WORKING PAPER SERIES

Efficiency and Its Impact on the Performance of European Commercial Banks

Mohsen Afsharian/Anna Kryvko/Peter Reichling

Working Paper No. 18/2011

OTTO VON GUERICKE
UNIVERSITÄT
MAGDEBURG

FACULTY OF ECONOMICS
AND MANAGEMENT

Impressum (§ 5 TMG)

Herausgeber:

Otto-von-Guericke-Universität Magdeburg
Fakultät für Wirtschaftswissenschaft
Der Dekan

Verantwortlich für diese Ausgabe:

Mohsen Afsharian, Anna Kryvko, Peter Reichling
Otto-von-Guericke-Universität Magdeburg
Fakultät für Wirtschaftswissenschaft
Postfach 4120
39016 Magdeburg
Germany

http://www.fww.ovgu.de/femm

Bezug über den Herausgeber

ISSN 1615-4274

Efficiency and Its Impact on the Performance of European Commercial Banks

Mohsen Afsharian* **Anna Kryvko*** **Peter Reichling***

August 2011

Abstract

The paper empirically analyzes the impact of the degree of efficiency on key performance figures of publicly traded European banks in the period from 2005 to 2009. Efficiency is measured by constructing non-parametric frontiers using the technique of data envelopment analysis on the cost, revenue, and profit sides. Decomposition of overall efficiency provides a detailed insight into effective risk and performance drivers in the banking industry. The results of our paper suggest that an increase in pure technical efficiency is related to more volatile assets, which is reflected in lower market values. Allocative and scale efficiency, however, boost capital market performance.

Keywords

Data Envelopment Analysis (DEA), Efficiency, European Banks, Bank Performance

JEL classification

C33, C61, D24, G21

* All authors are from Otto-von-Guericke University Magdeburg, Faculty of Economics and Management; corresponding author: Anna Kryvko, Otto-von-Guericke University Magdeburg, Faculty of Economics and Management, Department of Banking and Finance, Postfach 4120, 39106 Magdeburg, Germany, e-mail Anna.Kryvko@OvGU.de, phone +49.391. 67.18446.

1. Introduction

The financial crisis of 2008 substantiated the crucial role of banking stability for the economy. Globalization and increased competition drive higher efficiency in the financial industry. Despite of all improvements, efficiency progress, and strict regulations, a stable risk-return position of banks can unexpected easily be impaired. This fact motivated empirical work in recent years to assess performance and risk indicators in the banking industry.

The first group of studies (Short (1979), Bourke (1989), Molyneux/Thornton (1992), Bikker/Hu (2002), and Athanasoglou/Brissimis/Delis (2008)) analyzes the impact of bank-specific (capital, liquidity, and assets), industry-specific (market share, concentration, and economies of scale) and macroeconomic (inflation, business cycle, and money supply) determinants of bank profitability. Another group of papers concentrates on the relation between activity diversification, market valuation, and risk level of banks (Stiroh/Rumble (2006), Laeven/Levine (2007), and Elsas/Hackethal/Holzhäuser (2010)). Another important direction of empirical investigations concerns the influence of ownership structure, ownership concentration, and board structure on profitability, valuation, and risk-taking behaviour of financial institutions (Iannotta/Nocera/Sironi (2007), Caprio/Laeven/Levine (2007), Laeven/Levine (2009), Pathan (2009), and Barry/Lepetit/Tarazi (2011)).

A new aspect of research is dedicated to efficiency measurement and its influence on performance of banks. Empirical investigations use two main methodologies to estimate efficiency of banks: Stochastic Frontier Approach (SFA) and Data Envelopment Analysis (DEA). The study of Beccalli/Casu/Girardone (2006) is linked to the relevance of cost efficiency for stock performance of European listed banks. They find that stocks of efficient banks tend to outperform inefficient financial institutions, since changes in efficiency are reflected in stock prices. Applying both DEA and SFA for efficiency estimation, the analysis shows higher explanatory power of DEA-based efficiency scores compared to SFA-based scores. Besides, the authors find irrelevance of the cost to income ratio, as a traditional proxy for cost efficiency, in explaining stock prices.

The studies of Fiordelisi (2007), Fiordelisi/Molyneux (2010a), and Fiordelisi/Molyneux (2010b) show a positive impact of efficiency on value creation in European banks, where value is created in case that operating earnings exceed cost of invested capital. Fiordelisi/Molyneux (2010a) estimate positive influence of cost, revenue, profit and shareholder efficiency on shareholder value of listed and unlisted banks. Shareholder efficiency was introduced by Fiordelisi (2007). It indicates the ability to produce the maximum possible shareholder value with a certain quantity of inputs and outputs. Compared to cost and profit efficiency, shareholder efficiency shows higher explanatory power for economic value added (EVA). Fiordelisi/Molyneux (2010a) concentrate not only on efficiency parameters, but also simultaneously investigate bank-specific, industry-specific and macroeconomic determinants of value creation.

Assessing shareholder value creation, EVA is divided into two main components, i.e. economic profit and cost of capital, in order to identify the form of efficiency influence on EVA. The results show that revenue efficiency increases economic profit, whereas cost efficiency reduces cost of capital. Using DEA, Fiordelisi/Molyneux (2010b) decompose cost efficiency and total factor productivity into their main components. Focusing on several European countries, the authors analyze whether efficiency components are relevant for shareholder value. Their results show that all components possess power in explaining bank performance. However, total factor productivity exhibits the highest information content among all assessed factors.

The studies of Berger/DeYoung (1997), Kwan/Eisenbeis (1997), Altunbas et al. (2007), Koutsomanoli-Filippaki/Mamatzakis (2009), and Fiordelisi/Marques-Ibanez/Molyneux (2011) examine the link between efficiency and risk-taking behavior of banks. The first three mentioned studies assess the relation between efficiency and asset quality of banks estimated by problem loans (Berger/DeYoung (1997)), past-due and non-accrual loans (Kwan/Eisenbeis (1997)), and loan-loss reserves (Altunbas et al. (2007)). Berger/DeYoung (1997) find inverse Granger-causality between cost efficiency and non-performing loans. However, among highly efficient banks, an increase in cost efficiency tends to be followed by an increase in non-performing loans, indicating a short-term operating cost reduction at the expense of long-run loan quality. Kwan/Eisenbeis (1997) confirm a positive relation between inefficiency and risk, taking into account not only credit risk but also interest risk. The results of Altunbas et al. (2007) show that only least efficient banks take less risk with decreasing cost efficiency. Their efficient counterparts appear to take more risk. The empirical work of Koutsomanoli-Filippaki/Mamatzakis (2009) and Fiordelisi/Marques-Ibanez/Molyneux (2011) assesses influence of efficiency on bank default risk measured by Merton's (1974) model.[1] This forward-looking measure reflects market information in terms of stock prices, volatility, and leverage (Koutsomanoli-Filippaki/Mamatzakis (2009)). The last-mentioned studies find an inverse relation between efficiency and default risk of banks.

Most studies focus, however, on influences of cost, revenue and profit efficiency. Decomposing these efficiencies in their components allows a detailed analysis of value and risk drivers in the banking industry. However, this approach is rare in empirical literature. Therefore in our paper, a detailed insight of efficiency impact on risk and performance of European commercial banks is presented. Efficiency is measured by constructing non-parametric frontiers using DEA on the cost, revenue and profit sides. In this framework, we measure overall, allocative, technical, pure technical and scale efficiency. In contrast to most previous studies, we apply both production and intermediation models to determine efficiency. We assess efficiency scores obtained by these models and compare their influence on performance and risk of banks.

Additionally, the Malmquist index and its components are computed to provide a clearer picture of the basic sources of productivity change over time. To guarantee the quality of our analysis, the required financial data is mostly hand-collected directly from the banks' financial statements. To eliminate differences in accounting standards, annual financial statements reported under IFRS were considered. Applying several market-oriented and accounting-based performance and risk measures increases the likelihood to capture important influencing factors.

Our paper contributes to the literature in several ways. At first, production and intermediation approaches of efficiency determination are compared in explaining return-risk positions of banks. Secondly, decomposition of efficiencies into their components shows how managers' abilities are reflected in capital market performance of banks. Thirdly, not only popular shareholder value creation based on accounting figures is considered, but also capital market value creation is assessed. Fourthly in the robustness check, we not only use loan loss provisions as a popular accounting-based risk measure, but also realized losses on loans in form of direct write-downs and/or utilization of corresponding provisions. Finally, hand-collected financial data guarantees the quality of accounting figures used for the analysis.

[1] Fiordelisi/Marques-Ibanez/Molyneux (2011) use expected default frequency (EDF) based on a commercial implementation of Merton's model by Moody's KMV.

The remainder of the paper is organized as follows: Section 2 describes efficiency, risk and performance variables used in the study. Compiling all relevant input and output factors and their corresponding prices for efficiency estimation, the characteristics of the banking industry are presented. Data and summary statistics are described in Section 3. Empirical model specifications and regression results are provided in Section 4. Section 5 concludes.

2. Definition of Variables

2.1 Efficiency and Productivity Change

DEA is commonly used to analyze various notions of relative efficiency such as cost, revenue and profit efficiency of similar (homogenous) organizational units, so-called decision-making units (DMUs), in terms of utilization of inputs in generating outputs. The DEA approach is based on Farrell (1957) and on extensions of his work by Charnes/Cooper/Rhodes (1978) and Banker/Charnes/Cooper (1984), who introduced a non-parametric framework to measure and compare DMUs' relative efficiency. Since then, DEA has developed in many directions and applications, as summarized by Emrouznejad/Parker/Tavares (2008) who cite almost four thousand publications. DEA is also widespread applied in the banking industry. Berger/Humphrey (1997) and Fethi/Pasiouras (2010) present a review of numerous studies, which assess bank performance with DEA techniques.

DEA allows estimating cost, revenue and profit efficiency, total factor productivity changes, and their components. Decomposition of efficiency into components gives the opportunity for a detailed analysis of performance and risk drivers of banks. Cost efficiency reflects the managers' ability to minimize cost given a certain level of outputs. Cost efficiency is the product of technical and allocative efficiency, where technical efficiency comprises scale and pure technical efficiency. Technical efficiency evaluates the way of using inputs to produce a number of outputs. Pure technical efficiency determines technical efficiency exclusive scale effects (using variable returns to scale). It reflects the pure ability of managers to organize the optimal utilization of resources.[2]

[2] See Kumar/Gulati (2008). Figure 1 in Section 3 provides an overview of efficiency terms and efficiency components.

Scale efficiency measures the ability of managers to choose the optimum size of a bank to generate a certain production level. In case of decreasing returns to scale, a bank is too large to obtain advantages from scale. If a bank operates with increasing returns to scale, the size of the bank is too small for its scale of operations. Constant returns to scale indicate scale efficiency of a bank.[3] In case of cost efficiency, pure technical efficiency with input orientation reflects the ability to produce a given level of outputs with the minimum quantity of inputs. Here, scale efficiency describes the ability to choose the optimum input size. Allocative efficiency reflects a cost-efficient mix of inputs given their prices.

Revenue efficiency indicates whether a bank achieves the maximum level of revenue using a given quantity of inputs. Revenue efficiency also comprises technical efficiency and allocative efficiency – now with output orientation–, where, again, technical efficiency is the product of pure technical and scale efficiency. Here, pure technical efficiency mirrors the ability to produce the maximum level of outputs with a given quantity of inputs. The ability to choose the optimal output size is measured by scale efficiency, whereas the ability to manage the optimal production mix regarding its prices is reflected by allocative efficiency. Profit efficiency considers both cost minimization and revenue maximization.

The Malmquist productivity index measures total factor productivity changes over time. The Malmquist index can be decomposed into technological change, representing a shift in the efficient frontier, and technical efficiency change. The latter represents the product of pure technical efficiency change and scale efficiency change, which measure managerial effort and scale improvements between periods, respectively.

In order to estimate efficiency, input and output factors of banks' activities must be determined. Two popular models are specified in the literature to evaluate the banking industry: the production and the intermediation approach.[4] Within the production model, banks are considered as operating units that use labor, capital, and other resources to provide their products and services. Therefore, number of employees and fixed assets are used as input factors. In contrast to production companies, fixed assets in banking are of minor importance. However, software plays an important role in banking. Thus, the value of fixed assets is extended by the value of software in our study.

---

[3] See loc.cit.

[4] See Asmild et al. (2004).

As invested capital, equity and securitized financial liabilities are taken into consideration. Equity is an important factor in banking, since, according to the Basel accords, equity limits the volume of risky activities of banks. Furthermore, securitized financial liabilities are considered as invested debt capital. With these input factors (resources) banks provide loans to the public, corporate customers, other banks etc. They invest in securitized financial assets and manage deposits of both banks and customers. Banks also offer services that are linked to the fee and commission income. Thus, loans, securitized financial assets, deposits, and net commission income are used as output factors in the production model.

The intermediation approach treats banks as financial intermediaries, which collect their monetary funds from savers and investors and transpose these funds into further investments. In this approach, equity, securitized financial liabilities, and deposits characterize the input factors of banks. Outputs are loans, securitized financial assets, and net commission income. Thus, deposits are considered as output in the production model and as input in the intermediation model (see Table 1). According to Berger/Humphrey (1997), neither of these two approaches of efficiency determination is perfect, since both models do not fully capture the dual role of financial institutions as producing services and being financial intermediaries. Thus, we employ both models to compare the results regarding the respective influencing factors on banks' performance and risk.

In order to assess cost, revenue and profit efficiency, the prices of inputs and outputs are needed. The price for a unit of labor is calculated as total personnel expenses divided by the yearly average number of employees. The costs of fixed assets are computed as depreciations plus interest payments assuming debt-financed fixed assets. Here, the value of software and corresponding depreciations are also taken into account. The required return on equity determines the cost of equity and is estimated with the capital asset pricing model (CAPM). The prices for financial liabilities, financial assets, deposits, and loans are calculated by the ratio of the respective income or expense position over the value of the corresponding input or output factor. The net commission price per unit is determined as net commission income over the yearly average number of employees (see, again, Table 1).

	Production model	Intermediation model
Inputs	• Number of employees • Fixed assets • Equity • Financial liabilities	• Equity • Financial liabilities • Deposits
Outputs	• Loans • Financial assets • Deposits • Net commission income	• Loans • Financial assets • Net commission income
Prices	• Employees: $\frac{\text{Personnel Expenses}}{\text{Number of employees}}$ • Fixed assets: $\frac{\text{Depreciations} + \text{Interest Rate} \times \text{Fixed assets}}{\text{Fixed assets}}$ • Equity: Required return of equity holders • Financial liabilities: $\frac{\text{Interest expenses on financial liabilities}}{\text{Financial liabilities}}$ • Loans: $\frac{\text{Interest income on loans}}{\text{Loans}}$ • Deposits: $\frac{\text{Interest expenses on deposits}}{\text{Deposits}}$ • Financial assets: $\frac{\text{Interest income on financial assets}}{\text{Financial assets}}$ • Net commission income: $\frac{\text{Net commission income}}{\text{Number of employees}}$	

Table 1: Input and output factors of the production and the intermediation model

2.2 Performance Measures

Stock performance, Tobin's *q*, market-to-book ratio, and shareholder value created are used to measure performance of banks in the following. We examine market-oriented as well as accounting-based measures. Stock performance, measured by the average return ($\overline{R}$) of a company's stock, reflects market information. Tobin's *q* and market-to-book ratio include both market and accounting data. Analyzing shareholder value created, we calculate accounting-based residual income and additionally measure shareholder value added (Jensen's alpha) using market information.

Brainard/Tobin (1968) introduced a basic macroeconomic concept of investment behavior. Investments are encouraged if the market value of invested capital is higher than its replacement costs. In companies, replacement costs represent all costs that are needed to cover all items on the firm's balance sheet. The ratio of market value to replacement costs (Tobin's q) exceeds unity, if the internal rate of return of the investment is greater than cost of capital. This condition boosts the value and reflects the performance of the firm. A higher Tobin's q can result from higher returns to scale or from investment risk reduction caused by a superior risk-return trade off.[5] In order to measure Tobin's q, replacement costs of assets are approximated with the book value of assets. The market value of assets is equal to the sum of equity market value and book value of total liabilities:

$$(1) \qquad q = \frac{\text{Market value of assets}}{\text{Replacement costs of assets}} = \frac{\text{Market value of equity} + \text{Book value of liabilities}}{\text{Book value of assets}}$$

Additionally, focusing on direct equity valuation, market value over book value of equity (M/B) is also used in the following.

The aforementioned measures do not explicitly take cost of capital into consideration. According to the EVA model, value is created in a company only if operating earnings exceed cost of invested capital.[6] Since managing deposits or selling debt instruments represent a core activity of a bank, interest expenses belong to operating expenses in banking. Due to this financial institution specific, profits before interest expenses do not lead to economically meaningful interpretations. Subtracting interest expenses from operating profits leads to an equity valuation framework. On this basis, equity-oriented EVA is determined as excess income over capital charges on equity (residual income (RI)):

$$(2) \qquad \text{RI}_t = \text{NI}_t - r_{E,t} \cdot B_{t-1}$$

where	NI	=	Net income
	B	=	Book value of equity
	r_E	=	Cost of equity (E)
	t	=	Year 2004,…,2009

5 See Tobin (1969 and 1978) and Tobin/Brainard (1977).
6 See Stewart (2008), p. 224.

In order to avoid possible accounting distortions, adjustments concerning loan loss provisions and deferred taxes are made to net income and book value of equity in this study. These adjustments lead to adjusted residual incomes (RI^{adj}).[7]

Cost of equity can be estimated by the CAPM, where the expected return ($E(R_i)$) of security *i* depends on its level of systematic risk measured by the beta coefficient:[8]

$$(3) \qquad E(R_i) = r_f + \beta_i \cdot \left(E(R_M) - r_f \right)$$

where r_f = Risk-free return

β_i = Beta coefficient of security *i*

$E(R_M)$ = Expected return of the market portfolio

The difference between expected return of the market portfolio and risk-free return equals the market risk premium. The beta coefficient represents the coefficient of a linear regression of excess security on excess market return. We estimated the long-run market risk premium based on the average return of the Euro Stoxx 50 minus the average one-month Euribor from 1986 till 2006. The financial crisis time period is excluded from the market risk premium estimation, since capital markets then went down sharply resulting in a temporary negative risk premium. Beta coefficients (with respect to the Euro Stoxx 50) were taken from the Bankscope database for the year 2010 due to a stabilized stock price development during that year. Missing beta coefficients in the Bankscope database were self-calculated. Due to data limitations, we assume that our estimated beta coefficients are good proxies for systematic risk calculations.

The estimated risk premium for every single bank (market risk premium multiplied by the bank's beta coefficient) is assumed to stay constant. Though, the interest level, approximated by one-year Euribor, is taken into account to meet particularities in bank valuation. The interest level changes cost of equity year by year:

$$(4) \qquad E(r_{E,t}) = \text{1-Year Euribor}_t + \beta_i \cdot \left(E(R_M) - r_f \right)$$

---

[7] Details are given in the appendix.

[8] See Sharpe (1964).

Value creation measured by EVA concentrates on accounting figures. Fernandez (2002) introduced a market-oriented determination of shareholder value created. A company creates value if shareholder value added exceeds the required return on equity measured in market values.[9] Shareholder value added is defined as an increase in wealth of shareholders during the given period. This increase is not only provided by a positive difference of market price of equity, but also by dividends and other payments to shareholders. Assuming that adjusted shares prices (P^{adj}) reflect all capital yields and presenting created shareholder value in relative terms lead to:

$$\text{(5)} \qquad \frac{\text{Shareholder value created}_t}{P_{t-1}^{\text{adj}}} = \frac{P_t^{\text{adj}} - P_{t-1}^{\text{adj}}}{P_{t-1}^{\text{adj}}} - r_{E,t} = R_t^{\text{adj}} - r_{E,t}$$

The difference between rate of return and cost of equity, estimated by the CAPM, is known as Jensen's alpha (α).[10]

2.3 Risk Measures

Also in measuring risk of banks, both market-oriented (volatility and probability of default) and accounting-based (Z-score and loan loss provisions) measures are used. At first, we estimate volatility of stock returns (σ) based on monthly stock price data. After that, we concentrate on Z-score that measures distance to default. Here, we calculate different Z-scores using either accounting data or market prices. Subsequently, we describe probability of default based on Merton's model. We additionally use loan loss provisions as banks' internal credit risk estimations.

The Z-score,[11] as a popular risk measure associated with banks' probability of failure, is widely spread in empirical banking literature.[12] Defining insolvency as state in which losses (negative profits π) exceed equity ($E < -\pi$), probability of default can be expressed as:

---

9 See Fernandez (2002), p. 9.

10 See Jensen (1968).

11 This measure should not be confused with the Z-score, developed by Altman (1968). Altman's Z-score aggregates financial ratios of a linear discriminant function, which assesses bankruptcy potential of a company.

12 See, e.g., Bannier/Behr/Güttler (2010), Barry/Lepetit/Tarazi (2011), Boyd/Graham/Hewitt (1993), Foos/Norden/Weber (2010), Houston et al. (2010), Laeven/Levine (2009), and Lepetit et al. (2008).

$$\text{(6)} \qquad \Pr\text{ob}(\pi \leq -E) = \text{Prob}\left(\frac{\pi}{A} \leq -\frac{E}{A}\right) = \text{Prob}\left(\text{ROA} \leq -\frac{E}{A}\right)$$

where *A* and ROA denote assets and return on assets, respectively. Assuming normally distributed returns on assets, probability of default reads as follows:[13]

$$\text{(7)} \qquad \text{Prob}\left(\text{ROA} \leq -\frac{E}{A}\right) = \text{N}(-z)$$

$$\text{where} \qquad z = \frac{\frac{E}{A} + \mu_{\text{ROA}}}{\sigma_{\text{ROA}}}$$

$$\text{N(.)} = \text{Standard normal distribution}$$

The Z-score specifies the number of standard deviations of return on assets below its expected value so that equity is just absorbed, resulting in bankruptcy of the bank.[14] Z-score, as a measure of distance to default, shows a higher value in case of a lower probability of default. We calculate Z-scores using accounting data for net income, equity, and value of assets. In order to estimate mean and standard deviation of return on assets (μ_{ROA} and σ_{ROA}), we use the time period from 2004 till 2009. Following Laeven/Levine (2009) due to high skewness of the Z-score, a log-transformed Z-score is used for the regressions in Section 3.

Additionally, we determine market-oriented Z-scores (z^{M}) following Boyd/Graham/Hewitt (1993) and Ianotta/Nocera/Sironi (2007). Here, mean and standard deviation of return on assets are estimated based on monthly stock price data. The market-oriented return on assets (ROA^{M}) is computed as market profit over value of assets per share:

$$\text{(8)} \qquad \text{ROA}_t^{\text{M}} = \frac{P_t^{\text{adj}} - P_{t-1}^{\text{adj}}}{P_t^{\text{adj}} + \frac{D_t}{n_t}}$$

where *D* denotes book value of liabilities and *n* is the number of shares outstanding. The market equity-to-assets ratio – additionally needed to compute z^{M} according to formula (7) – is computed as follows:

---

13 See Boyd/Graham/Hewitt (1993).

14 See Boyd/Graham (1988), Boyd/Graham/Hewitt (1993), and Hannan/Hanweck (1988).

$$(9)\qquad \left(\frac{E}{A}\right)_t^{\mathrm{M}} = \frac{P_t^{\mathrm{adj}}}{P_t^{\mathrm{adj}} + \dfrac{D_t}{n_t}}$$

Availability of monthly data for debt book values and number of shares outstanding limits the computation of market-oriented Z-scores. Therefore, our calculations assume constant figures during the year. During the financial crisis, historical data led to deep negative estimated annual returns on assets. In these cases Z-scores became negative, so that a log-transformation was impossible. Hence, we calculated z^{M} based on monthly data.

Probability of default as an alternative measure of risk is derived from Merton's (1974) debt pricing model. According to the basic form of this model, a company defaults if the value of its assets (V_T) is less than the face value of a zero bond (D) on debt maturity date (T) – representing the entire liabilities of the regarded company. Under the assumption that the value of assets follows a geometric Brownian motion and applying Ito's Lemma, the probability of default (PD) is given by:

$$(10)\qquad \mathrm{PD} = \mathrm{Prob}(V_T < D) = \mathrm{Prob}(\ln V_T < \ln D) = \mathrm{N}\left(-\frac{\ln \dfrac{V_0}{D} + \left(\mu_V - \dfrac{\sigma_V^2}{2}\right)\cdot T}{\sigma_V \cdot \sqrt{T}} \right)$$

where a one-year period for the time to maturity is used in our calculations.[15] Market value of assets (V_0) and volatility of assets (σ_V) are estimated by simultaneously solving equations for equity value and asset volatility:[16]

$$(11)\qquad E = V_0 \cdot \mathrm{N}(d_1) - D \cdot e^{-r_f \cdot T} \cdot \mathrm{N}(d_2) \quad \text{and} \quad \sigma_V = \sigma \cdot \frac{E}{V_0} \cdot \frac{1}{\mathrm{N}(d_1)}$$

---

15 This simplification can be justified by large portions of demand deposits and savings on the liabilities side of banks, which are payable on a daily basis or on short-term notice. Therefore, these deposits compensate long-term deposits. Our assumptions corresponds to the common default forecasting horizon of one year; see, e.g., Bharath/Shumway (2008).

16 For this approach see, e.g., Bharath/Shumway (2008).

$$\text{where} \quad d_1 = \frac{\ln\left(\frac{V_0}{D}\right) + \left(r_f + \frac{\sigma_V^2}{2}\right)\cdot T}{\sigma_V \cdot \sqrt{T}}$$

$$d_2 = d_1 - \sigma_V \cdot \sqrt{T}$$

One-year Euribor is used as a proxy for the risk-free return (r_f) and σ denotes stock price volatility. The face value of debt is approximated by its book value. The expected return on assets μ_V is determined using the leverage formula:[17]

$$(12) \quad r_E = \mu_V + \frac{D}{E}\cdot(\mu_V - r_D) \Rightarrow \mu_V = \frac{r_E + \frac{D}{E}\cdot r_D}{1+\frac{D}{E}}$$

Cost of equity (r_E) is calculated applying the CAPM. Cost of debt (r_D) is determined as interest expenses divided by total interest bearing debt.

Loan loss provisions divided by total loans are used as an additional measure of credit risk. These provisions reflect expected future losses, which occur due to default risk in the lending business. The value of this position is generally determined as the difference between the carrying value (book value) of an asset and the present value of the expected future repayments from the borrower. Estimation of payment failure can be based on historical loss experience, solvency of debtor or industry, and market development. Latitude in the estimation of future credit risk allows banks to manipulate loan loss provisions. Therefore, realized loan losses are also used for a robustness check of the results. Realized losses are determined by direct loan write-downs and/or utilization of provisions. Here, we also take recoveries on already written-off claims into consideration.

An overview of the described performance and risk measures is presented in Table 2. These measures are used as dependent variables in the subsequent regression analysis. This allows estimation and comparison of efficiency impact on market-oriented and accounting-based banks' performance and risk measures.

---

[17] Note that N($-d_2$) using the notation of formula (10) represents the so-called risk-neutral PD. To receive the actual PD in formula (10), the corresponding distribution function hast to be shifted from mean r_f to mean μ_V. This is done by the help of the leverage effect to estimate μ_V based on observable cost of equity.

Performance		Risk	
Market-oriented			
$\overline{R}$	Average stock return	σ	Volatility of stock returns
α	Jensen's alpha	PD	Probability of default
q	Tobin's q	z^{M}	Market-oriented Z-score
M/B	Market-to-book ratio		
Accounting-based			
RI^{adj}	Adjusted residual income over adjusted book value of equity	z	Accounting-based Z-score
		LLP	Loan loss provisions over total loans

Table 2: Overview of performance and risk measures

3. Data and Summary Statistics

The empirical investigations of our paper focus on publicly traded commercial banks from 27 European countries between 2004 and 2009. To guarantee the quality of the analysis, the required financial data was mostly hand-collected directly from the banks' financial statements. To eliminate differences in accounting standards, annual financial statements reported under IFRS were considered. Thus, only listed banks were involved in the study, which have disclosed their annual reports under IFRS at least since 2005. Since the sample consists of group financial companies, consolidated financial statements were used.

Market information was taken from the Bankscope database. Missing stock prices were obtained from the respective stock exchanges. Insufficient financial statement and market information narrowed the sample to 444 observations (74 observations per year). The data comprises 24 countries of the European Union plus Switzerland, Liechtenstein, and Norway.

Summary statistics for performance and risk measures are reported in Table 3. The financial crisis between 2007 and 2008 is associated with performance deterioration, where a sharp decline in performance was observed in 2008. In the year 2009, banks on average show increasing performance compared to the previous year. Annual return and Tobin's q reflect a positive trend between 2004 and 2006. Taking cost of capital into consideration, residual income and Jensen's alpha showed performance reductions already in 2006.

Volatility shows an increasing trend over the sample period. Probability of default also increases during the period of examination. Z-scores, however, reflect higher risk during the years 2007 and 2008, but risk decreases in 2009 according to this measure. Increased risk during the crisis, displayed by the market-oriented Z-score, is much higher then reported by the accounting-oriented Z-score.

Year			2004	2005	2006	2007	2008	2009
Performance	Market-oriented	$\overline{R}$	0.17	0.26	0.28	–0.07	–0.52	0.67
		α	0.11	0.20	0.19	–0.15	–0.59	0.62
		q	1.07	1.09	1.16	1.14	1.00	1.01
		M/B	2.05	2.31	2.87	2.62	0.96	1.13
	Acc.-based	RI^{adj}	—	0.09	0.08	0.08	0.05	0.08
Risk	Market-oriented	σ	0.17	0.25	0.24	0.24	0.44	0.63
		PD [%]	0.01	0.09	0.11	2.36	3.93	7.24
		z^M	28.44	25.63	18.43	17.85	10.06	10.69
	Accounting-based	z	26.16	26.35	25.89	25.38	23.53	27.66
		LLP	0.01	0.03	0.02	0.02	0.02	0.03

Table 3: Cross-sectional average performance and risk figures for the period 2004–2009

In the following, we analyze the influence of efficiency on risk and performance of banks. Therefore, cost, revenue and profit efficiency (CE, RE, and PE) are dependent variables in the analysis. To assess the drivers of banks' performance and risk, corresponding measures are regressed on overall efficiencies and their components. Cost efficiency (CE) is decomposed into technical efficiency (TE) and input-oriented allocative efficiency (IAE). The former consists of input-oriented pure technical efficiency (IPTE) and input-oriented scale efficiency (ISE). Similarly, revenue efficiency (RE) is decomposed into output-oriented allocative efficiency (OAE), output-oriented pure technical efficiency (OPTE), and output-oriented scale efficiency (OSE). Overall efficiencies and their components applied in this study are summarized in Figure 1.

CE (cost efficiency) = TE × IAE

- **TE** (technical efficiency) = ISE × IPTE
  - **ISE** (input-oriented scale efficiency)
  - **IPTE** (input-oriented pure technical efficiency)
- **IAE** (input-oriented allocative efficiency)

RE (revenue efficiency) = TE × OAE

- **TE** (technical efficiency) = OSE × OPTE
  - **OSE** (output-oriented scale efficiency)
  - **OPTE** (output-oriented pure technical efficiency)
- **OAE** (output-oriented allocative efficiency)

PE (profit efficiency)

MI (Malmquist index) = TEC × TC

- **TEC** (technical efficiency change) = SEC × PTEC
  - **(I/O)SEC** (input/output-oriented scale efficiency change)
  - **(I/O)PTEC** (input/output-oriented pure technical efficiency change)
- **TC** (technological change)

Figure 1: Overview of efficiency terms and efficiency change measures[18]

Cross-sectional average values of efficiency scores according to the production and intermediation models are presented in Tables 4 and 5, respectively. The production model (see Table 4) shows that the analyzed European banks experienced a decreasing trend in cost, revenue and profit efficiency from 2004 to 2008. The intermediation model (see Table 5) shows different results. Here, efficiency scores decreased gradually in 2005 and subsequently increased before falling back by the end of the observation period.

[18] For the decomposition of efficiency measures see Cooper/Seiford/Tone (2007), pp. 258–272; for the decomposition of the Malmqist index in the DEA framework see Färe et al. (1992) and Färe et al. (1994).

	Year	2004	2005	2006	2007	2008	2009
Efficiency	CE	0.62	0.59	0.58	0.50	0.39	0.53
	TE	0.84	0.81	0.78	0.76	0.74	0.76
	ISE	0.94	0.92	0.92	0.92	0.87	0.89
	IPTE	0.89	0.88	0.85	0.83	0.85	0.87
	IAE	0.73	0.72	0.75	0.66	0.53	0.70
	RE	0.75	0.71	0.65	0.59	0.55	0.61
	OSE	0.93	0.91	0.91	0.91	0.86	0.87
	OPTE	0.90	0.90	0.86	0.84	0.86	0.88
	OAE	0.88	0.86	0.82	0.76	0.73	0.78
	PE	0.68	0.64	0.58	0.54	0.47	0.52

Table 4: Cross-sectional averages of cost, revenue and profit efficiency (CE, RE, and PE) and their components in the *production approach*

	Year	2004	2005	2006	2007	2008	2009
Efficiency	CE	0.79	0.76	0.78	0.81	0.79	0.74
	TE	0.93	0.90	0.92	0.93	0.93	0.91
	ISE	0.97	0.94	0.97	0.97	0.95	0.93
	IPTE	0.96	0.96	0.95	0.95	0.98	0.98
	IAE	0.85	0.84	0.85	0.87	0.86	0.82
	RE	0.83	0.81	0.81	0.82	0.80	0.78
	OSE	0.96	0.94	0.96	0.97	0.95	0.93
	OPTE	0.96	0.96	0.96	0.96	0.98	0.98
	OAE	0.89	0.89	0.87	0.88	0.87	0.86
	PE	0.78	0.69	0.70	0.72	0.74	0.71

Table 5: Cross-sectional averages of cost, revenue and profit efficiency (CE, RE, and PE) and their components in the *intermediation approach*

The Malmquist index generally compares technologies between periods. In the DEA framework, it can be used to analyze sources of productivity changes over time. According to the Färe/Grosskopf/Lindgren/Roos (1992) decomposition, the Malmquist index breaks down into efficiency change (EC) and technological change (TC). EC measures the change in technical efficiency of banks between two periods. TC measures technological improvement between two periods, i.e. a shift in the efficient frontier. Regarding the Färe/Grosskopf/Norris/Zhang (1994) decomposition, pure technical efficiency change and scale efficiency change can be input- (IPTEC, ISEC) or output-oriented (OPTEC, OSEC).[19] Pure technical efficiency change measures the managerial effort between two periods. Scale efficiency change reflects scale improvement between two periods. The input or output orientation of efficiency change calculation does not influence the Malmquist index. The corresponding cross-sectional results for the production and the intermediation approach are summarized in Tables 6 and 7, respectively.

	Years	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009
Efficiency change	MI	0.988	0.967	1.022	1.005	0.968
	TEC	0.971	0.964	0.969	0.983	1.054
	ISEC	0.980	1.005	0.989	0.948	1.029
	IPTEC	0.993	0.965	0.981	1.037	1.025
	OSEC	0.976	1.014	0.990	0.945	1.030
	OPTEC	0.995	0.955	0.980	1.043	1.026
	TC	1.016	1.004	1.062	1.027	0.927

Table 6: Cross-sectional averages of the Malmquist index (MI) and its components in the *production approach*

	Years	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009
Efficiency change	MI	0.990	1.003	0.978	0.972	0.944
	TEC	0.971	1.030	1.006	1.002	0.987
	ISEC	0.975	1.030	1.005	0.977	0.978
	IPTEC	0.997	1.000	1.002	1.027	1.009
	OSEC	0.976	1.031	1.004	0.978	0.979
	OPTEC	0.997	0.999	1.002	1.025	1.008
	TC	1.019	0.974	0.972	0.972	0.957

Table 7: Cross-sectional averages of the Malmquist index (MI) and its components in the *intermediation approach*

Comparing efficiency scores measured by the production and the intermediation model in single years shows that the intermediation approach yields significantly higher efficiency scores (see Table 8). These results confirm the findings of Drake/Hall/Simper (2009), who compared, however, only pure technical efficiency scores. In case of efficiency changes, still

[19] See, again, the overview in Figure 1.

more than half of the efficiency change measures show significantly different results (see Table 9). Thus, the production and the intermediation model produce significantly different efficiency scores for banks, especially in single year efficiency measurement.[20]

	Year	2004	2005	2006	2007	2008	2009
Efficiency	CE	**−0.072*****	**−0.060*****	**−0.082*****	**−0.105*****	**−0.093*****	**−0.081*****
	TE	**−0.088*****	**−0.076*****	**−0.119*****	**−0.156*****	**−0.162*****	**−0.127*****
	ISE	**−0.098*****	**−0.113*****	**−0.078*****	**−0.166*****	**−0.278*****	**−0.118*****
	IPTE	**−0.146*****	**−0.153*****	**−0.157*****	**−0.261*****	**−0.343*****	**−0.199*****
	IAE	**−0.021****	**−0.023****	**−0.043*****	**−0.060*****	**−0.079*****	**−0.051*****
	RE	**−0.061*****	**−0.048*****	**−0.076*****	**−0.099*****	**−0.086*****	**−0.073*****
	OSE	**−0.020****	**−0.037*****	**−0.059*****	**−0.121*****	**−0.139*****	**−0.083*****
	OPTE	**−0.088*****	**−0.090*****	**−0.147*****	**−0.225*****	**−0.241*****	**−0.171*****
	OAE	**−0.035*****	**−0.038*****	**−0.053*****	**−0.069*****	**−0.090*****	**−0.064*****
	PE	**−0.078*****	−0.043	−0.073	**−0.141*****	**−0.226*****	**−0.191*****

Table 8: Average differences of *efficiency scores* based on the production model and the intermediation model (*******, ******, and ***** indicate significance at the 1 %, 5 % and 10 % level, resp.)

	Years	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009
Efficiency change	MI	0.018	0.010	**−0.039*****	**0.052*****	**−0.030*****
	TEC	0.016	**−0.051*****	**−0.048*****	−0.001	**0.054*****
	ISEC	0.020	**−0.025****	**−0.027*****	**0.026***	0.017
	IPTEC	−0.003	0.061	**−0.099*****	**0.055*****	**−0.071*****
	OSEC	0.019	**−0.034*****	**−0.027*****	**0.029*****	0.021
	OPTEC	−0.002	−0.021*	**−0.021*****	**−0.024****	**0.037*****
	TC	−0.005	−0.012	**−0.020*****	**−0.025****	**0.035*****

Table 9: Average differences of *efficiency change scores* based on the production model and the intermediation model (denotation of significance according to Table 8)

[20] Note, that higher efficiency scores do not necessarily support superiority of the intermediation model. For example, the intermediation model efficiency scores from Table 5 apparently do not reflect the slump of the financial crisis. Instead, the quality of the model can be evaluated based on its explanatory power; see Section 4 on this.

The following section presents the results regarding the question, which components of efficiency drive market-oriented performance, shareholder value created, and risk level of banks. In addition, the explanatory power of the two models will be compared.

4. Regression Analysis

In order to evaluate how efficiency drives performance and risk of European listed banks, the following general regression equations are formulated:

(13)
$$\text{Performance}_{i,t} = \beta_0 + \beta_1 \cdot \text{Efficiency Change}_{i,t,t-1} + \varepsilon_{i,t}$$
$$\text{Risk}_{i,t} = \beta_0 + \beta_1 \cdot \text{Efficiency Change}_{i,t,t-1} + \varepsilon_{i,t}$$

The regression analysis consists of cross-sectional and time-series observations, where subscript i denotes single banks (i = 1,…,74), and t stands for year 2005,…,2009. The residual ε represents the idiosyncratic error term. In order to take not only current year efficiency into consideration, but also efficiency of the previous year, lagged efficiency variable can be included in the regression. Due to high correlation of efficiency scores of two consecutive years, the percentage change of efficiency between two years (denoted by Δ in the tables) is considered as dependent variable in the following.

Since panel data regression is applied, the Hausman (1978) test was run to test the hypothesis of no correlation between unobserved heterogeneity and the regressors. Since the hypothesis could not be rejected, the generalized least square random effect (GLS RE) technique is used – controlling for existing scale heteroscedasticity across panels and serial correlation within panels.

The regression results of the performance analysis, applying the production model, are presented in Table 10. The overall R-squared indicates that cost efficiency possesses the highest influence on purely market-oriented performance of banks. Stock return and Jensen's alpha are explained by cost efficiency to 16.39 % and 16.68 %, respectively. Within cost efficiency, both input-oriented allocative and technical efficiency play an important role for purely market-oriented performance. Though, only scale efficiency, as a component of technical efficiency, influences stock return and Jensen's alpha. Revenue efficiency is also significant here, but with low explanatory power (3.52 % for stock return and 3.77 % for Jensen's alpha).

Within revenue efficiency, again, only scale and allocative efficiency play a significant positive role. Interestingly – where the overall R-squared exceeds one percent –, input-oriented efficiency measures show higher overall coefficients of determination compared to output-oriented ones. Pure technical efficiency is insignificant for stock return and Jensen's alpha. However, it negatively influences Tobin's *q* and market-to-book ratio. Accounting-based shareholder value measured by residual income is only affected by profit efficiency. Technological change turns out to be insignificant for all performance measures.

The intermediation approach shows, in general, a considerably lower explanatory power to bank performance compared to the production model (see Table 11). Only few overall efficiencies or efficiency components are significant. Again, pure technical efficiency negatively influences Tobin's *q* and market-to-book ratio. At the same time, input-oriented allocative efficiency boosts these performance measures.

The applied GLS RE technique ignores a possible correlation between panels. But the Pesaran (2004) test confirms cross-panel correlation. In order to combine heteroscedastic error terms across panels and correlated error terms within and across panels, feasible generalized least squares (FGLS) technique and panel-corrected standard error (PCSE) linear regression can be used for estimation. In case the number of periods is less than the number of panels (banks), the FGLS estimation can lead to invalid results.[21] Therefore, PCSE estimation was applied to check the results obtained with GLS RE regression.[22] Direction and significance of efficiency influence on performance almost mirror our GLS RE findings of both the production and the intermediation model.

Summarizing the obtained results, the production approach superiorly explains performance of banks compared to the intermediation model. From this perspective, capital market participants view banks as production units considering deposits as important part of their operating activities. Cost efficiency, compared to revenue efficiency, exhibits the strongest influence on market-oriented performance of banks in our sample. Profit efficiency does not possess, however, a strong effect on performance. Assessing the main components of cost and revenue efficiency indicates that scale and allocative efficiency drive the performance of banks. Pure technical efficiency shows either no effect or negative influence on performance.

---

21 See Beck/Katz (1995).

22 Results are not reported in this paper but are available from the authors upon request.

Efficiency change	Performance	Market-oriented performance measures: $\overline{R}$ Coefficient	$\overline{R}$ R^2	α Coefficient	α R^2	Tobin's q Coefficient	Tobin's q R^2	M/B Coefficient	M/B R^2	Accounting-based performance measure RI^{adj} Coefficient	RI^{adj} R^2
	ΔCE	**0.6241*****	0.1639	**0.6365*****	0.1668	–0.0475	0.0029	–0.5883	0.0050	0.0088	0.0008
	ΔTE / TEC	**0.5804*****	0.0244	**0.6006*****	0.0256	–0.3444	0.0174	–3.0456	0.0122	–0.0143	0.0000
	ΔISE / ISEC	**0.8919*****	0.0228	**0.9237*****	0.0239	–0.6031	0.0256	–4.5973	0.0153	–0.0379	0.0006
	ΔIPTE / IPTEC	0.2266	0.0031	0.2357	0.0033	**–0.1260*****	0.0013	**–1.4250*****	0.0014	–0.0049	0.0003
	ΔIAE	**0.4810*****	0.0991	**0.4888*****	0.1002	0.0190	0.0000	–0.0238	0.0006	0.0132	0.0006
	ΔRE	**0.3047****	0.0352	**0.3190****	0.0377	–0.0979	0.0042	–0.9069	0.0027	0.0161	0.0150
	ΔOSE / OSEC	**0.7463****	0.0175	**0.7717****	0.0183	–0.5353	0.0232	–4.0205	0.0135	–0.0915	0.0039
	ΔOPTE / OPTEC	0.3124	0.0058	0.3236	0.0061	**–0.1274*****	0.0014	**–1.4909*****	0.0017	0.0293	0.0020
	ΔOAE	**0.2630***	0.0197	**0.2777***	0.0215	0.0394	0.0002	–0.4219	0.0000	0.0273	0.0203
	ΔPE	0.1114	0.0107	**0.1162***	0.0114	–0.0626	0.0083	**–0.6012***	0.0061	**0.0199***	0.0098
	MI	0.0666	0.0017	0.0634	0.0015	–0.0188	0.0008	0.0453	0.0000	–0.0110	0.0038
	TC	–0.0484	0.0008	–0.0566	0.0010	0.0621	0.0020	0.7666	0.0046	–0.0111	0.0015

Table 10: Regression results of *performance measures* on efficiency changes according to the *production model* (Δ indicates a relative change of the respective efficiency measure from year *t*–1 to year *t*, one plus Δ corresponds to the efficiency change from the Malmquist index decomposition; R^2 means overall R^2; *******, ******, and ***** denote significance at the 1 %, 5 % and 10 % level, resp.)

Performance		Market-oriented performance measures								Accounting-based performance measure	
		$\overline{R}$		α		Tobin's q		M/B		RI^{adj}	
		Coefficient	R^2	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2
Efficiency change	ΔCE	0.0692	0.0006	0.0642	0.0005	0.0689	0.0008	**0.5495****	0.0001	–0.0281	0.0015
	ΔTE / TEC	0.2946	0.0034	0.2848	0.0031	–0.0425	0.0001	–0.4501	0.0000	–0.0256	0.0001
	ΔISE / ISEC	0.4250	0.0026	0.3990	0.0023	0.0116	0.0001	1.0887	0.0010	–0.0896	0.0015
	ΔIPTE / IPTEC	0.0863	0.0009	0.1735	0.0009	**–0.0593***	0.0004	**–1.1174***	0.0009	0.0089	0.0015
	ΔIAE	0.1734	0.0000	–0.0065	0.0000	**0.0929***	0.0011	**0.7537****	0.0001	–0.0253	0.0023
	ΔRE	**0.1234***	0.0073	**0.1256****	0.0074	0.0081	0.0008	0.1207	0.0018	0.0183	0.0201
	ΔOSE / OSEC	0.5588	0.0046	0.5358	0.0041	0.0098	0.0001	1.1678	0.0011	–0.0789	0.0006
	ΔOPTE / OPTEC	0.1199	0.0004	0.1187	0.0004	–0.0607	0.0004	**–1.1790****	0.0010	0.0036	0.0003
	ΔOAE	0.1252	0.0051	**0.1305***	0.0054	0.0179	0.0016	0.2796	0.0031	**0.0301****	0.0256
	ΔPE	0.0078	0.0007	0.0073	0.0006	–0.0019	0.0002	–0.0166	0.0001	–0.0010	0.0000
	MI	0.1749	0.0059	0.1711	0.0055	0.0156	0.0000	0.1318	0.0000	0.0116	0.0004
	TC	0.1333	0.0023	0.1305	0.0022	0.0337	0.0000	0.3043	0.0000	0.0244	0.0004

Table 11: Regression results *of performance measures* on efficiency changes according to the *intermediation model* (annotations of Table 10 apply)

Analyzing the influence of efficiency on risk of banks (second equation of formulas (13)), the same statistical tests and regression techniques were run, that were applied in performance analysis. The results of the production model are reported in Table 12. The figures show that pure technical efficiency increases volatility of stock returns and probability of default. It reduces distance to default measured by Z-scores. These findings indicate that improvements in pure technical efficiency are accompanied by higher risk taking of banks.

Table 12 also contains unexpected results concerning allocative efficiency. Input-oriented allocative efficiency shows a positive impact on volatility and a negative impact on the market-oriented Z-score. Additionally, it positively influences loan loss provisions. However, after controlling for cross-panel correlation, significance of allocative efficiency influence on the mention risk measures disappears in PCSE regression.

The intermediation approach possesses higher explanatory power of technical efficiency (components) for stock volatility and probability of default (see Table 13). Again, there is a positive relation between market-oriented risk and pure technical efficiency. However, allocative efficiency and technological change drive market-oriented risk reduction. These results imply that the ability to efficiently manage input quantities and outputs levels is related to higher asset volatility, which in turn is reflected in higher equity volatility. The latter causes a reduction in stock prices, which can be recognized looking at Tobin's *q* and market-to-book value (see Tables 10 and 11). This negative effect is, however, compensated by scale and allocative efficiency in case of purely market-oriented performance measures.

Controlling for cross-panel correlation, loan loss provisions decrease with increasing pure technical efficiency. Additionally, to exclude income smoothing of banks, we replaced loan loss provisions by realized loan losses in terms of direct write-downs on loans and/or utilization of corresponding provisions. The corresponding results show no evidence that pure technical efficiency reduces write-downs on loans.

	Risk	Market-oriented risk measures						Accounting-based risk measures			
		σ		PD		z^M		*z*		LLP	
		Coefficient	R^2	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2
Efficiency change	ΔCE	**0.2578*****	0.1239	**0.0737****	0.0491	**–0.2949*****	0.0199	0.0270	0.0003	**0.0048****	0.0081
	ΔTE / TEC	**0.4650****	0.0693	**0.1753****	0.0391	**–0.6641*****	0.0162	–0.0984	0.0066	–0.0019	0.0000
	ΔISE / ISEC	0.1108	0.0015	0.1280	0.0065	0.1002	0.0000	0.0655	0.0009	0.0027	0.0017
	ΔIPTE / IPTEC	**0.4569*****	0.0558	0.1293	0.0182	**–0.8131*****	0.0190	**–0.1519***	0.0047	0.0027	0.0017
	ΔIAE	**0.1398****	0.0371	0.0301	0.0090	–0.1415	0.0050	0.0364	0.0000	**0.0050****	0.0087
	ΔRE	**0.1846***	0.0556	0.0563	0.0183	**–0.2586****	0.0107	**–0.0575***	0.0024	0.0010	0.0000
	ΔOSE / OSEC	0.0451	0.0003	0.0808	0.0026	0.2243	0.0006	0.0559	0.0008	–0.0083	0.0007
	ΔOPTE / OPTEC	**0.5252*****	0.0734	**0.1660****	0.0312	**–0.8131*****	0.0190	**–0.1815****	0.0073	0.0019	0.0015
	ΔOAE	0.0885	0.0094	0.0157	0.0000	**–0.1308***	0.0017	–0.0688	0.0006	0.0011	0.0002
	ΔPE	**0.1110***	0.0457	0.0455	0.0302	**–0.0125***	0.0055	0.0109	0.0014	0.0009	0.0006
	MI	–0.0154	0.0003	–0.0154	0.0007	0.0889	0.0002	0.0640	0.0018	–0.0013	0.0003
	TC	–0.1159	0.0182	–0.0175	0.0031	**0.2520***	0.0062	–0.0634	0.0000	–0.0014	0.0003

Table 12: Regression results of *risk measures* on efficiency changes according to the *production model* (annotations of Table 10 apply)

Risk		Market-oriented risk measures						Accounting-based risk measures			
		σ		PD		z^M		z		LLP	
		Coefficient	R^2	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2
Efficiency change	ΔCE	–0.0051	0.0000	0.0315	0.0047	**0.3893****	0.0060	–0.0321	0.0038	**–0.0053***	0.0003
	ΔTE / TEC	0.5380	0.0507	**0.2922***	0.0772	–0.1050	0.0006	0.0261	0.0032	–0.1308	0.0010
	ΔISE / ISEC	–0.2972	0.0054	0.0793	0.0037	1.3567	0.0092	–0.0063	0.0028	–0.0134	0.0003
	ΔIPTE / IPTEC	**0.8596*****	0.0955	**0.3498****	0.0762	**–0.8033*****	0.0089	0.0434	0.0004	–0.0101	0.0020
	ΔIAE	**–0.1601*****	0.0118	**–0.0506****	0.0038	**0.4731*****	0.0088	–0.0522	0.0017	–0.0014	0.0000
	ΔRE	0.0768	0.0125	0.0348	0.0094	–0.0197	0.0001	–0.0074	0.0000	**–0.0040****	0.0027
	ΔOSE / OSEC	–0.2786	0.0047	0.0781	0.0036	1.3378	0.0087	–0.0510	0.0037	–0.0153	0.0001
	ΔOPTE / OPTEC	**0.8679*****	0.0950	**0.3572****	0.0778	**–0.8069*****	0.0087	0.0630	0.0003	–0.0095	0.0017
	ΔOAE	0.0089	0.0001	0.0015	0.0002	0.0372	0.0003	–0.0212	0.0001	**–0.0044***	0.0037
	ΔPE	0.0099	0.0048	0.0115	0.0328	0.0013	0.0000	0.0006	0.0005	–0.0003	0.0028
	MI	0.0167	0.0003	0.0582	0.0136	0.2049	0.0026	0.0382	0.0000	–0.0028	0.0001
	TC	**–0.1319****	0.0100	0.0007	0.0000	**0.3264*****	0.0059	0.0446	0.0018	–0.0006	0.0000

Table 13: Regression results of *risk measures* on efficiency changes according to the *intermediation model* (annotations of Table 10 apply)

In order to check the robustness of the achieved results, several macroeconomic and bank-specific control variables were included in the regression. We control for assets size (natural logarithm of assets), financial structure (leverage), and profitability of banks (return on equity). Income diversification is taken into account by the ratio of non-interest income over net operating income. Macroeconomic variables include (logarithm of) real GDP per capita and inflation rate of the corresponding country. Conditioning on these additional bank and macroeconomic characteristics, the described results stay robust.

Purely market-oriented performance is still positively affected by input-oriented scale and allocative efficiency. Increasing pure technical efficiency causes higher asset volatility and, hence, increasing stock volatility. With respect to shareholder value determined by adjusted residual income, results differ from our other performance findings. Here, output-oriented pure technical and allocative efficiency influence accounting-based shareholder value in a positive way. This indicates that the managers' ability to improve pure technical efficiency is reflected in superior accounting figures (residual income and contrariwise loan loss provisions). In contrast, purely market-oriented performance is not driven by pure technical efficiency.

If loan loss provisions are replaced by realized loan losses, the significant influence of pure technical efficiency disappears. This, once more, supports our finding, that pure technical efficiency is improved accompanied by higher asset risk. The latter does not occur in accounting figures, but is incorporated in stock prices in terms of Tobin's *q* and market-to-book ratio. With regard to stock return and Jensen's alpha, this effect interferes with scale efficiency. The main robustness check results are summarized in Table 14, where according to the direction, only significant results are denoted by plus or minus sign.

		Performance					Risk					
		Market-oriented				Acc.-based	Market-oriented			Accounting-based		
		$\bar{R}$	α	q	M/B	RI^{adj}	σ	PD	z^M	z	LLP	RLL
Efficiency change	ΔCE	+	+						+		−	
	ΔTE / TEC	+	+	−	−			+				
	ΔISE / ISEC	+	+									
	ΔIPTE / IPTEC			−	−		+	+	−		−	
	ΔIAE	+	+				−	−	+			
	ΔRE	+	+			+					−	−
	ΔOSE / OSEC											
	ΔOPTE / OPTEC			−	−	+	+	+	−		−	
	ΔOAE					+					−	−
	ΔPE			−	−						−	−
	MI											
	TC						−		+			

Table 14: Robustness check results with respect to macroeconomic and industry-specific variables (+ and − indicate significance with positive and negative influence, resp.; production model results for performance measures, intermediation model results for risk measures; RLL denotes realized loan losses over total loans)

5. Conclusions

We analyzed the relation between efficiency on the one hand and performance and risk on the other hand of European listed banks. Decomposition of overall efficiencies into their components allows a detailed analysis of performance and risk drivers of the European commercial banking industry in the period between 2004 and 2009. To guarantee the quality of the analysis, all accounting data was hand-collected from annual reports under IFRS. Market-oriented and accounting-based measures were used as dependent variables in the regression analysis to capture all possible influencing factors of efficiency on performance and risk of banks.

The impact of postulating the production or the intermediation model was also examined. Comparing efficiency scores shows that the intermediation model yields significantly higher figures compared to the production approach. Assessing the influence of efficiency on performance and risk of banks, we found, however, evidence for superiority of the production model in explaining performance. Contrariwise, the intermediation model seems to superiorly predict risk. Market-oriented performance is mostly affected by cost efficiency. Allocative and scale efficiency are the main drivers for performance of banks. These results demonstrate that abilities to choose the right operating size and to manage competitive input and output prices lead to superior performance in the banking industry.

As a further important finding, our sample shows that pure technical efficiency is associated with higher asset risk. Higher asset risk is reflected in higher stock volatility and, hence, causes lower market values. This implies that bank managers can improve pure technical efficiency by taking more risk. This form of higher risk is not captured by accounting figures, but priced by the capital market. Due to this effect of indicating seemingly lower credit risk, accounting-based residual income increases and loan loss provisions decrease with higher pure technical efficiency.

In contrast to previous studies, we also applied realized loan losses as risk measure, calculated by direct write-downs and utilization of loan loss provisions. Realized loan losses are not affected by pure technical efficiency. This, again, implies that managers are able to influence accounting information in this respect, whereas the capital market incorporates this circumstance. Table 15 summarizes the main results of our paper.

Intermediation vs. production approach	• Intermediation model shows higher efficiency scores • Production model superiorly explains performance • Intermediation model superiorly explains risk
Scale efficiency	• Improvement in market-oriented performance
Allocative efficiency	• Improvements in market-oriented performance • Risk reduction
Pure technical efficiency	• Market value reduction • Increase in risk • Accounting-based measures show opposite results
Technological change	• Risk reduction
Scale efficiency change	• Improvement in market-oriented performance
Pure technical efficiency change	• Market value reduction • Increase in risk

Table 15: Summary of main results

Appendix

There are many possible adjustments that can be applied for accounting components of EVA. The adopted adjustments shall eliminate accounting distortions and lead to improvements in explaining market values. Industry specifics and different reporting standards must be taken into consideration in the set of adjustments. Uyemura/Kantor/Pettit (1996) present common bank-specific adjustments, that affect loan loss provisions, deferred taxes, non-recurring events (e.g. restructuring charges), and securities accounting. Fiordelisi (2007) and Fiordelisi/Molyneux (2010a) capitalize also research and development (R&D) costs and operating lease payments.

Latitude in estimating future credit risk allows banks to manipulate loan loss provisions for income smoothing purposes. In order to avoid possible distortions from income smoothing of listed European banks, only incurred losses during the year in form of utilization of provisions and/or direct write-downs through profit and loss are considered. This important information, interestingly, has not been disclosed by many publicly-traded European banks during the observation years. This lack of financial information has sharply narrowed the sample of banks, limiting the analysis to 74 banks. Deferred taxes, as non-current cash cost, establish a kind of provisions for possible future cash payments, what can distort actual realized returns on invested capital. Therefore, calculating residual income, only current tax payments are taken into consideration. Calculating residual income, net income and equity book values are adjusted by loan loss provisions and deferred taxes as follows:

(14) $$\mathrm{RI}_t^{\mathrm{adj}} = \mathrm{NI}_t^{\mathrm{adj}} - r_{E,t} \cdot B_{t-1}^{\mathrm{adj}}$$

$$\begin{aligned} \text{where} \quad \mathrm{NI}_t^{\mathrm{adj}} &= \text{Net income}_t + \text{Deferred taxes}_t \\ &\quad + \left(\text{Loan loss provisions}_t + \text{Recoveries}_t - \text{Write-offs}_t\right) \cdot (1 - \mathrm{tr}) \\ B_{t-1}^{\mathrm{adj}} &= \text{Book value of equity}_{t-1} + \text{Loan loss provisions}_{t-1} \\ &\quad + \text{Deferred tax liabilities}_{t-1} - \text{Deferred tax assets}_{t-1} \\ \mathrm{tr} &= \text{tax rate} \end{aligned}$$

Since from an external point of view, it is difficult to distinguish between investment and disinvestment character of restructuring activities, restructuring charges are not taken into consideration. Securities accounting adjustment is also ignored, since trading is one of the core activities of banks leading to better or worse performance in the reporting year. Adoption of

IAS 36 eliminates the reason for goodwill adjustment. Concerning R&D, production costs for in-house development of software were already capitalized according to IAS 38. No other development costs were recognized or disclosed in net income statements. Leasing payments only influence net income in equity valuation frameworks. Net income must be adjusted by adding lease payments and subtracting amortization amounts. Assuming equality of both amounts leads to unaffected net income.

References

Altman, E.I. (1968): Financial ratios, discriminant analysis and the prediction of corporate bankruptcy, *Journal of Finance* 23, pp. 589–609.

Altunbas, Y., Carbo, S., Gardener, E.P.M., Molyneux, P. (2007): Examining the relationships between capital, risk, and efficiency in European banking, *European Financial Management* 13, pp. 49–70.

Asmild, M., Paradi, J.C., Aggarwall, V., Schaffnit, C. (2004): Combining DEA window analysis with the Malmquist index approach in a study of the Canadian banking industry, *Journal of Productivity Analysis* 21, pp. 67–89.

Athanasoglou, P.P., Brissimis, N.S., Delis, M.D. (2008): Bank-specific, industry-specific and macroeconomic determinants of bank profitability, *Journal of International Financial Markets, Institutions and Money* 18, pp. 121–136.

Banker, R.D., Charnes, A., Cooper, W.W. (1984): Some models for estimating technical and scale inefficiencies in data envelopment analysis, *Management Science* 30, pp. 1078–1092.

Bannier, C.E., Behr, P., Güttler, A. (2010): Rating opaque borrowers: why are unsolicited ratings lower?, *Review of Finance* 14, pp. 263–294.

Barry, T.A., Lepetit, L., Tarazi, A. (2011): Ownership structure and risk in publicly held and privately owned banks, *Journal of Banking and Finance* 35, pp. 1327–1340.

Beccalli, E., Casu, B., Girardone, C. (2006): Efficiency and stock performance, *Journal of Business Finance and Accounting* 33, pp. 245–262.

Beck, N., Katz, J.N. (1995): What to do (and not to do) with time-series cross-section data, *American Political Science Review* 89, pp. 634–647.

Berger, A.N., DeYoung, R. (1997): Problem loans and cost efficiency in commercial banks, *Journal of Banking and Finance* 21, pp. 849–870.

Berger, A.M., Humphrey, D.B. (1997): Efficiency of financial institutions: international survey and directions for future research, *European Journal of Operational Research* 98, pp. 175–212.

Bharath, S.T., Shumway, T. (2008): Forecasting default with the Merton distance to default model, *Review of Financial Studies* 21, pp. 1339–1369.

Bikker, J.A., Hu, H. (2002): Cyclical patterns in profits, provisioning and lending of banks and procyclicality of the new Basel capital requirements, *BNL Quarterly Review* 221, pp. 143–175.

Bourke, P. (1989): Concentration and other determinants of bank profitability in Europe, North America and Australia, *Journal of Banking and Finance* 13, pp. 65–79.

Boyd, J.H., Graham, S.L. (1988): The probability and risk effects of allowing bank holding companies to merge with other financial firms: a simultaneous study, *Federal Reserve Bank of Minneapolis Quarterly Review* 12, pp. 3–20.

Boyd, J.H., Graham, S.L., Hewitt, R.S. (1993): Bank holding company mergers with nonbank financial firms: effect on the risk of failure, *Journal of Banking and Finance* 17, pp. 43–63.

Brainard, W.C., Tobin, J. (1968): Pitfalls in financial model building, *American Economic Review* 58, pp. 99–122.

Caprio, G., Laeven, L., Levine, R. (2007): Governance and bank valuation, *Journal of Financial Intermediation* 16, pp. 584–617.

Charnes, A., Cooper, W.W., Rhodes, E.L. (1978): Measuring the efficiency of decision making units, *European Journal of Operational Research* 2, pp. 429–444.

Cooper, W.W., Seiford, L.M., Tone K. (2007): *Data envelopment analysis, a comprehensive text with models, applications, references and DEA-solver software*, 2nd ed., New York.

Drake, L., Hall, M.J.B., Simper, R. (2009): Bank modelling methodologies: a comparative non-parametric analysis of efficiency in the Japanese banking sector, *Journal of International Financial Markets, Institutions and Money* 19, pp. 1–15.

Elsas, R., Hackethal, A., Holzhäuser, M. (2010): The anatomy of bank diversification, *Journal of Banking and Finance* 34, pp. 1274–1287.

Emrouznejad, A., Parker, B.R., Tavares, G. (2008): Evaluation of research in efficiency and productivity: a survey and analysis of the first 30 years of scholarly literature in DEA, *Socio-Economic Planning Science* 42, pp. 151–157.

Farell, M.J. (1957): The measurement of productive efficiency, *Journal of the Royal Statistical Society* 120, pp. 253–290.

Färe, R., Grosskopf, S., Lindgren, B., Roos, P. (1992): Productivity changes in Swedish pharmacies 1980-1989: a nonparametric Malmquist approach, *Journal of Productivity Analysis* 3, pp. 85–101.

Färe, R., Grosskopf, S., Norris, M., Zhang, Z. (1994): Productivity growth, technical progress, and efficiency change in industrialized countries, *American Economic Review* 84, pp. 66–83.

Fernandez, P. (2002): *Valuation methods and shareholder value creation*, San Diego.

Fethi, A.D., Pasiouras, F. (2010): Assessing bank efficiency and performance with operational research and artificial intelligence techniques: a survey, *European Journal of Operational Research* 204, pp. 189–198.

Fiordelisi, F. (2007): Shareholder value efficiency in European banking, *Journal of Banking and Finance* 31, pp. 2151–2171.

Fiordelisi, F., Molyneux, P. (2010a): The determinants of shareholder value in European banking, *Journal of Banking and Finance* 34, pp. 1189–1200.

Fiordelisi, F., Molyneux, P. (2010b): Total factor productivity and shareholder returns in banking, *Omega* 38, pp. 241–253.

Fiordelisi, F., Marques-Ibanez, D., Molyneux, P. (2011): Efficiency and risk in European banking, *Journal of Banking and Finance* 35, pp. 1315–1326.

Foos, D., Norden, L., Weber, M. (2010): Loan gross and riskiness of banks, *Journal of Banking and Finance* 34, pp. 2929–2940.

Hausman, J.A. (1978): Specification tests in econometrics, *Econometrica* 46, pp. 1251–1271.

Houston, J.F., Lin, C., Lin, P., Ma, Y. (2010): Creditor rights, information sharing, and bank risk taking, *Journal of Financial Economics* 96, pp. 485–512.

Iannotta, G., Nocera, G., Sironi, A. (2007): Ownership structure, risk and performance in the European banking industry, *Journal of Banking and Finance* 31, pp. 2127–2149.

Jensen, M.C. (1968): The performance of mutual funds in the period 1945-1964, *Journal of Finance* 23, pp. 389–416.

Koutsomanoli-Filippaki, A., Mamatzakis, E. (2009): Performance and Merton-type default risk of listed banks in the EU: a panel VAR approach, *Journal of Banking and Finance* 33, pp. 2050–2061.

Kumar, S., Gulati, R. (2008): An examination of technical, pure technical, and scale efficiencies in Indian public sector banks using data envelopment analysis, *Eurasian Journal of Business and Economics* 1, pp. 33–69.

Kwan, S., Eisenbeis, R.A. (1997): Bank risk, capitalization, and operating efficiency, *Journal of Financial Services Research* 12, pp. 117–131.

Laeven, L., Levine, R. (2007): Is there a diversification discount in financial conglomerates?, *Journal of Financial Economics* 85, pp. 331–367.

Laeven, L., Levine, R. (2009): Bank governance, regulation and risk taking, *Journal of Financial Economics* 93, pp. 259–275.

Lepetit, L., Nys, E., Rous, P., Tarazi, A. (2008): Bank income structure and risk: an empirical analysis of European banks, *Journal of Banking and Finance* 32, pp. 1452–1467.

Merton, R.C. (1974): On the pricing of corporate debt: the risk structure of interest rates, *Journal of Finance* 29, pp. 449–470.

Molyneux, P., Thornton, J. (1992): Determinants of European bank profitability: a note, *Journal of Banking and Finance* 16, pp. 1173–1178.

Pathan, S. (2009): Strong boards, CEO power and bank risk-taking, *Journal of Banking and Finance* 33, pp. 1340–1350.

Pesaran, M.H. (2004): General diagnostic tests for cross section dependence in panels, Working Paper, University of Cambridge.

Sharpe, W.F. (1964): Capital asset prices: a theory of market equilibrium under conditions of risk, *Journal of Finance* 19, pp. 425–442.

Short, B.K. (1979): The relation between bank profit rates and banking concentration in Canada, Western Europe and Japan, *Journal of Banking and Finance* 3, pp. 209–219.

Stewart, G.B. (2008): *The quest for value: a guide for senior managers*, New York.

Stiroh, K.J., Rumble, A. (2006): The dark side of diversification: the case of US financial holding companies, *Journal of Banking and Finance* 30, pp. 2131–2161.

Tobin, J. (1969): A general equilibrium approach to monetary theory, *Journal of Money, Credit, and Banking* 1, pp. 15–29.

Tobin, J. (1978): Monetary policy and the economy: the transmission mechanism, *Southern Economic Journal* 44, pp. 421–431.

Tobin, J., Brainard, W.C. (1977): Asset markets and the cost of capital, in: Belass, B., Nelson, R. (eds.), *Economic progress private values and private policies: essays in honor of William Fellner*, Amsterdam, pp. 235–262.

Uyemura, D.G., Kantor, G.C., Pettit, J.M. (1996): EVA for banks: value creation, risk management, and profitability measurement, *Journal of Applied Corporate Finance* 9, pp. 94–113.

Otto von Guericke University Magdeburg
Faculty of Economics and Management
P.O. Box 4120 | 39016 Magdeburg | Germany

Tel.: +49 (0) 3 91/67-1 85 84
Fax: +49 (0) 3 91/67-1 21 20

www.fww.ovgu.de/femm

ISSN 1615-4274