Estimating the Efficiency of the Czech Banking Sector Using Dynamic Data Envelopment Analysis

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Abstract

This paper estimated the efficiency in the Czech banking sector during the period 2001–2011. We applied the Dynamic Data Envelopment Analysis (DEA) on the data of the Czech banks. The results of Dynamic DEA models showed that the average efficiency computed under the assumption of constant returns to scale reached the value 86.7% and the average efficiency estimated under the assumption of variable returns to scale was 95.7%. The efficiency slightly increased in the analyzed period.

Keywords: Efficiency, Dynamic Data Envelopment Analysis, Czech banking sector, commercial banks;

1. Introduction

The Czech financial system can be characterized as bank-based system and banks play an important role in the economy on the side of corporations and business as well as households. The transformation and consolidation of the Czech banking sector was realized during the1990s. In years 1998–2001 the second round of privatization were occurred with the sale to foreigners of majority equity interests in four large Czech banks: Československá obchodní banka (ČSOB), Česká spořitelna (ČS), Komerční banka (KB) and Investiční a poštovní banka (IPB). These Big Three (ČSOB, ČS and KB) are still the dominant players in the market. Their combined market share in terms of assets is about 50% and they have extensive detail branch networks. In years 2000–2011 the number of banks was almost constant. There were several mergers and acquisitions in the Czech banking market during analysed years. The Czech banking sector has almost a stable shareholder structure. The Czech Republic joined the European Union (EU) in 2004. In 2009, the small and open Czech economy was hit hard by the global financial and economic crisis. Thanks to its very strong deposit base and the very small percentage of loans denominated in foreign currency, the banking sector remained stable throughout the global financial crisis.

Empirical analyses of the efficiency in the Czech banking sector exist several. Most of the empirical studies estimated the banking efficiency in 1990s and authors investigated that the private banks were more efficient than state-owned banks, e.g. Taci & Zampieri (1998), Bonin, Hasan & Wachtel (2005), Fries & Taci (2005), Matoušek & Taci (2005) or Weill (2003). Stavárek & Polouček (2004) and Stavárek (2005) found that the Czech banking sector showed itself as the most aligned banking industry among transition countries. Results of Andries & Cocris (2010) showed that the banks in the Czech Republic are inefficient from the perspective of costs. To improve the efficiency banks need to improve the quality of assets owned by improving the lending process and reduce the share of nonperforming loans. However Staněk (2010) found that efficiency of the Czech banking sector has improved in the last ten years. Also Staníčková & Skokan (2012) evaluated the banking sector of the Czech Republic as a highly efficient. Stavárek & Řepková (2012) found that the efficiency increased in the period 2000–2010 and they found that the largest banks perform significantly worse than medium-sized and small banks.

In the Czech Republic there is the lack of studies examining the banking efficiency using Dynamic Data Envelopment Analysis; therefore it offers opportunity for this research. The network structure of Data Envelopment Analysis models was applied on the Czech banks by Jablonský (2012).

The aim of the paper is to estimate the efficiency of the Czech commercial banks during the period 2001–2011. We applied the Dynamic Data Envelopment Analysis (DEA) on the data of the Czech banks. The structure of the

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paper is follow. Next section describes theoretical background of the banking efficiency and presents the dataset used in the empirical part of the paper. Section 3 reveals the estimated results and last section concludes the paper with summary of key findings.

2. Methodology and Data

The Data Envelopment Analysis is a mathematical programming technique that measures the efficiency of a decision-making unit (DMU) relative to other similar DMUs with the simple restriction that all DMUs lie on or below the efficiency frontier (Seiford & Thrall, 1990). The DEA measures the relative efficiency of a homogeneous set of decision-making units in their use of multiple inputs to produce multiple outputs. DEA also identifies, for inefficient DMUs, the sources and level of inefficiency for each of the inputs and outputs (Charnes et al., 1995). The analysis is performed in only one time period, hampering the measurement of efficiency changes when there is more than one time period.

Window analysis and the Malmquist index were the first methods used to verify productivity change over time. However, these models do not capture the effect of carry-over activities (links) between two consecutive time periods. These models have inputs and outputs for each period, but linking activities between the periods are not computed explicitly (Costa, Ramos & Souza, 2012). The Dynamic Data Envelopment Analysis model proposed by Fare & Grosskopf (1996) is the first innovative system that formally addresses the activities in different interconnected time periods. Thus, Dynamic DEA is a new approach which estimates performance of a group of DMUs during several periods of time. The Dynamic DEA model takes into account the internal heterogeneous organizations of DMUs for which divisions are mutually connected by link variables and trade internal products with each other. Additionally, each DMU has carry-over variables that take into account a positive or negative factor in the previous period. This model has the huge advantage of being able to evaluate the policy effect on the individual divisions of each DMU (Kawaguchi, Tone & Tsutsui, 2013).

The CCR (Charnes, Cooper & Rhodes, 1978) model presupposes that there is no significant relationship between the scale of operations and efficiency by assuming constant returns to scale (CRS) and it delivers the overall technical efficiency. The CRS assumption is only justifiable when all DMUs are operating at an optimal scale. However, firms or DMUs in practice might face either economies or diseconomies to scale. Banker, Charnes & Cooper (1984) extended the CCR model by relaxing the CRS assumption. The resulting BCC (Banker, Charnes & Cooper, 1984) model was used to assess the efficiency of DMUs characterized by variable returns to scale (VRS). The VRS assumption provides the measurement of pure technical efficiency (PTE), which is the measurement of technical efficiency devoid of the scale efficiency (SE) effects.

Tone & Tsutsui (2010) pointed out a concept of carry-over. Figure 1 presents the Dynamic DEA model described by Tone & Tsutsui (2010).

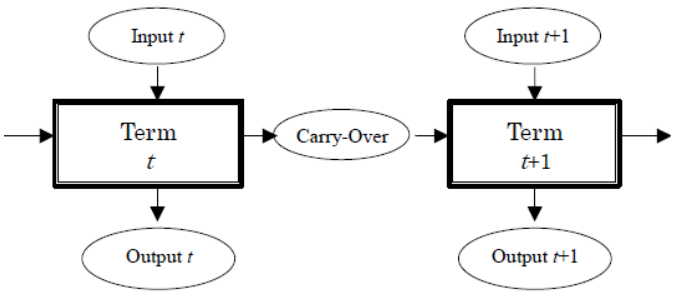

Figure 1. Dynamic DEA model

In this paper we adopted the Dynamic DEA model proposed by Tone & Tsutsui (2010) and Tone (2001). Mathematical formulation of the Dynamic DEA was described e.g. by Lotfi & Poursakhi (2012). We estimated the dynamic model in the slacks-based measure (SBM) framework, called Dynamic SBM (DSBM). The SBM model is non-radial and can deal with inputs/outputs individually, contrary to the radial approaches that assume proportional changes in inputs/outputs.

2.1. Data and selection of variables

The data set used in this paper was obtained from the database BankScope and the annual reports of commercial banks during the period 2001–2011. All the data is reported on unconsolidated basis. We analyzed only commercial banks that are operating as independent legal entities. As we have reliable data extracted directly from annual reports we eliminate the risk that incomplete or biased data may distort the estimation results. One important point is that the calculation of the Dynamic DEA requires strictly balanced panel data. We use panel data of 11 Czech commercial banks (with regard to mergers and acquisitions of banks).

In order to conduct the Dynamic DEA estimation, inputs and outputs need to be defined. Four main approaches have been developed to define the input-output relationship in financial institution behavior (intermediation, production, asset and profit approach). We adopted intermediation approach which assumes that the banks' main aim is to transform liabilities (deposits) into loans (assets). Consistently with this approach, we assume that banks bank collects deposits to transform them, using labor, in loans. We employed two inputs (labor and deposits), and two outputs (loans and net interest income). We measure labor by the total personnel costs covering wages and all associated expenses and deposits by the sum of demand and time deposits from customers, interbank deposits and sources obtained by bonds issued. Loans are measured by the net value of loans to customers and other financial institutions and net interest income (NII) as the difference between interest incomes and interest expenses. Descriptive statistics of inputs and outputs are in Table 1.

Table 1. Descriptive statistics (in CZK mln)

Variable	Deposits	Labor	Loans	NII
Mean	131036.41	1808.24	86920.10	4990.97
Median	45428.2	551.3	32213.6	1332
Max	595092	8525	441587	29460
Min	332.8	20	185.3	32.9
St.Dev.	170844.24	2371.13	104273.75	6793.29

3. Empricial analysis and Results

We adopted Dynamic SBM models that can evaluate the overall efficiency of decision making units for the whole terms as well as the term efficiencies. We used the Dynamic DEA to estimate efficiency under the assumptions of constant and variable returns to scale. For empirical analysis we used MaxDEA software.

The banking efficiency was estimated using the Dynamic DEA models, especially input-oriented model with constant returns to scale and input-oriented model with variable returns to scale. The reason for the using of both techniques is the fact that the assumption of constant returns of scale is accepted only in the event that all production units are operating at optimum size. This assumption, however, in practice it is impossible to fill, so in order to solve this problem we calculate also with variable returns of scale. One important point is that the calculation of the Dynamic DEA requires strictly balanced panel data. We use panel data of 11 Czech commercial banks (with regard to mergers and acquisitions of banks). The results of the Dynamic DEA efficiency scores are presented in Table 2.

Table 2. Efficiency in the Czech banking sector

	CRS	Inefficiency	VRS	Inefficiency
2001	0.8644	0.1356	0.9556	0.0444
2002	0.8983	0.1017	0.9837	0.0163
2003	0.8924	0.1076	0.9725	0.0275
2004	0.8744	0.1256	0.9414	0.0586
2005	0.8002	0.1998	0.8985	0.1015
2006	0.8543	0.1457	0.9353	0.0647
2007	0.8549	0.1451	0.9809	0.0191
2008	0.8651	0.1349	0.9758	0.0242
2009	0.9158	0.0842	0.9628	0.0372
2010	0.8580	0.1420	0.9520	0.0480
2011	0.8574	0.1426	0.9691	0.0309
Mean	0.8668	0.1332	0.9571	0.0429

During the period 2001–2011, the average efficiency calculated using the CRS ranges from 80 to 92% and the average efficiency computed using the VRS ranges from 90 to 98%. It shows that the Czech banks are in average considered to be efficient with only marginal changes over time. The average efficiency calculated under the assumptions of constant returns to scale reach the value of 87% and the average efficiency computed under the assumptions of variable returns to scale was 96%. The results of the CCR model and the BCC model show that the model with VRS achieves higher degree of the efficiency than the model with the CRS by eliminating the part of the inefficiency that is caused by a lack of size of production units. The average inefficiency of the Czech banking sector in CCR model was 13% and the average inefficiency in BCC model reached 4%. The reason of the inefficiency of the Czech banks is mainly an excess of client deposits in balance sheet of banks.

The development of the average efficiency show that the efficiency score was increasing in the period 2001–2003. In the period 1999–2001, large Czech banks were privatized and the new owners and managers probably learnt to adapt in the new environment. Reflection of this process is the gradual increase of the efficiency in the Czech banking sector. The average efficiency decreased in 2005. This decrease was influenced by decreasing of loans and net interest income in ČSOB, Banco Popolare (in 2005 called IC bank) or LBBW (in 2005 it was BAWAG bank). It was probably caused by reason that CNB increased the basic interest rate in 2005. During the period 2006–2009 the efficiency of the Czech banking sector was increasing. The structure of the financial market was stabilized. In 2010 the average efficiency decreased, we can suppose that this development was as a result of the

financial crisis. Because the analyzed outputs (loans and net interest income) decreased in the balance sheet of individual banks.

Table 3. Efficiency of the Czech commercial banks

DMU	Technical Efficiency Score (CRS)	Pure Technical Efficiency Score (VRS)	Scale Efficiency Score
CS	0.7842	1.0000	0.7842
CSOB	0.6633	0.8625	0.7691
GE MONEY	0.9850	0.9953	0.9897
JT BANK	0.9166	0.9610	0.9538
KB	0.7601	0.9798	0.7758
LBBW	0.8847	0.9001	0.9830
POPO	0.8742	1.0000	0.8742
PPF	0.8978	0.9194	0.9765
RB	0.8333	0.9110	0.9147
UNICREDIT	0.9373	1.0000	0.9373
VOLKSBANK	0.9983	0.9984	0.9999
Mean	0.8668	0.9571	0.9053

The efficiency of individual banks, especially technical efficiency, pure technical efficiency and scale efficiency, is shown in Table 3. The highest value of the average efficiency achieved Volksbank and GE Money Bank. The lowest efficient banks in CCR model were ČSOB, Komerční banka and Česká spořitelna. The lowest values of the scale efficiency reached also these three banks. These mentioned banks are in the group of the largest bank of the national banking sector. Thus, largest banks were the least efficient in the analyzed period. These large banks reached higher value in BCC model, thus large banks in the market are too large and they improperly chosen their size (range of operation). Česká spořitelna achieved 100% in BCC model. Also Banco Popolare and UniCredit bank was 100% efficient under the assumptions of variable returns to scale.

4. Conclusion

The aim of the paper was to estimate the efficiency of the Czech commercial banks during the period 2001–2011. We applied the Dynamic Data Envelopment Analysis on the data of the Czech commercial banks. We estimated efficiency under the assumptions of constant and variable returns to scale. In the analyzed period, the average efficiency calculated using the constant returns to scale ranged from 80 to 92% and the average efficiency computed using the variable returns to scale ranged from 90 to 98%. The average inefficiency of the Czech banking sector in CCR model was 13% and the average inefficiency in BCC model reached 4%. The reason of the inefficiency of the Czech banks was mainly an excess of client deposits in balance sheet of banks. We found that the efficiency score was increasing in the period 2001–2003. This increase was probably caused by better management in privatized banks. In 2005 the average efficiency decreased. It was influenced by decreasing of loans and net interest income in several banks, what was probably caused by reason that CNB increased the basic interest rate in 2005. During the period 2006–2009 the efficiency of the Czech banking sector was increasing and the structure of the financial market was stabilized. In 2010 and 2011 the average efficiency decreased what was caused by the financial crisis.

We found that the highest value of the average efficiency achieved Volksbank and GE Money Bank. In contrast, the lowest efficient bank in CCR model was ČSOB, Komerční banka and Česká spořitelna. These banks, which are three largest banks in the Czech banking sector, reached the lowest values of the scale efficiency. Thus, largest banks are the least efficient in the Czech banking industry. These large banks reached higher value in BCC model, large banks are too large and they improperly chosen their size (range of operation).

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