
Conclusion

The financial institutions are transforming themselves in response to fundamental changes in regulation and technology. One way to respond is by attempting to improve their efficiency by M&A. There is evidence of M&A exploiting scale efficiency[36].

Our empirical results show an increasing level of output, technical efficiency, scale efficiency and productivity during the analyzed period.

Benchmark classification shows that the majority of the examined banks were operating with increasing or constant returns to scale region.

All the banks involved in the M&A processes have significantly improved their efficiency measures and productivity indices. However, it should be noticed that merger processes mainly take place among "large" and "very large" banks, which are already efficient before the mergers.

One of the most important observations and conclusions resulting from this study is that the basic measure influencing the efficiency of the analyzed banks is their size. The majority of technical efficient banks in the Polish banking sector are banks categorized under the heading "very large", while the majority of banks which are inefficient are banks categorized under the heading "small" and "medium". It should be noticed, that the panel of data does not include banks established after 1997 (and includes banks which are specialized in car loans - those banks are "small" or "medium" and are efficient).

On the other hand, the ownership structure also has an influence on technical efficiency and productivity. The majority of technical efficient banks in the Polish banking sector are the banks categorized under the heading "banks with majority foreign equity", while the majority of banks which are inefficient are banks categorized under the heading "banks with majority Polish equity".

The study shows that a considerable number of "small banks" still constitute the principal source of technical and scale inefficiency. It has become noticeable that the consolidation processes involve basically "very large banks", and there are still many inefficient and poorly capitalized banks. The positive results obtained from the assessment of M&A conducted by commercial banks show that those processes should be continued and should also involve "small" and "medium" banks.

[36] See Group of Ten Report on consolidation in the financial sector (January 2001), which can be obtained through the websites BIS, The IMF and the OECD: www.bis.org, www.imf.org, www.oecd.org.

8
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9
Annex: Definitions and measures of productive efficiency

The analysis of technical efficiency can have an output augmenting orientation or an input-conserving orientation. Koopmans (1951, p60) provided a formal definition of technical efficiency: a producer is technically efficient if any increase in any output requires reduction in at least one other output or an increase in at least one input, and if reduction in any inputs requires an increase in at least one other input or reduction in at least one output.

Debreu (1951) and Farrell (1957) introduced a measure of technical efficiency. Their measure is defined as one minus the maximum equiproportionate reduction in all inputs that still allow continued production of given outputs.

In order to relate the Debreu-Farrell measure to the Koopmans definition, it is useful to introduce the same notation and terminology[37].

Let producers use inputs $x=(x_1,...,x_m)\in R_+^N$ to produce outputs $y=(y_1,...,y_s)\in R_+^M$ (1.1)

Production technology can be represented with an input set:

$L(y) = \{x: (y, x) \text{ is feasible}\}$ (1.2)

$\forall y\in R_+^M$ has isoquant[38]: $IsoqL(y) = \{x: x\in L(y), \theta x\notin L(y), \theta\in[0,1) \}$ (1.3)

and efficient subset: $EffL(y) = \{x: x\in L(y), x'\notin L(y), x'\leq x \}$ (1.4)

For future reference (1.4) we note: $EffL(y) \subseteq IsoqL(y)$. Shepard (1970)[39] introduced the input distance function to provide a functional representation of a multiple output technology[40].

$D_I(y,x) = max\{\theta: x/\theta\in L(y) \}$ (1.5)

Clearly $D_I(y,x) \geq 1$, and it follows from (1.3) that: $Isoq\ L(y) = \{x: D_I(y, x)=1 \}$ (1.6)

The Debreu-Farrell input-oriented measure of technical efficiency can be given a more formal interpretation as: $DF_I(x ,y) = D_I(y,x)^{-1} = min\{\theta: x^*\theta\in L(y)\}$ (1.7)

Production technology can also be represented with an output set:

$P(x) = \{y: (x,y) \text{ is feasible}\}$ (1.8)

$\forall y\in R_+^N$ has isoquant: $IsoqP(x) = \{y: y\in P(x), \theta y\notin P(x), \theta\in(1,+\infty)\}$ (1.9)

and efficient subset: $EffP(x) = \{y: y\in P(x), y'\notin P(x), y'\geq y \}$ (1.10)
having the property that $Eff(x) \subseteq IsoqP(x)$.

Shephard's (1970) output distance function in output oriented model provides another functional representation of production technology.

$D_O(x,y) = min\{\theta: y/\theta\in P(x) \}$ (1.11)

Clearly $D_O(x,y)\leq 1$ and it follows from (1.9) that: $IsoqP(x) = \{y: D_O(x,y)=1 \}$ (1.12)

The Debreu-Farrell output-oriented measure of technical efficiency is defined as:

37 Charnes O., C.Fried, A. Knox Lovell, B. Shelton, S. Schmidt (1993) pp.10-11.
38 The best practice frontier.
39 Shephard R.W. (1970).
40 The input distance function between the point (y, x) and the *best practice frontier.*

$DF_0(x, y) = D_0(x,y)^{-1} = max\{\theta: \theta^*y \in P(x)\}$ (1.13)

and consequently $IsoqP(x) = \{y: DF_0(x,y)=1\}$ (1.14)

The two technical efficiency measures are illustrated in Figure A1 and A2.

In the input-oriented upper panel, input vectors x^C and x^D technical efficiency measurements is defined as θ^C, θ^D and $\theta^C=\theta^D=DF_I(y,x^C)=DF_I(y,x^D)=1$, and consequently $max\{DF_I(y,x^A),DF_I(y,x^B)\}<1$ but $DF_I(y, \theta^A x^A)=DF_I(y, \theta^B x^B)=1$. Similar remarks apply to the output-oriented lower panel. For output vectors y^C, y^D technical efficiency measurements are $\theta^C=\theta^D=DF_0(x,y^C)=DF_0(x, y^D) = 1$ and $max\{DF_0(x,y^A), DF_0(x,y^C)\} < 1$[41].

Figure A1. Debreu-Farell technical measurement for two inputs and one output (input-oriented model)

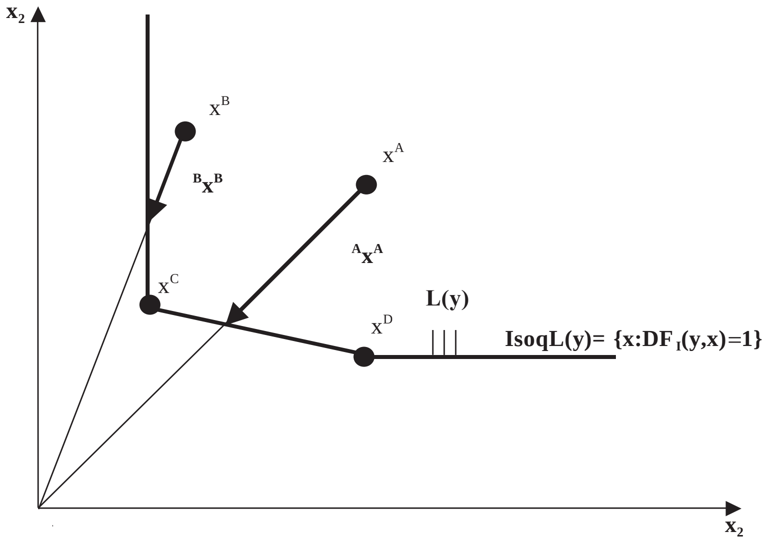
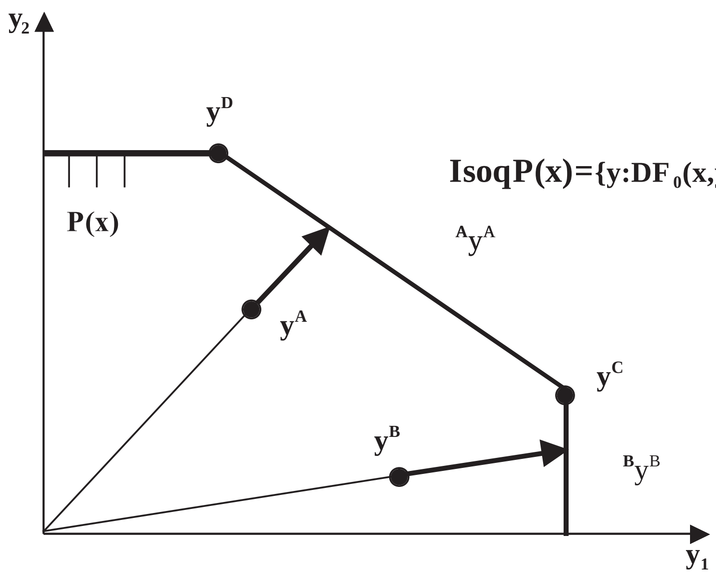


Figure A2. Debreu-Farrell technical measurement for two output and one inputs (output-oriented model)



Source: Harold O. Fried, C. A. Knox Lovell, Shelton S. Schmidt (1993).

Notice: θ-measurement in input-oriented model and output-oriented model has signed two different measures.

41 Charnes O., C.Fried, A. Knox Lovell, B. Shelton, S. Schmidt (1993) pp.10-11.

Basic DEA models

During the last twenty years all DEA models have been modified. We want to present some CCR models and BCC models below:

z_0 – function; X_0 – is vector of input *([1 x m])*; X – is an *(n x m)* input matrix , $x_{ij}\geq 0$; Y_0 – is vector of output

([1 x s]);Y – is an *(n x s)* output matrix with columns, $y_{rj}\geq 0$; λ- is vector of constants; s^+, s^- - additional parameters; ε - a very small number.

Measure- θ_{CCR} (input-oriented) can be calculated by solving CCR DEA input oriented model:

$min\ z_0$[42] $= \theta - \vec{1}\ s^+ - \vec{1}\ s^-$ (1.15)

$s.t.: \theta X_0 - X\lambda - s^- = 0$

$Y\lambda - s^+ = Y_0, \lambda, s^+, s^- \geq 0$

Measure- θ_{CCR} (output-oriented) can be calculated by solving output oriented CCR- model:

$max\ z_0 = \theta + \vec{1}\ s^+ + \vec{1}\ s^-$ (1.16)

$s.t.: \theta Y_0 - Y\lambda + s^+ = 0$

$X\lambda + s^- = X_0, \lambda, s^+, s^- \geq 0$

Measure θ_{BCC} (input-oriented) can be calculated by solving the input-oriented BCC- model:

$min\ z_0 = \theta - \vec{1}\ s^+ - \vec{1}\ s^-$ (1.17)

$s.\ t.: \theta X_0 - X\lambda - s^- = 0$

$Y\lambda - s^+ = Y_0$

$\vec{1} * \lambda = 1, \lambda, s^+, s^- \geq 0$

Measure θ_{BCC} (output-oriented) can be calculated by solving the output-oriented BCC- model:

$max\ z_0 = \theta + \vec{1}\ s^+ + \vec{1}\ s^-$ (1.18)

$s.t.: \theta Y_0 - Y + s^+ = 0$

$X + s^- = X_0$

$\vec{1} * \lambda = 1, \lambda, s^+, s^- \geq 0$

Measure θ_{NIRS}[43] (input-oriented) can be calculated by solving the input-oriented BCC-model with additional condition that $\vec{1} * \lambda \leq 1$.

$min\ z_0 = \theta - \vec{1}\ s^+ . \vec{1}\ s^-$ (1.19)

$s.\ t.: \theta X_0 - X\lambda - s^- = 0$

$Y\lambda - s^+ = Y_0$

$\vec{1} * \lambda \leq 1, \lambda, s^+, s^- \geq 0$

Measure θ_{NIRS} (output-oriented) can be calculated by solving the output-oriented BCC-model[44] with additional condition that * 1.

$max\ z_0 = \theta + s^+ + s^-$ (1.20)

$s.t.\ \theta Y_0 - Y\lambda + s^+ = 0$

$X\lambda + s^- = X_0$

$\vec{1} * \lambda \leq 1, \lambda, s^+, s^- \geq 0.$

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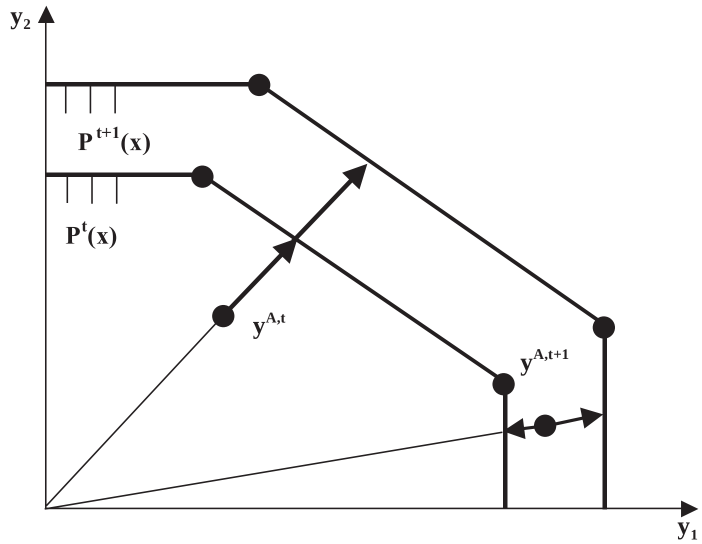
42 z_0 – normal linear function with mathematical programming, that derive with equation (1.15).
43 θ_{NIRS} – this measure is used for determinate in which region given DMU is operating.
44 Notice: θ measure with models CCR, BCC in output and input oriented are not equal.

The non-parametric Malmquist approach

This approach to the decomposition of productivity change into technical change and efficiency change uses linear programming techniques to decompose what Caves, Christensen and Diewert (1982) refer to as a Malmquist (1953) productivity index[45].

The basic idea (for two outputs and one input) is illustrated in Figure A3 technical progress has occurred between time periods t and $t+1$, since $P^t(x) \subseteq P^{t+1}(x)$. The technical efficiency of producer A appears to have improved from time period t to time period $t+1$ as well. Note that $y^{A,t} \in P^t(x)$ and $y^{A,t+1} \in P^{t+1}(x)$, but $y^{A,t+1} \notin P^t(x)$. Note finally that the fact that the input vector is the same in both time periods is for expository convenience only[46].

Figure A3. Malmquist productivity index (output-oriented)



Source: Harold O. Fried, C. A. Knox Lovell, Shelton S. Schmidt (1993).

A Malmquist output-oriented productivity index is defined as:

$$M_0^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t,) = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \tag{1.21}$$

This productivity index is the geometric mean of pair of ratios of output distance functions. The first ratio compares the performers of data from periods t and $t+1$ relative to production possibilities existing in period t, and second compares the performance of same data relative to production possibilities existing in period $t+1$. The right side of (1.21) can be rewritten as[47]:

$$M_0^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \underbrace{\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}}_{E} \underbrace{\left[\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)} \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \right]^{\frac{1}{2}}}_{TC} \tag{1.22}$$

Expression (1.22) decomposes the Malmquist out-oriented productivity index into the product of two terms. The first term is the ratio of two output distance functions involving data and technology from periods $t+1$ and t, respectively[48]. Consequently the first term (E) has a value of unity when there is no change in technical efficiency, and has a value greater or less than unity according to whether or not technical efficiency has improved or declined. The second term (TC) has a value of unity when technical change has not occurred along either ray, and has a value greater than or less than unity according to whether or not technical change has on balance been progressive or regressive.

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[45] Harold O., Fried, C. A. Knox Lovell, Shelton S. Schmidt (1993) p. 50.
[46] op.cit.
[47] op.cit.
[48] Recall from equation (1.11) that these output distance functions are reciprocals of Dedreu-Farrell output-oriented technical efficiency measures.

10
Statistical Annex

Tab. A1. Credit Institutions in Poland (1997- 2001)

Financial Institution	Number of Institutions				
	1997	**1998**	**1999**	**2000**	**2001**
1. Banks	1378	1272	858	754	713
1.1 Commercial banks	83	83	77	74	71
1.2 Cooperative banks	1295	1189	781	680	642
2. Credit Unions	198	220	228	147	140
Assets (in PLN million)					
	1997	**1998**	**1999**	**2000**	**2001**
1. Banks	247668.9	318726.8	363427.4	428486.3	477371.3
1.1 Commercial banks	236414.6	305034.5	348033.1	410445.3	455862.5
1.2 Cooperative banks	11254.3	13692.3	15394.3	184356.0	21508.7
2. Credit Unions	368.2	590.3	882.7	1199.3	1759.4
Financial Sector Assets as Percentage of GDP (%)					
	1997	**1998**	**1999**	**2000**	**2001**
1. Banks	53.3	57.7	59.2	62.8	66.3
1.1 Commercial banks	50.9	55.5	56.7	60.2	63.2
1.2 Cooperative banks	2.4	2.5	2.5	2.6	3.1
2. Credit Unions	0.1	0.1	0.1	0.2	0.2

Source: NBP,KSKOK.

Tab. A2. Ownership Structure of the Banking Sector (1997- 2001)

Number of Banks					
	1997	**1998**	**1999**	**2000**	**2001**
1.Commercial banks	83	83	77	74	71
1.1.Banks with majority of state ownership	15	13	7	7	7
1.2.Private sector banks of which	68	70	70	67	64
1.2.1.Banks with majority Polish equity	39	39	31	20	18
1.2.2.Banks with majority foreign equity	29	31	39	47	48
2.Cooperative banks	1295	1189	781	680	642
Total (1+2)	1378	1272	858	754	713
The Banking Sector Assets (%)					
	1997	**1998**	**1999**	**2000**	**2001**
1.Commercial banks	95.5	95.7	95.8	95.8	95.5
1.1.Banks with majority of state ownership	49.3	45.9	23.9	22.9	23.2
1.2.Private sector banks of which	46.2	49.8	71.8	72.9	72.4
1.2.1.Banks with majority Polish equity	30.9	33.2	24.6	3.4	3.2
1.2.2.Banks with majority foreign equity	15.3	16.6	47.2	69.5	69.2
2.Cooperative banks	4.5	4.3	4.2	4.2	4.5
Total (1+2)	713	100	100	100	100
Loans* to Non-Financial Sector (%)					
	1997	**1998**	**1999**	**2000**	**2001**
1.Commercial banks	94.5	95.0	94.9	94.6	94.2
1.1.Banks with majority of state ownership	43.2	23.2	20.5	21.2	20.5
1.2. Private sector banks. of which	51.3	72.4	73.7	73.4	73.7
1.2.1.Banks with majority Polish equity	33.1	3.2	2.4	3.2	2.4
1.2.2.Banks with majority foreign equity	18.2	21.9	50.9	70.2	71.3
2.Cooperative banks	5.5	5.0	5.8	5.4	5.8
Total (1+2)	100	100	100	100	100
Deposit of Non-Financial Sector (%)					
	1997	**1998**	**1999**	**2000**	**2001**
1.Commercial banks	94.8	94.8	95.5	94.8	94.4
1.1.Banks with majority of state ownership	58.0	53.6	23.2	28.9	28.7
1.2. Private sector banks. of which	36.8	41.2	72.4	65.9	65.7
1.2.1.Banks with majority Polish equity	24.1	27.5	20.1	2.4	1.8
1.2.2.Banks with majority foreign equity	12.7	13.7	45.6	63.5	63.9
2.Cooperative banks	5.2	5.2	4.0	5.2	5.6
Total (1+2)	100	100	100	100	100

* Loans net of loan loss provisions.

Source: NBP, KSKOK.

Tab. A3. Banking Sector's Efficiency Indicators and Concentration Level – Poland 1997-2001(%)

Efficiency Ratios	**1997**	**1998**	**1999**	**2000**	**2001**
Profit before tax over average assets (ROA) (%)	3.00	1.75	1.60	1.51	1.36
Profit before tax over tier 1 equity (ROE) (%)	67.5	28.4	23.1	21.7	18.5
Net interest margin (NIM) (%)	5.23	4.58	4.01	4.26	3.38
Herfindahl - Hirschman (HH) Indices	**1997**	**1998**	**1999**	**2000**	**2001**
For loans	0.055	0.049	0.066	0.065	0.073
For assets	0.074	0.067	0.079	0.076	0.086
For deposits	0.120	0.108	0.118	0.115	0.119
5 Largest Banks (C5) (in %)	**1997**	**1998**	**1999**	**2000**	**2001**
For loans	43.7	37.5	48.5	48.7	50.3
For assets	48.4	44.8	49.8	48.5	54.2
For deposits	54.9	45.6	58.3	57.7	62.2

Notice: Net interest margin (NIM) = net interest income (interest income minus interest expenses) over average assets.

Source : NBP, (Wróbel, Pawłowska 2002).

Tab. A4. List of M&A That Have Taken Place in Poland During 1997-2001

Banks after M&A	Banks Participating in the M&A Deals	Assets of Acquired Bank (in mil of PLN)	Total Assets after M&A	Capital of Acquired Banks	Total Capital after M&A
1997					
Powszechny Bank Kredytowy SA	Powszechny Bank Kredytowy acquired the banking business of Bank Morski	10853	10943	969	969
BIG Bank GDAŃSKI SA	Bank GDAŃSKI S.A. merged with Bank Inicjatyw Gospodarczych S.A.	3115	8164	324	866
Kredyt Bank PBI S.A.	Kredyt Bank SA merged with Polski Bank Inwestycyjny S.A. and acquired Prosper-Bank S.A.	1826	6456	219	416
Bank Handlowy S.A.	Bank Handlowy S.A. took controlling interest in Bank Rozwoju Cukrownictwa SA	15158	15410	1730	1758
Total		24547	40973	3242	4009
1998					
Hypo Vereinsbank Polska S.A.	Vereinsbank AG acquired Bayerische Hypo-Bank AG	740	1671	276	368
BRE Bank S.A.	Bank Rozwoju Eksportu merged with Polski Bank Rozwoju SA	6142	8012	816	1130
Total		6882	9683	1092	1498
1999					
Group Pekao SA	Banking group included four state banks: Powszechny Bank Gospodarczy SA, Pomorski Bank Kredytowy SA, Bank Depozytowo Kredytowy SA, Bank Polska Kasa Opieki S.A.	34661	58768	1767	3243
Powszechny Bank Kredytowy S.A.	Powszechny Bank Kredytowy acquired the banking business of Pierwszy Komercyjny Bank	13683	16380	1146	1146
Bank Inicjatyw Spo eczno Ekonomicznych S.A.	Bank Inicjatyw Spo eczno Ekonomicznych merged with Bank Energetyki S.A.	364	873	58	120
Bank Przemys owo Handlowy S.A.	Bank Przemys owo Handlowy merged with Hypo Vereisbank Polska S.A.	13197	14742	1446	1146
BWR S.A.	BWR S.A. acquired the banking business of BWR Bank Secesyjny	1038	1122	108	108
Total		62942	91885	4515	6341

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2000					
Powszechny Bank Kredytowy SA	Powszechny Bank Kredytowy merged with Bank Austria Creditanstalt Poland S.A.	17537	19622	1726	1873
Wielkopolski Bank Kredytowy S.A.	Wielkopolski Bank Kredytowy SA acquired Gliwicki Bank Handlowy S.A.	10567	11949	738	738
Bank Wspó pracy Regionalnej SA	Bank Wspó pracy Regionalnej SA acquired the banking business of BWR REAL BANK S.A.	806	1206	109	109
Total		28910	32777	2573	2720
2001					
BIG Bank Gdański S.A.	BIG BANK S.A. merged with parent bank: BIG Bank Gdański SA	16231	27614	1580	1809
Bank Handlowy w Warszawie S.A.	CITIBANK (Poland) SA merged with Bank Handlowy w Warszawie S.A.	21001	32143	3035	3995
Bank Zachodni WBK S.A.	Wielkopolski Bank Kredytowy SA merged with Bank Zachodni S.A.	9321	22891	932	1813
ING Bank Śląski S.A.	ING Bank Śląski SA merged with ING Bank N.V. Branch. and acquired Wielkopolski Bank Rolniczy	19074	25448	1530	2055
Gospodarczy Bank Wielkopolski SA	Gospodarczy Bank Wielkopolski merged with Ba tycki Bank Regionalny S.A.	19074	25448	1530	2055
Nordea B. Polska S.A.	Bank W asności Pracowniczej – Unibank S.A. merged with Nordea Bank Polska	584	831	171	171
BPH-PBK S.A.*	Powszechny Bank Kredytowy S.A. merged with Bank Przemys awo Handlowy	18178	41187	2172	4258
Total		85556	151418	9476	14193

* This M&A took place on 31 December 2001 - on 1 January 2002 and General Inspectorate of Banking Supervision classified it in 2002.

Notice: calculations with the end of year precede M&A.

Source: NBP publications, Polish daily newspaper "Rzeczpospolita".

Tab. A5. Summary Statistics of M&A That Took Place During 1997-2001 Among Polish Banks

	Number of M&A	Number of Banks Involved in M&A	Assets of Banks Involved in M&A (in million PLN)	M&A as Percentage of the Total Commercial Banking Assets
1997	4	9	40973	17
1998	2	4	9683	4
1999	5	12	91885	30
2000	3	6	32777	10
2001	7	15	151418	34
Total	21	46	326736	

Notice: calculations in 2001 was included a merger between Powszechny Bank Kredytowy S.A. and Bank Przemysławo Handlowy.

Source: NBP.

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Tab. A6. ROE, ROA by Asset Size and Ownership, in Period 1997-2001(%)

	Characteristic by Asset Size	Number of Banks (%)	Number of Banks	ROE	ROA
1997	very large	9.4	5	33.70	2.46
	large	13.2	7	24.67	1.81
	medium	18.9	10	29.25	2.39
	small	58.5	31	13.10	1.34
1998	very large	18.8	10	30.01	1.05
	large	7.5	4	20.47	1.19
	medium	35.9	19	16.57	1.53
	small	37.8	20	9.41	0.95
1999	very large	20.7	11	31.84	1.51
	large	5.7	3	7.10	0.48
	medium	35.8	19	14.06	1.27
	small	37.8	20	1.09	0.03
2000	very large	24.5	13	17,7	1,11
	large	3.8	2	6,62	0,40
	medium	43.4	23	7,86	0,63
	small	28.3	15	-9,43	-2,57
2001	very large	23.4	13	8,43	1,1
	large	4.2	2	-0,04	-0,07
	medium	51.1	24	5,29	0,87
	small	21.3	10	-0,55	-0,08
	Characteristic by Ownership	**Number of Banks (%)**	**Number of Banks**	**ROE**	**ROA**
1997	Banks with majority of state ownership	11.3	6	32.17	2.73
	Banks with majority Polish equity	56.6	30	18.49	1.48
	Banks with majority foreign equity	32.1	17	12.05	1.37
1998	Banks with majority of state ownership	17.0	9	47.34	1.97
	Banks with majority Polish equity	47.2	25	10.89	0.79
	Banks with majority foreign equity	35.8	19	13.29	1.52
1999	Banks with majority of state ownership	13.2	7	31.84	1.51
	Banks with majority Polish equity	41.5	22	7.10	0.48
	Banks with majority foreign equity	45.3	24	14.06	1.27
2000	Banks with majority of state ownership	13.2	7	14.06	0.61
	Banks with majority Polish equity	24.5	13	-11.39	-2.98
	Banks with majority foreign equity	62.3	33	10.07	0.77
2001	Banks with majority of state ownership	14.9	7	9.11	0.33
	Banks with majority Polish equity	23.4	11	-11.14	-0.69
	Banks with majority foreign equity	61.7	29	8.68	0.46

Notice: the numbers of banks in 2001 have decreased from 53 to 47 due to M&A.

Source: own analysis.

Tab. A7. Average Technical Efficiency, Scale Efficiency, in Period 1997-2001

Year	Statistic	e_crs	e_vrs	e_s	e_nirs
1997	average	0.64	0.76	0.85	0.75
	standard deviation	0.30	0.30	0.18	0.30
	min value	0.10	0.10	0.44	0.10
	Numbers of efficient banks	13	22	13	22
1998	average	0.66	0.79	0.84	0.79
	standard deviation	0.29	0.29	0.18	0.28
	min value	0.09	0.10	0.41	0.10
	Numbers of efficient banks	12	25	12	24
1999	average	0.72	0.82	0.89	0.80
	standard deviation	0.27	0.26	0.14	0.27
	min value	0.16	0.18	0.53	0.18
	Numbers of efficient banks	18	28	17	25
2000	average	0.73	0.81	0.90	0.78
	standard deviation	0.25	0.23	0.12	0.24
	min value	0.31	0.33	0.53	0.31
	Numbers of efficient banks	18	20	15	21
2001	average	0.74	0.81	0.93	0.79
	standard deviation	0.25	0.25	0.10	0.26
	min value	0.13	0.19	0.67	0.13
	Numbers of efficient banks	16	21	16	21

Source: M. Pawłowska (2003).

Tab. A8. Average Changes of Malmquist Productivity Index (M), Technical Efficiency Change (E) and Technological Change (TC) in Period 1997-2001

	Statistic	E	TC	M
1997/1998	Average	1.10	1.11	1.24
	Number of banks that increase productivity	26	32	30
	Number of banks that decrease productivity	19	17	19
	Lack of change	8	3	3
1998/1999	Average	1.28	0.91	1.06
	Number of banks that increase productivity	27	16	25
	Number of banks that decrease productivity	16	31	22
	Lack of change	9	5	4
1999/2000	Average	1.08	0.90	0.96
	Number of banks that increase productivity	22	6	20
	Number of banks that decrease productivity	16	37	23
	Lack of change	13	10	8
2000/2001	Average	1.03	0.99	1.01
	Number of banks that increase productivity	19	20	23
	Number of banks that decrease productivity	16	20	17
	Lack of change	12	7	7

Source: M. Pawłowska (2003).

Tab. A9. Technical Efficiency, Scale Efficiency, by Assets Size and Ownership Structure, (1997-2001)

Technical Efficiency, Scale Efficiency, by Assets Size					
Year	Characteristic by Assets size	e_crs	e_vrs	e_s	e_nirs
1997	very large	0.75	0.98	0.76	0.98
	large	0.57	0.96	0.61	0.94
	medium	0.80	0.86	0.91	0.86
	small	0.58	0.64	0.89	0.64
1998	very large	0.68	0.97	0.72	0.97
	large	0.75	1.00	0.87	0.97
	medium	0.76	0.85	0.86	0.84
	small	0.54	0.63	0.87	0.62
1999	very large	0.70	0.97	0.74	0.96
	large	0.79	1.00	1.00	0.90
	medium	0.83	0.91	0.93	0.88
	small	0.61	0.65	0.92	0.62
2000	very large	0.80	0.93	0.88	0.93
	large	0.74	0.81	0.89	0.81
	medium	0.79	0.81	0.96	0.82
	small	0.59	0.72	0.84	0.59
2001	very large	0.78	0.93	0.85	0.90
	large	0.82	0.94	0.86	0.94
	medium	0.82	0.85	0.99	0.84
	small	0.50	0.56	0.89	0.50
Technical Efficiency, Scale Efficiency, by Ownership Structure					
Years	Characteristic by Ownership	e_crs	e_vrs	e_s	e_nirs
1997	Banks with majority of state ownership	0.63	0.81	0.77	0.78
	Banks with majority Polish equity	0.52	0.63	0.83	0.64
	Banks with majority foreign equity	0.85	0.94	0.90	0.94
1998	Banks with majority of state ownership	0.58	0.75	0.80	0.79
	Banks with majority Polish equity	0.55	0.69	0.80	0.69
	Banks with majority foreign equity	0.84	0.94	0.90	0.93
1999	Banks with majority of state ownership	0.83	0.92	0.90	0.92
	Banks with majority Polish equity	0.53	0.61	0.89	0.60
	Banks with majority foreign equity	0.85	0.98	0.89	0.95
2000	Banks with majority of state ownership	0.85	0.96	0.91	0.91
	Banks with majority Polish equity	0.50	0.60	0.87	0.51
	Banks with majority foreign equity	0.80	0.87	0.91	0.86
2001	Banks with majority of state ownership	0.79	0.90	0.88	0.89
	Banks with majority Polish equity	0.53	0.55	0.97	0.53
	Banks with majority foreign equity	0.81	0.89	0.93	0.86

Source: M. Pawłowska (2003).

Tab. A10. The Average Changes of Malmquist Productivity Index (M), Technical Efficiency Change (E) and Technological Change (TC) in Period 1997-2001

Years	Characteristic by Asset Size	E	TC	M
1998/1997	very large	1.01	1.06	1.06
	large	1.04	1.12	1.17
	medium	1.09	1.12	1.21
	small	1.16	1.11	1.37
1999/1998	very large	1.07	0.92	0.94
	large	0.99	1.00	0.99
	medium	1.21	0.96	1.04
	small	1.50	0.85	1.15
2000/1999	very large	1.09	0.92	1.00
	large	1.29	0.89	1.01
	medium	1.11	0.93	1.01
	small	1.00	0.86	0.87
2000/2001	very large	1.06	0.94	0.99
	large	0.93	1.01	0.94
	medium	1.06	1.00	1.07
	small	0.95	1.00	0.91
Years	**Characteristic by Ownership**	**E0**	**TC**	**M**
1998/1997	Banks with majority of state ownership	1.08	1.10	1.19
	Banks with majority Polish equity	1.12	1.11	1.28
	Banks with majority foreign equity	1.07	1.10	1.20
1999/1998	Banks with majority of state ownership	1.78	0.81	1.24
	Banks with majority Polish equity	1.27	0.89	1.01
	Banks with majority foreign equity	1.13	0.96	1.05
2000/1999	Banks with majority of state ownership	1.07	0.94	1.01
	Banks with majority Polish equity	1.18	0.85	0.98
	Banks with majority foreign equity	1.04	0.92	0.95
2001/2000	Banks with majority of state ownership	0.94	1.06	0.99
	Banks with majority Polish equity	1.21	0.93	1.10
	Banks with majority foreign equity	0.99	0.99	0.99

Source: M. Pawłowska (2003).

11
Glossary

Asset Approach (AA) – In this approach banks are considered only as financial intermediaries between liability holders and funds beneficiaries (i.e. debtors).

BCC model - This model was defined by Banker, Charnes, Cooper (1984) and estimates efficiency on the assumption of variable returns to scale (VRTS). The BCC model distinguishes between technical and scale inefficiencies by estimating pure technical efficiency at a given scale of operation.

CCR model - This model was the first DEA ratio model (as defined by Charnes, Cooper, Rhodes (1978)) which yields an objective evaluation of overall efficiency and identified inefficiencies. The CCR model estimates efficiency on the assumption of constant returns to scale (CRTS).

Data Envelopment Analysis (DEA) – This is a non-parametric linear programming technique that computes a comparative ratio of outputs to inputs for each unit, which is reported as the relative efficiency score. The efficiency score is usually expressed as a number between 0 and 1. This method assumes that there are decision-making units (DMUs) to be evaluated. Each DMU consumes varying amounts of m different inputs to produce s different outputs. A decision-making unit with a score less than 1 is deemed inefficient relative to other units. An efficient DMU depicts the efficient frontier that represents achieved efficiency. The mathematical programming approach to the construction of production frontiers and the measure of efficiency relative to the constructed frontiers is frequently given the descriptive title of data envelopment analysis.

e_crs – This measure of efficiency is defined under constant returns to scale assumption (CRST).

e_nirs – This measure of efficiency is defined under non-increasing returns to scale assumption (NIRST).

e_s – This measure of efficiency is defined as result of dividing: e_crs/e_vrs. This is scale efficiency.

e_vrs - This measure of efficiency is defined under variable returns to scale assumption (VRST).

Intermediation Approach (IA) - In this approach banks are viewed as mediators who transform and transfer financial resources from units in surplus to units in deficit.

Malmquist productivity index – This index is defined as the geometric mean of pair of ratios of output distance functions. The first ratio compares the performers of data from periods t and $t+1$ relative to production possibilities existing in period t, and the second compares the performance of same data relative to production possibilities existing in period $t+1$. This index is divided into two components: technical efficiency change (E), technological change (TE). That is, an increase in productivity from one year to the next may be due to improved technical efficiency (E), technological progress (TE), or a combination of both (M).

NIRS model - In order to identify types of return to scale effects the NIRS DEA model is used. This model identifies in which region the entity is functioning: increasing, decreasing or constant returns to scale.

Production Approach (PA) – In this approach banks are mainly considered as producers of deposit accounts and loan services.

User Cost Approach (UCA) – This approach is not related to macroeconomic functions carried out by banks, the net contribution to bank revenue determines the nature of inputs and output.

Scale efficiency – Scale efficiency is defined relative to the form of the locus of technically efficient production plans.

Technical efficiency - Technical efficiency is related to the production of outputs given some inputs: a production plan is technically efficient if there is no way to produce the same output(s) with less input(s) or to produce more output(s) with the same input(s). Technical efficiency considers scale and scope economies.

Value Added Approach (VAA) – This approach is not related to macroeconomic functions carried out by banks, the identification of inputs or outputs is based on the share of value added.